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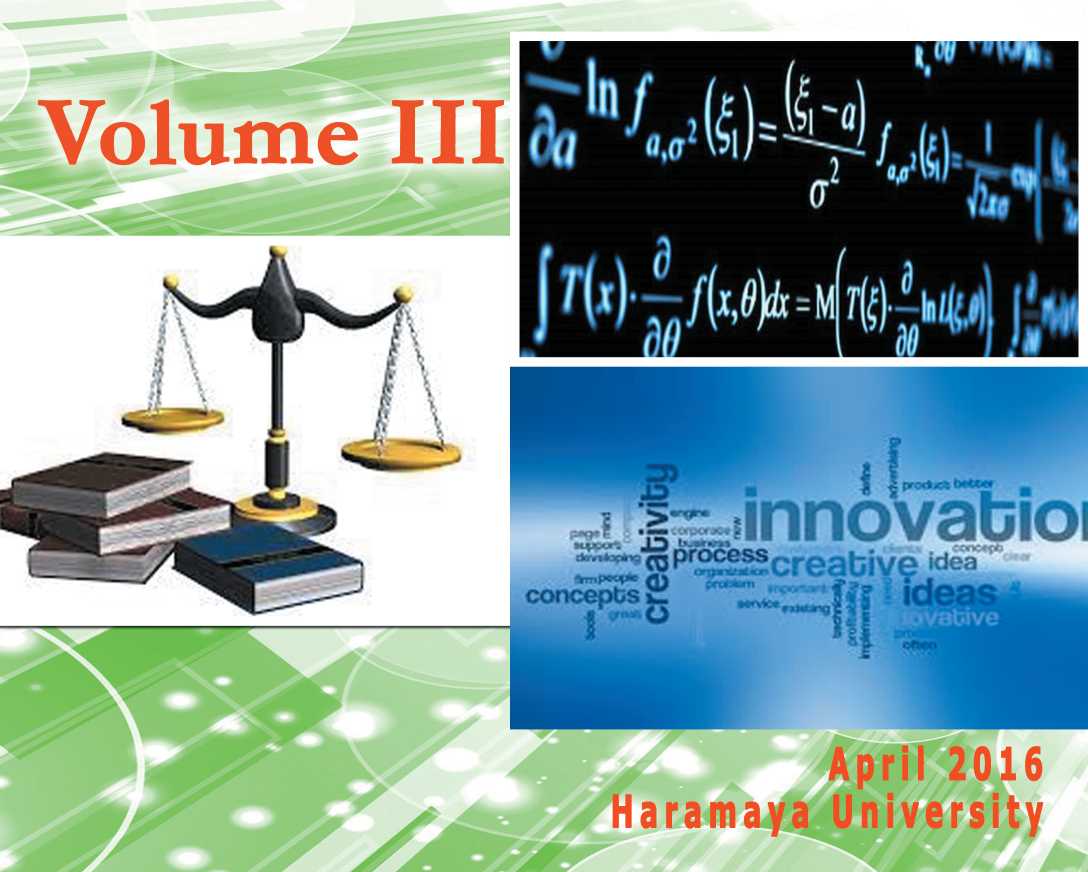
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**Energy, Engineering, and Information Technologies**



**Theme III**

1. Chelating Agent Free Solid Phase Extraction (CAF-SPE) of Lead, Cadmium and Chromium by Fe-Al-Zr Ternary Mixed Oxide N anocomposite

Kassahun Challa1, Endale T1. Isabel Diaz 2, and Abi M. Taddesse1

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Abstract: Synthesis of Fe-Al-Zr ternary mixed oxide nanocomposite was performed by using ferric nitrate nona hydrate, aluminum nitrate nona hydrate and zirconium oxide via impregnation method. The method was based on the adsorption of Pb(II), Cd(II) and Cr(VI) ions on the column packed with Fe-Al-Zr mixed oxide nanocomposite; elution of the column was performed with 0.5 M HCl and subsequent determination by FAAS. The effects of different experimental variables such as pH, eluent type, flow rate and interfering ions on the recovery of the analytes were investigated and optimum conditions were established. The adsorption of Pb(II), Cd(II) and Cr(VI) on the mixed nanocomposite was investigated for different parameters and the adsorption capacities were evaluated using the Langmuir and Freundlich isotherm models.

The mixed oxide nanocomposite prepared by sintering the mixed oxy- hydroxide at 400oC showed a very high adsorption capacity of Pb(II), Cd(II) and Cr(VI).Thus, these nanocomposites can be used as good adsorbents to preconcentrate the Pb(II), Cd(II) and Cr(VI) ions from aqueous solutions

Keywords: Adsorption; Impregnation; Nanocomposite; Point zero charge; Preconcentration

1. Introduction

Heavy metals are released into the environment from industrial applications, including mining, refining and production of textiles, paints and dyes. These pollutants greatly threaten the health of human populations’ and the natural ecosystems even at low concentration. As they do not degrade biologically like organic pollutants, their presence in drinking water or industrial effluents is a public health problem due to their absorption and therefore possible accumulation in organisms (Chang et al, 2009). The toxicities of heavy metals may be caused by the inhibition and reduction of various enzymes, complexes with certain ligands of amino acids and substitution of essential metal ions from enzymes. Hence, their determination in industrial effluents, various water resources, environmental and biological samples is important, especially in the environment monitoring and assessment of occupational and environmental exposure to toxic metals (Ghaedi et al, 2011).

Lead, cadmium and chromium (VI) are the major toxic pollutants, which can enter the water streams through various industrial operations. The potential sources of chromium (VI) wastes are effluents from metallurgy, electroplating, leather tanning, textile dyeing, paint, ink and aluminum manufacturing industries. Lead is used as industrial raw material in the manufacture of storage batteries, pigments, leaded glass, fuels, photographic materials, solder and steel products. Cadmium has been widely dispersed into the environment through the air by its mining and smelting as well as by other man-made routes: usage of phosphate fertilizers and presence in sewage sludge (Nadeem et al, 2006).

Lead and chromium (VI) are toxic contaminants, even in very low concentrations. Severe lead poisoning can cause encephalopathy, with permanent damage, while moderate lead poisoning result in neurobehavioral and intelligent deficit .The presence of lead in drinking water, even in low concentrations may cause anemia, hepatitis and nephritic syndrome. Lead poisoning in humans causes severe damage to kidney, nervous system, reproductive system, liver and brain (Chen et al, 2007).

Chromium (VI) is carcinogenic to both humans and animals. Strong exposure of chromium (VI) causes cancer in the digestive tract and lungs and may cause gastric pain, nausea and vomiting, severe diarrhea and hemorrhage. According to the United States Environmental Protection Agency (USEPA, 2007), the maximum permissible limits in waste water and potable water are 0.1 mg/L and 0.015 mg/L for lead (II) and 1.0 mg/L and 0.05 mg/L for chromium (VI) and 0.2 to 3.0 mg/L for Cd(II), respectively (Park et al, 2005).

However, the direct determination of heavy metal ions at trace levels in real samples remains a challenging problem because of their low concentration and matrix effects even with frequently used sophisticated instrumental techniques such as X-ray Diffraction (XRD), Fourier transforms infrared spectroscopy (FTIR), inductively coupled plasma atomic emission spectrometry (ICP-AES), electro thermal atomic absorption spectrometry (ET-AAS) etc. without sample preconcentration and separation.

Different techniques were used for the separation and preconcentration of metals in a solution. These methods, however, have not enough sensitivity and selectivity to establish the heavy metal amounts of real solution without using a preconcentration step. A preconcentration step be able not only to concentrate the analyte but also to simplify the matrix of the sample that is usually strongly desired. These include liquid- liquid extraction, precipitation, cation exchange resins, cloud point extraction and solid phase extraction. These have been used for the separation and enrichment of trace amounts of heavy metals from aqueous solutions. However, disadvantages such as significant chemical additives, solvent losses, complex equipment’s, large secondary

wastes, pre filtration problems and time consuming procedures, limit the application of most of these techniques(Chang et al, 2009).

Chelating agent assisted SPE technics have been utilized widely in various domestic and industrial applications for many years and gained attention in the field of metal extraction from various contaminated sites for minimizing environmental pollution. A high resistance to biodegradability is requisite to attain stability of the metal—chelate complex during industrial processes; however, non-biodegradable chelating agents may have certain deleterious effects on the ecosystem. Chelating agents may perturb the natural speciation of metals and may have a dissolution effect on heavy metals adsorbed in sediments. Chelating agents contain nearly 10% nitrogen which may eventually become present in aquatic systems, and thus chelating agents may have a significant effect on the eutrophication process (Garimaet al, 2015).

Chelating agent free (SPE) technic addresses these problems. It can extend the detection limits and remove interfering constituents thereby improving the precision and accuracy of the analytical results. There has been sustained interest in the application of this method to various contaminants in complex matrix environmental samples. This preconcentration technique has the advantage of high recovery, short analysis time, high enrichment factor, low cost, consumption of organic solvents and ecologically safe(Ozcan et al, 2011). Up to now, several kinds of sorbent, such as activated carbon, polymeric fibers, chelating resins, activated alumina inorganic ion-exchanger, silica gel and alumina have been used to preconcentrate trace metal ions. However, they suffer from lack of selectivity, which leads to high interference of other existing species with the analyte metal ion and chemical stability

Recently, a utilization of nanometer-sized material in SPE as metals ions extractors has turned out to be an active area of research in the field of separation science because of their special properties. Magnetic nanoparticles, a new kind of nanometer-sized material, are widely used in the fields of biotechnology, biomedicine and as an efficient adsorbent with large specific surface area and small diffusion resistance. (Saber-Tehrani et al, 2011).

Sorption characteristics of single-component Al or Fe hydro (oxides) have been widely studied; limited work has been conducted on the sorption characteristics of mixed Al—Fe hydro (oxide). Many studies have shown that in both soils and aquatic environments Al and Fe-hydro (oxides) often control the biogeochemical cycling of nutrients, such as phosphate, via colloidal transport and/or adsorption/desorption mechanisms. Since, naturally occurring oxides are typically co-precipitated mixtures; it is reasonable to postulate that co-precipitated mixed metal Al—Fe hydroxides are likely to play a major role in the geochemical cycling of nutrients and contaminants (Shwe et al., 2012).

Magnetic Fe—Zr binary oxide was used as adsorbent for removal of phosphate from aqueous solution. The adsorbent collected with a high gradient magnet. The magnetic Fe—Zr binary oxide adsorbent possessed favorable adsorption capacity for phosphate and exhibited good regeneration property. Experimental parameters such as the effect of pH, contact time, ionic strength and effect of other anions were also investigated (Cichocki et al, 1997).

In the present study a new ternary nanocomposite of (Fe-Al-Zr) oxide was successfully synthesized using impregnation method due to its advantages such as good homogeneity, low reaction temperature, fine and better adsorption capacity, high surface area, good regeneration property, low cost and time saving processing. Therefore, the proposed method gives very low LOD and good RSD, and can be applied to the determination of trace of Pb(II), Cd(II) and Cr(VI) ions in various real samples. The present method is superior in terms of linear range, detection limits, and selectivity. The detection limit achieved was satisfactory for the samples studied, and can be improved by using more sensitive detectors such as ICP-AES and ICP-MS.

1. Material and Methods
   1. Experimental Site

Preparation of the adsorbent and FAAS measurements as well as adsorption experiments such as optimization of the operational parameters and adsorbent capacity determination were conducted at the Chemistry Research Laboratory of the Haramaya University. The XRD pattern, SEM-EDX and BET of the as-synthesized nanocomposite were analyzed in Instituto de Catalisis y. Petroleoquimica, CSIC, C/Marie Curie 2, Madrid, Spain whereas the FTIR spectra of the nanocomposite were determined at the Chemistry department of Addis Ababa University.

* 1. Materials and Instruments
     1. Apparatus and equipment

X-ray diffractometer (XRD) (BRUKER D8 Advanced XRD) was used for the characterization of the synthesized powder sample. Fourier transform infrared spectrophotometer (FTIR) (Perkin Elmer) was employed to describe the interaction between aqueous chromium, cadmium and leadand solid Fe-Al-Zr ternary mixed oxide nanocomposite. FAAS (Model 210/211 VGP) was used to determine the concentration of Chromium, Cadmium and Lead, Deionizer (B114), Dry oven(Gallenkamp made in UK),pH-meter(model 3310 JENWAY, Japan), Furnace (BIBBY Stuart, UK) and Orbital shaker S01 (Stuart, UK) were also used in this study.

The common laboratory apparatus which were used during the study were different sized beakers, Erlenmeyer flasks, burettes, funnels, graduated cylinders, volumetric flasks, capped test tubes, droppers, glass pipettes, spatula, measuring cylinders, fraction collector, stirrer, analytical balance, conical flask, cotton wool and a60 cmx8 mm glass column.

1. Chemicals and reagents

The chemicals and reagents used include: Potassium dichromate (IGC^Oy, 99% BDH chemicals Ltd, England), Cd(NO3)2.4H2O (99%Sigma-Aldrich, England) and Pb(NO3)2 (99% Sigma-Aldrich Chemie GmbH) which were used for preparation of stock standardsolution. Al(NO3)3.9H2O (98% Merck Germany), Fe(NO3)3.9H2O (98%, BDH chemicals Ltd, England), ZrO2(95% LR, China),H2SO4 (98%, laboratory reagent, LOBA, India)HNO3 (69% LR, Breckland Scientific Supplies, U.K), and sodium hydroxide(NaOH, 97.5% BDH chemicals Ltd, England). All chemicals used were analytical grade and used with no further purification.

* 1. Experimental Rocedures
     1. Sample reparation

Stock solutions (1000 mg/L each) ofCr(VI), Cd(II) and Pb(II) metal ions were prepared from I<2Cr2O7,Cd(NO3)2.4H2O and Pb(NO3)2, respectively by dissolving appropriate amount in 1 L of slightly acidified double distilled water. The working solutions (20 mg/L for Pb, 5 mg/Lfor Cd and 5 mg/Lfor Cr(VI) were prepared by suitable dilution of the stock solutions. The water samples analyzed were filtered prior to analysis using a cellulose membrane filter (Millipore) of 0.45 pm pore size. The pH of the sample solutions was adjusted each time to the optimum value with a dilute HCl (0.1M) or NaOH (0.1M) solution (Marisa, et al, 2008).

Buffer solutions were prepared from 1 mol/L sodium sulfate and 1 mol/L sodium hydrogen sulfate for pH-2, from 1 mol/L sodium acetate and 1 mol/L acetic acid for pH 3—6, from 0.1 mol/L potassium di-hydrogen phosphate and 0.1 mol/L disodium hydrogen phosphate for pH-7, from 0.1 mol/L ammonium chloride and ammonia for pH 8—10, and from 0.1 mol/L sodium di-hydrogen phosphate and 0.1 mol/L sodium hydroxide for pH 11—12 (Celal et al, 2007).

* + 1. Synthesis of Fe-Al-Zr ternary mixed oxides nanocomposite

The Fe-Al-Zr ternary mixed oxide nanocomposite was prepared by impregnation method (Aguila et al., 2008). In which 0.1 molar nano sized Fe-Al-Zr ternary mixed oxide was prepared by impregnating ZrO2 with Al and Fe nitrate aqueous solution in deionized water with 1:3 ratios. Three samples of the adsorbent having different molar percentages of [Fe(NO3)3.9H2O, Al (NO3)3.9H2O and ZrO2]precursors as (90, 8, 2), (80, 10, 10), (70, 25, 5) % or molar ratio 45:4:1, 8:1:1 and 14:5:1, respectively, were prepared for this study. During the synthesis process, three beakers (1L) were utilized. The amount of Al and Fe nitrates were dissolved in separate beakers. They were mixed together in a third beaker while stirring after complete dissolution. The ZrO2 powder was added on the mixed salt solution then the sample left for 6 hour without disturbance then dried at 110oC in an oven over night, and further calcined at 400,600 and 700oC for 3 hour. The percentage composition of the as-synthesized Fe-Al-Zr ternary mixed oxide nanocomposite powders calcined at 400, 600 and 700oC were calculated based on the equation given below.

M % = *concentration(ppm)* \*

voluna e diluted

M ass o F "amp l a taken \*1001)

\* 100%

(5)

* 1. Characterization of the As-Synthesized Adsorbent
     1. FTIR analysis of adsorbent

A Fourier transform infrared spectrum of the as-synthesized powder was recorded by using a FTIR spectrometer (Bruker Optics EQUINOX 65) at room temperature (Li et al, 2007).The FTIR analysis was also performed to identify the nature and symmetry of interlayer anions and the presence of impurity phases of Fe-Al-Zr ternary mixed oxide nanocomposite before and after adsorption in terms of wave numbers, the vibrational infrared extends in the range of 4000 to 400 cm-1.

1. Elemental analysis of adsorbent

The percentages of iron, aluminum and zirconium in the selected as-synthesized powders were determined by flame atomic absorption spectrophotometer. For this purpose, 0.5 g of the as-synthesized powder for three replication were digested with a mixture of concentrated nitric acid (7 mL), concentrated hydrochloric acid (4 mL) and hydrogen peroxide (2 mL) using acid digestion tube till clear solution appeared. The samples were transferred to 100 ml volumetric flasks and brought to volume using deionized water. One mL of this solution was diluted further to 50 mL and the concentration of iron was read from the solution in 50 ml volumetric flasks. The results were corrected for the dilution factor (Bock, 1978).

* 1. Column Preparation

The adsorption experiments were carried out using columns that were equipped with a stopper for controlling the column flow rate. Fe-Al-Zr ternary mixed oxides nanocomposite was employed to pack the solid-phase extraction column as follows: the column was prepared by introducing 500 mg of Fe-Al-Zr ternary mixed oxides nanocomposite into an empty glass column using the dry packing method. Small amount of glass wool was spread uniformly in the lower part of the column to retain the nanocomposite in the column. Another glass wool was placed on the top of the packed nanocomposite in order to maintain the integrity of the column. Before loading the sample, the column was cleaned by washing the sorbent bed with dilute HCl (0.5 mol/ L) and water respectively (Ozcan, 2011). The column was preconditioned by passing blank solution having the same pH as the sample solution prior to each use.

* 1. Preconcentration and Determination Procedure

The column adsorption technique is particularly advantageous over the batch or static equilibration method for possible application of large sample volumes (Mahmoud, 1997). This property enables the preconcentration of metal ions at very low trace levels. Separation/preconcentration and the procedure based on the solid phase extraction via theFe-Al-Zr ternary mixed oxides nanocomposite were tested with model sample solution. To this effect each 50mL of sample solution containing 5 mg/L Cr(VI), 5 mg/L Cd(II) and 20mg/L Pb(II) was taken and the pH was adjusted to the desired value using dilute HCl(0.1M) or NaOH(0.1M) solution (Marisaet al, 2008). The columnwas conditioned to the working pH by passing the blank solution having same pH values as the sample solution. This was followed by passing sample solution through the column at a flow rate of 5mL/min. The retained analytes on the sorbent were then eluted with 15 mL of 0.5 M HCl solution as desorbing and this was aspirated into air- acetylene flame for determination of Cr(VI), Cd(II) and Pb(II) ions by FAAS.

* 1. Optimization of the Operational Parameters

To evaluate the potentiality of the nanosorbent for selective preconcentration of Cr(VI), Cd(II) and Pb(II) ions from sample solution, the method was optimized for various parameters such as, pH of sample solution, eluent type, foreign ions, sample volume and flow rate. These parameters play an important role in the adsorption of the ions onto the sorbent of interest. The percentage recovery (% R) in each case was calculated by using the following equation (Nasser et al, 2011).

%R **= 5? \* 100**

*n0*

Q? *\*Vg*

*c0\*vs*

\* 100

(7)

Where Tigris amount of metal ions eluted from nanocomposite, np is die starting amount of each metal ions, CE is concentration metal ions eluted from nanocomposite, CD is die starting concentration of each metal ions, VB and Vs are volume of eluent and sample solution respectively.

* + 1. Effect of pH

The first variable optimized was the pH of the sample solution, because pH is one of the most important environmental factors influencing not only the site of nanocomposite but also the solution chemistry of heavy metals. The recovery was determined by applying the general sorption procedure by changing the pH of the sample solution in the range of 2-10. The sample solutions were adjusted to the desired pH with (0.1M) diluted hydrochloric acid and/or a (0.1M) diluted sodium hydroxide solution and passed through the nanocomposite of Fe-Al-Zr ternary mixed oxide. The sample solution eluted with 15 mL of 0.5 M HCl eluent was then analyzed by FAAS. Quantitative recoveries (>95%) were obtained at a wide range of pH values (1.5-8). In order to prevent the negative effects of basic solution such as precipitation, pH -2 was selected for subsequent studies. In all experiments regarding pH effect all the other parameters were kept constant (Ozcan et al, 2010).

* + 1. Effect of amount of Fe-Al-Zr ternary mixed oxides nanocomposite

The amount of Fe-Al-Zr ternary mixed oxides nanocomposite is another important parameter that affects the recovery of the analyte. A quantitative retention is not obtained when the amount of Fe-Al-Zr ternary mixed oxides nanocomposite is less, whereas an excess amount of Fe-Al-Zr ternary mixed oxides nanocomposite prevents the elution of the retained analyte by a small volume of eluent quantitatively (Nilofar and Ali, 2010). To these effect different amounts of the nano sorbent (200-900 mg) were studied keeping all other parameters constant.

* + 1. Effect of type, concentration and volume of elution solution

In order to determine the most suitable solution for the elution of Pb(II),Cr(VT) and Cd(II) ions from the nanocomposite packed in column, two different types of eluting agents (HCl and HNO3) having different concentration (0.1-2 M) and volume(5-25 mL) were evaluated to eluate the retained analyte on the sorbent (Ali, 2012). In order to determine type and concentration of eluent solution 50 mL of the model solution containing 20, 5 and 5 mg/L of the respective metal ions Pb(II), Cd(II) and Cr(VI)) was passed through the column. For this study all other parameters were kept constant.

* + 1. Effect of flow rate of sample solution

Flow rate of sample solution not only affects the retention of analyte on the sorbent, but also controls the time of analysis. Flow rate of the sample for the recoveries of the analytes was examined in the range of 1-10 mL /min-by using a stopper for controlling the column flow rate. In doing so, all other parameters were maintained as constant.

* + 1. Effect of volume of sample solution

The solid phase extraction technique is a common procedure for extraction and separation of metal ions from large sample volumes to obtain high preconcentration factor in the solid phase extraction studies (Ozcan et al, 2010). In order to determine the maximum applicable sample solution (or minimum analyte concentration), the effect of the volume of sample solution on the recovery of the analytes were investigated by using model solutions and by applying general procedure mentioned in Section 3.5.Under the optimized conditions, the effect of the sample volume on the efficiency of recovery was examined by passing 25, 50, 100, 150, 200, and 250 mL of sample solutions containing 10 mg of Pb(II), Cd(II) and Cr(VI) ions with analyte concentration of 0.4, 0.2, 0.1, 0.067, 0.05 and 0.04 mg/L, respectively.

* 1. Adsorption Isotherm and Capacity

The adsorption isotherm and the adsorption capacity of the as synthesized Fe-Al-Zr ternary mixed oxides nanocomposite forCd(II), Cr(IV) and Pb(II) ions were studied by using the batch method at room temperature. The amount of the sorbent and the pH of the solutions were adjusted to the optimum value with dilute HCl (0.1M) or NaOH (0.1M) solutions. Initial concentration of each Cd(II), Pb(II), and Cr(VI) ions was varied from 20 to 100 mg/L. In separate flask, 25 mL of solutions containing different amounts of initial Cd(II), Pb(II), and Cr(VI) ions concentration with pH of 7, 6 and 2, respectively were added followed by 0.1 g of metal oxide powder. The solutions were shaken for 2 hour at 120 rpm at room temperature to reach equilibrium. After the reaction period, all samples were filtered and analyzed for the corresponding Cr(VI), Cd(II) and Pb(II), ions concentration with flame atomic absorption spectrometry(Yilmaz and kartal, 2012).

1. Analytical Features

Method detection limit was a relative measure of the performance of a particular laboratory method or analysts. In order to determine the instrumental detection limit for each analytes Cr(VI), Pb(II) and Cd(II), 50 mL of blank solution was passed through the column under the optimum experimental conditions (pH = 7 for Cd(II), pH = 6 for Pb(II) and pH = 2 for Cr(VI) eluent, 0.5 mol/L HCl; flow rate, 5 mL/min). Blank solutions were prepared by adding a minimum amount of each analyte to the water in order to obtain readable analyte signals.

The sorbed analyte was eluted by 50 mL of 0.5 mol/ L HCl solution (there is no preconcentration) and concentration of this blank solution was measured about 10 times. The instrumental detection limit based on mean of blank values plus three times the standard deviation of the blank values. The analytical detection limit calculated by dividing the instrumental detection limit by the preconcentration factor. The standard deviations for each element were calculated from the ten blank measurements and multiplied by three to determine method detection limit of the instrument. The limit of quantification (LOQ) was accepted that it usually equals about three times the LOD value (Ozcan et al, 2011)

1. Results and Discussion
   1. Elemental Analysis of As-Synthesized Adsorbent

Elemental content of the selected adsorbent in sample-3(70-25-5) was analyzed through FAAS. The obtained result pertaining to the percentages of iron, aluminum and zirconium oxides were at wave length of 248.3, 309.3 and 360.1 nm, respectively. ( Table 1). The analysis was performed using a standard solution of each analyte prepared at a series of concentrations. The as-synthesized mixed oxide powder was dissolved by acid digestion method, in which 0.5 g of the sample was dissolved in 100 mL volumetric flasks using a mixture of acids with appropriate concentrations volume ratios. The unknown concentration of each metal ion was determined from its calibration plot prepared from series of concentrations of standard versus the corresponding absorbance reading (appendix Figures 1).

The FAAS result indicated that the percentage composition of Fe, Al and Zr in the as- synthesized selected nanocomposite was found to be 67.82%, 23.44% and 4.3%, respectively and this is not far from the theoretical composition that is from sample-3 (70-25-5) for Fe-Al-Zr, respectively. The difference in the percentage of iron, aluminum and zirconium may be due to insufficient dissolution, vaporization and lack of atomization.

Table 1. Conditions for FAAS determinations.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Element | Wave | length Slit (nm) | Flow rate of oxidant | and fuel |
|  | (nm) |  | Air (L/min) |  |
|  |  |  | Acetylene(L/min) |  |
| Pb | 283.3 | 0.7 | 2.0 | 17.0 |
| Cd | 228.8 | 0.7 | 2.0 | 17.0 |
| Cr(VI) | 357.9 | 0.7 | 2.0 | 17.0 |
| Fe | 248.3 | 0.7 | 2.0 | 17.0 |
| Zr | 360.1 | 0.7 | 2.0 | 17.0 |

* + 1. Infrared spectroscopic studies

The FT-IR spectrum of the selected Fe-Al-Zr sample-3 (70-25-5) ternary mixed oxide nanocomposite sample was carried out in IKBr medium of spectrum-65 FT-IR (Perkin Elmer) in the range of 4000-400 cm-1 before and after adsorption shown in figure 7. Accordingly, the absorption peaks at 3400 and 2922 cm-1 were assigned to symmetrical stretching and bending vibration of the O-H group, respectively (Sujana and Anand, 2010). Absorption peaks at 1635 and 1384 cm-1 the bending vibrations of the O-H group may actually be attributed to the presence of physiosorbed water on the surface oxides. The bands at 542 cm-1 and 460 cm-1 were assigned to the symmetrical stretching vibrations of the mixed metal oxides M-O and M-M-O, respectively (Zhang et al, 2009).

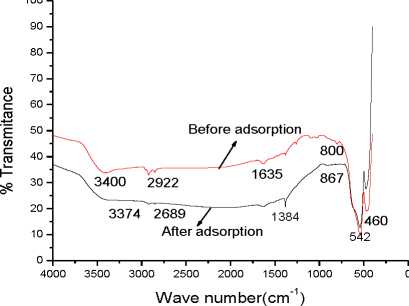


Figure 1. FT-IR Spectrum of the selected nano sized Fe-Al-Zr ternary mixed oxide adsorbent before and after adsorption of metal ions sample-3 (70-25-5).

The intensity of the peaks after adsorption were relatively higher than before adsorption. This was may be due to the availability of more of H2O in aqueous media and is assigned to the deformation of water molecules and also indicated the presence of physisorbed water and hydroxyl groups on the metal oxide surface. After adsorption, new peak appeared at 867 cm-1 which is bending vibration of adsorbed metals and the peak at 1384 cm-1 corresponds to adsorbed water of metal oxides (Hisato et al., 1969). This indicated that there are adsorbed metal ions on the adsorbent surface. The broad

peak appearance in this spectrum at 3374 cm-1 further suggests the presence of a mixture of compounds on the nanocrystal surface (Amanda et al, 2005).

From the FTIR spectra, it could be concluded that specific adsorption of aqueous metal ions occurred on Fe—Al—Zr ternary mixed oxide and the exchange of surface hydroxyl group by metal ions is the main adsorption mechanism (Li et al., 2008).

* 1. Optimum Conditions for Cadmium, Lead and Chromium Removal by the Sorbent
     1. Effect of pH

The first variable optimized was the pH of the sample solution, because pH is one of the most important environmental factors influencing not only the site of adsorbent but also the solution chemistry of heavy metals (Mostafavi et al, 2006). According to the result in Figure 2, the recoveries of Pb(II) 98%, Cd(II) 101.1% and Cr(VI) ions 100%at pH value of 6, 7 and 2, respectively.

At higher pH value, the adsorption of these metal ions decreased due to precipitation of Pb(II), Cd(II) and Cr(VI) ions forming Pb(OH)2, Cd(OH)2 and H&2O7- on the surface of the nanocomposite. This precipitate blocks the pores of the nanocomposite of Fe-Al-Zr which led to a decrease of its adsorption capacity. On the other hand, at lower pH values, the H3O+ ions compete with the metal ions for the exchange sites in the adsorbent and restricted the approach of metal cations as a result of the repulsive force (bo-lin et al, 2012). Based on these results, the best adsorption pH for quantitative recovery of Pb(II), Cd(II) and Cr(VI) ions was 6, 7 and 2, respectively.

|  |  |
| --- | --- |
| **120** -I |  |
| **100 ■** |  |
| 2. **80 ■** | **?■\*\*\*X\*|** |
| >- |  |
| **60 ■** | **—Pb(ll)** |
| **§ 40 ■**  DC | B **Cd (II)** |
| 20 **■** |  |
|  | **-\*-Cr(VI)** |
| 0 -1 | III! |
| **0 5 10 15** | |
|  | **pH** |

Figure 2.: Recoveries of Cadmium, Lead and Chromium (VI) as a function of pH (eluent: 15 mL of 0.5M HCl, amount of adsorbent: 500 mg, n = 3).

* + 1. Effect of amount of Fe-Al-Zr ternary mixed oxide nanocomposite

The amount of Fe-Al-Zrnanocomposite is another important parameter that affects the recovery of heavy metals. A quantitative retention is not obtained when the amount of sorbent is less. Whereas, an excess amount of adsorbent prevents the elution of the retained analyte by a small volume of eluent quantitatively as suggested by Nilofar and Ali (2010). Therefore, the influences of the amount of Fe—Al—Zr nanocomposite on the retention of cadmium, chromium and lead ions were examined by using the spiked solution containing the analytes.

The recoveries of Cd(II), Pb(II) and Cr(VI) ions increased with increasing amounts of Fe—Al—Zr nanosorbent and reached a maximum value of 95% and above at 500 mg (Figure 2). Above 500 mg ofFe—Al—Zr nanocomposite, the recoveries of Cd(II), Pb(II) and Cr(VI) ions decreases because the retained metal ions cannot be eluted completely with 15 mL of 0.5 M HCl solution. Whereas as amount of nanocomposite was below 300mg quantitative recoveries of Cd(II), Pb(II) and Cr(VI) ions were not obtained because at low adsorbent dose enough active sites are not available. Therefore, 500mg of adsorbent was used for subsequent experiments because of easy elution and for obtaining sufficient recovery in analyte containing various ions.

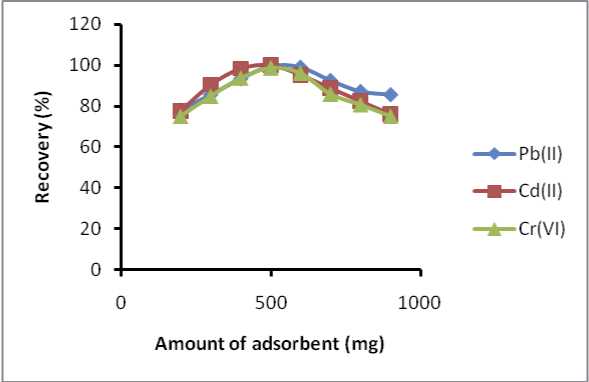


Figure 3. Effect of amount of Fe—Al—Zr nanocomposite on the extraction recovery of Pb(II), Cd(II) and Cr(VI) (eluent; 15 mL of 0.5M HCl, pH 6, 7 and 2, respectively, n=

3).

* + 1. Effect of type, concentration and volume of the eluent

The selection of suitable eluent in SPE procedure is very important, and it must be optimized. A suitable and efficient eluent must be used for elution of adsorbed metal ions from Fe—Al—Zr nanocomposite with small volume to obtain a high enrichment factor, while does not influence the lifetime and reusability of solid phase. In fact, the selection of the eluent was really difficult due to the limitation of FAAS to tolerate organic solvents, and the eluent should not destroy the solid phase. In lower pH, the ligand—metal complex dissociates to release metal ions. Therefore, acidic eluents are the best choice to obtain efficient extraction (Mahmoud et al, 2012).

For the elution process nitric acid and hydrochloric acid having various concentration and volume where tested to obtain quantitative recovery values for Cd(II), Cr(VI) and Pb(II) ions from the nanocomposite of Fe-Al-Zr packed in column. According to the

result in Table 4, HCl solutions that give maximum recovery were found as optimum eluents. The results hown that the recovery was increased as the HCl concentration increased up to 0.5 M and then become decrease. The use of low concentrations of HCl is beneficial because it can increase the lifetime of the column; whereas high concentration decreases the lifetime of the column by dissolving the adsorbent. Therefore 0.5M of hydrochloric acid was chosen as the eluent owing to its effective elution of the adsorbed Cd(II), Cr(VI) and Pb(II) ions from aqueous solution with higher recoveries (Table 5).

Various volumes of 0.5 M HCl were also examined as eluent for desorbing the retained analytes from the solid phase. Since quantitative recovery (>95%) was obtained with 15 mL of 0.5 M HClsolution, it was selected as an eluent for the recovery of Cd(II), Cr(VI) and Pb(II) ions by Fe—Al—Zr nanocomposite(Figure. 4).In the eluent volume lower than 15 mL, because of insufficient eluent volume, the recoveries of the analyte ions were not quantitative.

Table 2. Percent recovery of metal ions using different solution of HCl and HNO3 (eluent volume = 15 mL, adsorbent dose =500 mg).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Eluent type |  | HCl  0.1M | HCl  0.5M | HCl 1 M | HCl 2 M | HNO3  0.1M | HNO3  0.5M | HNO3 1 M | HNO3 2 M |
| (%)  Recovery | Cd(II) | 94 | 99.8 | 94.5 | 91 | 91.3 | 94.3 | 91 | 89.5 |
|  | Pb(II) | 90.4 | 98.4 | 91.2 | 90.6 | 90 | 92 | 89.6 | 87.4 |
|  | Cr(VI) | 76.9 | 98.5 | 92.6 | 91.5 | 90.1 | 93.6 | 92.3 | 91 |

|  |  |
| --- | --- |
| **120** -1 |  |
| **100 ■** | **H—„** |
| **^ 80 -**  **f>,** | **P**1 |
| 60 **■** | **—Pb(ll)** |
| § 40 **■** |  |
| Pi | U **Cd** (II) |
| **20 -** |  |
|  | **-\*-Cr(VI)** |
| C | **10 20 30 40** |
|  | Volume ofHCL(mL) |

Figure 4. Effect of the volume of 0.5 mol/L HCl solution on the recovery of Cd(II), Pb(II) and Cr(VI) ions by 500 mg Fe—Al—Zr nanocomposite(n =3).

* + 1. Effect of sample volume

The influence of sample volume on recoveries of cadmium, lead and chromium were also examined in order to determine the maximum applicable sample volume or minimum analyte concentration.

As can be seen from Figure 5, quantitative recoveries 99.8% for Cr(VI), 99.3% for Pb(II) and 100% for Cd(II) were obtained with sample volumes of 75 mL. The recoveries of Cr(VI), Pb(II) and Cd(II) ions decrease probably due to the excess analytes loaded over the column capacity with increasing sample volume above 150 mL as suggested by (Ozcan et al, 2011). After the preconcentration of 75mL for sample solution, since 15 mL of 0.5M HCL eluent solution was used for the analysis, the preconcentration factor which was calculated by the ratio of the highest% recovery of sample volume for analyte (75 mL) and the lowest eluent volume (15 mL) was found to be 5. As a result, it can be concluded that 5 mg/L, 20 mg/L and 5 mg/L of Cr(VI), Pb(II) and Cd(II) ions, respectively could be determined by applying this preconcentration method with sufficient precision and accuracy.

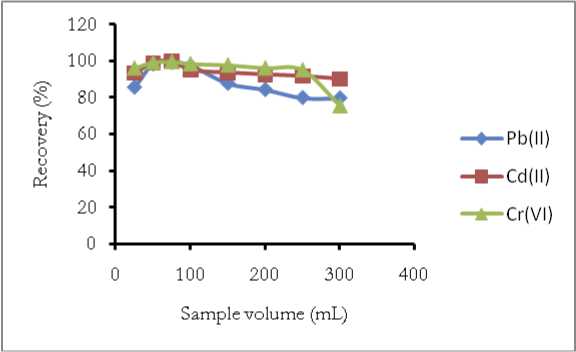


Figure 5. Plot of % recovery of Cr(VI), Pb(II) and Cd(II) ions by 500 mg Fe—Al—Zr nanocomposite as a function of sample volume, (Eluent; (15 mL of 0.5 M HCl) n = 3).

* + 1. Effect of flow rate of sample solution

The flow rate of the sample solution through the column is another important parameter, since it not only affects the recovery of analyte, but also controls the time of analysis. Because a large volume of sample solution is needed in the preconcentration, it is always expected that sample solutions can be passed through the column at a higher flow rate without reducing the recoveries. In order to evaluate the effect of flow rate, a set of solutions (50 mL) containing 10 pg Pb(II), Cd(II) and Cr(VI) was adjusted to the optimum pH value. They were then passed through the column at a flow rate that varied from 0.5 to 5 mL/min adjusted by gravity action. The analyte was desorbed with 15 mL of 0.5 mol/L HCl solution from the nanocomposite of Fe-Al-Zr ternary mixed oxide and determined as mentioned in the recommended procedure.

According to the results, flow rates in the examined range had no significant effect on the recoveries of the Pb(II), Cd(II) and Cr(VI). These results indicate that the Pb(II), Cd(II) and Cr(VI) sorption is very rapid. This fact is a useful feature of the proposed method, because it permits a higher sample throughput. Therefore, the flow rate of 5 mL/min was found to be suitable for optimum loading of the analyte and was used for further studies. The percent recovery of the target ions as a function of sample flow rate

is shown in Figure 6. As can be seen, the percent recovery decreased with increase in flow rate, which is due to the shorter contact time between the adsorbent and the sample. Therefore, a flow rate of 5 mL/min was chosen to compromise between the analytical time and the quantitative recovery.

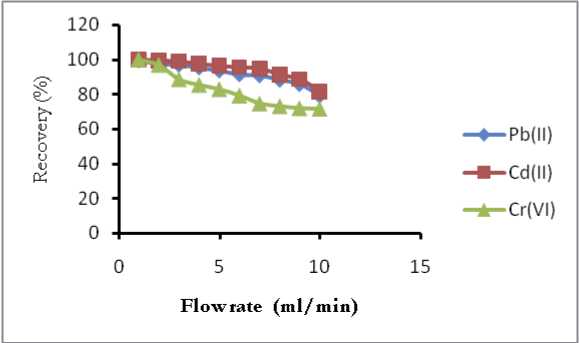


Figure 6. plot of % recovery of Cr(VI), Pb(II) and Cd(II) ions as a function of eluent (0.5 M HCl) flow rate of sample solution(n=3, adsorbent dose =500 mg).

1. Analytical Figures of Merit

By using direct aspiration in FAAS without the preconcentration system the range of correlation for Pb(II), Cd(II) and Cr(VI) determination were between 0.993 and 0.998. Calibration equation calculations were based on the average of triplicate readings for each standard solution.

The recovery of spiked Pb(II), Cd(II) & Cr(VI) and the precision of the procedure for 7 replicates determined as the percent relative standard deviation of recovery at the optimum conditions given above (amount of Fe-Al-Zr nanocomposite, 500 mg; volume of solution, 50 mL; pH 6, 7 and 2 respectively; elution solution, 15 mL 0.5 mol/L HCl; flow rate, 5 mL/min) were in the range of 92%-111% (mean, 98.2±3.9%) and about 3.9%, respectively.

In order to determine the instrumental detection limit, 50 mL of a blank solution (Deionized water) was passed through the column and retained Pb(II), Cd(II) and Cr(VI) were eluted using 50mL of the elution solution mentioned above. There was no preconcentration step. The instrumental detection limit based on 3 times the standard deviation of the blank (LODi =3o/m; where m is the slope of calibration curve) was found to be 0.085 mg/L for Pb(II), 0.061 mg/L for Cd(II) and 0.021 mg/L for Cr(VI) (N= 20). The analytical or method detection limit (MDL) was calculated by dividing the instrumental detection limit by the enrichment factor (5 in the present work). The limit of quantification (LOQ) was calculated as 3 times the LOD value(Ali, 2012).The relative standard deviation (n = 10) was <0.5% for Pb(II), Cd(II) and Cr(VI) ions , indicating that this method is highly precise and reproducible (Table 3).

Table 3. Results for Method detection limits for tap water, lake water and waste water samples.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Metal ions | RSD % | IDL(mg/L) | MDL for tap  Water  (mg/L) | MDL for lake Water (mg/L) | MDL for waste Water (mg/L) |
| Pb(II) | 0.051 | 0.085 | 0.02 | 0.034 | 0.008 |
| Cd(II) | 0.381 | 0.061 | 0.012 | 0.012 | 0.009 |
| Cr(VI) | 0.261 | 0.021 | 0.0042 | 0.013 | 0.017 |

1. Conclusions

The proposed CAF-SPE procedure provides a simple, selective, accurate and precise method for the preconcentration and determination of Pb(II), Cd(II) and Cr(VI) in large volumes of various sample solution. The main advantages of the method over the many other solid-phase preconcentration methods were permitting study in a wide range of pH with no necessity for buffer to control the pH values precisely, the ability to study in an acidic medium, higher sample volume, and not requiring the chelating agent. Lower pH values were generally preferred for analyzing real samples, because real samples (geological, biological, etc.) were dissolved generally with acids and it is unlikely that sample components would precipitate.

The influence of pH, amount of Fe-Al-Zrnanocomposite, eluent type and concentration, reusability of sorbent and volume of sample solution on the recovery of Pb(II), Cd(II) and Cr(VI) ions were investigated. The optimum of these parameters (pH 6, 7 and 2 for Pb(II), Cd(II) and Cr(VI) ions respectively; amounts of Fe-Al- Zrnanocomposite (500 mg), eluent volume, concentration and type (15 mL of 0.5 M HCl), and sample volume (75 mL)) were obtained.

The preconcentration procedure described in this paper allows Cr(VI), Pb(II) and Cd(II) ions determination at low level in various water samples, whose analysis would be restricted due to poor sensitivity of flame atomic absorption spectrometry. The selectivity was excellent, making it possible to detect and determine Pb (II), Cd(II) and Cr(VI) ions in the presence of high concentration of foreign ions.

Therefore, the proposed method gives very low LOD and good RSD, and can be applied to the determination of trace of Pb(II), Cd(II) and Cr(VI) ions in aqueous systems. The present method is superior in terms of linear range, detection limits, and selectivity. The detection limit achieved was satisfactory for the samples studied, and can be improved by using more sensitive detectors such as ICP-AES and ICP-MS.

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1. Synthesis and Characterization of magnetic Al2O3/Fe3O4/ZrO2 Ternary Oxides Nanocomposite for Nitrate Sorption from Aqueous Solution

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Abstract: Ground water serves as the sole source of drinking water worldwide for urban and rural communities. In recent years, increased industrialization and agricultural activities generate highly toxic pollutants such as nitrate into the ground water which have serious global problems. Adsorption process by inorganic adsorbents is one of the promising environmentally friendly and convenient methods for nitrate removal as recently reported. The objective of this research was to synthesize Al2O3/Fe3O4/ZrO2heterojunction ternary oxides nanocomposite for its application on nitrate sorption from aqueous solution. This adsorbent was efficiently synthesized from respective salt precursors by a two steps co­precipitation method under nitrogen atmosphere in basic condition (pH 12) using sodium hydroxide solution. The as-synthesized adsorbent was characterized by FT-IR and AAS techniques. Batch equilibrium study resulted maximum adsorption capacity (Vmax) of 28.83 mg g-1 at 250C. Kinetic and isotherm studies showed that the adsorbent undergoes both physisorption and chemisorptions in the sorption process.

Keywords: Nanocomposite; Sorption; Magnetite; Nitrate; ZrO2; Ternary oxides

1. Introduction

In many parts of the world, groundwater serves as the sole source of drinking water in rural communities and urban areas. However, in recent years, increased industrial and agricultural activities have resulted in the generation of toxic pollutants such as inorganic anions, heavy metal ions, and synthetic organic chemicals which have increased public health concern about the quality of groundwater. Among the number of inorganic anions which have been found in potentially harmful concentrations in numerous drinking water sources, nitrate ion (NO3-) is of prime concern on a global scale (Amit and Mika, 2011; Pahlavanzadeh and Mohammadi, 2012).

Because of the link between health problems and excessive concentration of nitrate in drinking water, different regulatory agencies in various countries have set different nitrate concentration limits. The maximum nitrate concentration limit recommended by WHO and the EU is 50 mg L-1 NO3”, while that of EPA is 45 mg L-1 NO3” (EPA. 2009, WHO, 2011). However, in Australia, the recommended limit is 50 mg L-1 NO3” for infants up to 3 months old and 100 mg L-1 NO3” for adults and children over the age of 3 months (NHMRC, 2011) and South Africa stipulated a much lower permissible level, 20 mg L-1 NO3” (Masukume et al, 2011).

Various physicochemical and biological methods for the removal of nitrate and nitrite from water have been reported in a number of publications. These include biological denitrification, chemical denitrification (using zero-valent Fe0 and Mg0), nano (SiO2- FeOOH-Fe) reduction, electrodialysis, reverse osmosis, ion exchange, bioelectrochemical, photocatalytic reduction and adsorption (Noelia and Jacinto, 2011; Xu et al, 2011; Jiang et al, 2012).

However, most of these nitrate removal processes have been adversely affected the environment, are not cost effective, less reusability and have low removal capacity. Thus, among the three known sorbent systems (Biomedia, Geomedia and Synthetics), adsorption of nitrate by synthetic inorganic nanocomposites is considered as an attractive method since it has been proved to be effective, efficient, economical, simple to perform and could overcome the problems existed in chemical precipitation and biological treatment methods for water purification (Fei et al, 2011; Jia-Qian et al., 2012; Xuehua etal., 2012). Further, separation of adsorbent from the matrix after sorption is also an important task in using inorganic adsorbents to efficiently use the adsorbent without loss in regeneration cycle. Thus magnetite adsorbents are suitable for this purpose. For efficient use of magnetic separation technology it is important to develop magnetic adsorbents with simple preparation process, inexpensive and with high adsorption capacity. Magnetic iron oxide (Fe3O4)based NCs are considered valuable candidates for the developmentof next-generation adsorbents with great potential for the efficient treatment of large volume of wastewater and fast separation using an external magnetic field (Liyuan et al., 2013; Robert et al, 2014). Magnetic separation has been shown to be a very effective method due to its great advantages, such as high speed, simplicity.It also enables to separate the adsorbent without loss and effective to operate as compared to the conventional physical separation methods (Liyuan et al., 2013).

The main objective of this work was to synthesize Al2O3/Fe3O4/ZrO2 heterojunction ternary oxides nanocomposite for its application on nitrate sorption from aqueous solution, to investigate the nitrate adsorption behavior under batch condition.

1. Materials and methods
   1. Materials

The chemicals employed for the synthesis and nitrate sorption studies were: ZrOCl2.8H2O, FeCl2.4H2O, FeCR6H2O, Al(NO3)3.9H2O, NaOH and KNO3. All reagents are of analytical grade and used with no further purification. Salt precursors and standards of nitrate samples at a required concentration range were prepared by dissolving and appropriate dilution of the stock solution with DI water.

1. Synthesis of magnetic AhO3/Fe3O4/ZrO2 nanocomposite

The magnetic Al2O3/Fe3O4/ZrO2 heterojuntion ternary oxide nanocomposites at different mole ratios of the metals were prepared by chemical co-precipitation method as reported by Liyuan et al. (2013) with some modification. As reported by Anamaria et al. (2012), the mole ratio of Fe2+/Fe3+ of magnetite was selected to be 0.5. Accordingly, four different compositions of AhO3/Fe3O4/ZrO2with Al/ Fe/ Zr mole ratios of (S-1) 20:75:05, (S-2) 25:70:05, (S-3) 20:70:10 and (S-4) 25:65:10 were prepared for the present work to select the adsorbent with higher surface area for sorption studies.

1. Characterization of Fe3O4/AFO3 / ZrO2

The surface functional groups of the selected nanocomposite with maximum surface area were examined by FT-IR. The concentration of Fe and Zr metal component in the selected composite was analyzed by Flame atomic absorption spectroscopy (AAS) and the nitrate concentration in all parameters was analyzed by UV-Vis spectrophotometer.

1. Nitrate Analysis

The absorbance of each standard was measured with ELICO-SL-164 double beam UV- Vis spectrophotometer at a wavelength of 220 nm and the calibration curve was plotted as absorbance versus standard concentration (mg L-1). Finally, the absorbance of each NO3~ sample was measured and the concentrations of all unknown sample solutions were directly obtained from the standard curve (Lenore et al., 1999).

1. AAS Analysis

Concentration of Al was not determined due to lack of oxidant (nitrous oxide gas). The concentration of Fe and Zr present in the as synthesized adsorbent was measured by first calibrating the instrument base line using an initially measured absorbance values of a series of standard solutions. The concentration of each metal was calculated from the linear graph plotted as concentration vs instrument signal. The values of slopes and intercepts of the regression lines were tested at 95% confidence limit. The method validation was done through method blank (matrix blank) analysis to estimate recovery test.

1. Effect of the amount of adsorbent on nitrate adsorption

The effect of adsorbent dose on the uptake of nitrate by the as-synthesized nanosized Al-Fe-Zr ternary oxides system was investigated using different amounts of adsorbents while other experimental conditions remained constant. 50 mL of 15 mg L-1 of NO3- was mixed with each of 5, 15, 25, 50, 75 and 100 mg nanoadsorbents in conical polyethylene flasks and kept for 24 h on a shaker at optimum adsorption pH (pH 3). The solids and solutions were separated and the filtrates were analyzed for nitrate.

2.7 Batch adsorption studies

Adsorption of nitrate onto the Al-Fe-Zr ternary oxides nano adsorbent was studied by batch experiments. Typically, 25 mg of adsorbent was placed in a conical flask containing 50 mL of aqueous solution of KNO3. The initial pH and concentration were fixed to pH 3 and 15 mg L-1 of nitrate. All solutions were stirred continuously at constant temperature (25°C) in a water bath with a shaker to achieve equilibrium. After equilibrium had been attained, the solid in each sample was separated by a magnet and the remaining none magnetic impurities by filtration through a What-Man filter paper N°-42 followed by sintered glass. The resulting solution was then kept in a refrigerator at 4°C for next day analysis. Reproducibility of each measurement was determined through triplicate experiments and the average value was reported. The amount of nitrate adsorbed at equilibrium (qe in mg g-1) was calculated by (eqn. 2.7.1).

(2.7.1)



The percent removal of anions at equilibrium is calculated as:

R = x 100%

(2.7.2)

C[

Where: Ci and Ce are the initial and equilibrium concentrations of nitrate in solution (mg L-1) respectively, V is the volume of solution (in L) and m is mass of the adsorbent (in g) (Amit and Mika, 2011; Safia et al, 2013).

2.8. Nitrate Adsorption Isotherms

The equilibrium isotherms describe how the adsorbent interacts with the adsorbate. The correlation of experimental results to adsorption model can help to understand the mechanisms of adsorption and the nature of the adsorbent surface, and this is also an important procedure in the practical design and operation of adsorption. The isotherms of nitrate adsorption by the Al-Fe-Zr ternary oxides nano adsorbent were determined by using initial nitrate concentration range of 6 to 15 mg L-1 of KNO3. 25 mg of the adsorbent was equilibrated with 50 mL of 6, 9, 12 and 15 mg L-1 of KNO3 in separate flasks for 24 h on a water bath shaker at 250C and pH 3. After equilibration, the solid adsorbent and the suspensions were magnetically separated and filtered and the filtrate solutions were analized for nitrate concentration. All nitrate uptake experiments were conducted in triplicates (Saeed et al, 2014).

The distribution of nitrate betweenthe adsorbent and solution at equilibrium state was investigated using Langmuir, Freundlich, and Dubinin—Redushkevich (D—R) isotherm models which have been extensively used for evaluation of adsorption behavior for different solid—liquid systems. The widely used linear expressions of the Langmuir isotherm models are represented in (eqn. 2.8.1)

ce ce , **1** .

Or, alternatively (2.8.1)

qe Q0 kz,q0 ’ 7 v ’

**1** **111**

(3.4)

qe KlQd Ce @d '

where qe (mg g-1) is the equilibrium amount of nitrate adsorbed per unit weight of adsorbent, Ce (mg L-1) is the concentration of nitrate in the liquid phase at equilibrium, Kl(L mg-1) is the Langmuir constant and related to binding energy of adsorption and Qois attained adsorption capacity corresponding to a monolayer coverage. From slope and intercept of the graph of Ce/qe vs Ce, Qo and Kl were determined respectively (Chabani et al, 2009; Seliem et al, 2011). The dimensionless constant called separation factor (Rl) was computed from (eqn. 3.5) as:

.v=-r- W

where C0 (mg L-1) is the initial nitrate concentration and Kl is the Langmuir constant. The value of Rl indicates the type of isotherm to be irreversible (Rl= 0), favorable (0 <Rl< 1), linear (Rl= 1), or unfavorable (Rl> 1) (Gammoudi et al., 2011; Aghaii et al., 2013).

As reported by Gammoudi et al. (2012), the Freundlich isotherm had been proposed as the earliest empirical equation and would have been shown to be consistent with exponential distribution of active centers and characteristic of heterogeneous surfaces. This model states that reactions take place in several sorption sites and as the amount of solute adsorbed rises, the binding surface energy decreases exponentially. The linear form of Freundlich equation is given by (eqn. 2.8.3):

(2.8.3)



where Kf is the Freundlich constant related to the adsorption capacity; n is an empirical parameter related to the intensity of adsorption, which varies with the heterogeneity of the adsorbent.By plotting log qe vs log Ce, the coefficients, Kf and n were determined from straight line obtained.

1. Adsorption Kinetics

Experiments to determine adsorption kinetics were conducted in triplicate by batch techniques. 25 mg of the adsorbent was equilibrated with 50 mL of 5, 10, and 15 mg L-1 of KNO3 in a 150 mL conical polyethylene flask for 1, 2, 4, 8, 12 and 24 h using a shaker at 25°C and pH 3. After equilibration, the solid and the liquid phases were magnetically separated and filtered. The clear colorless filtrate was used for nitrate determination.

(2.9.1)



where qt is the adsorptive capacity of adsorbent at time t (mg g-1), V is the volume of solution (L), C0 and Ct (mg L-1) are the initial concentration and equilibrium concentration of nitrate at time t, respectively and m is the mass of adsorbent (g).

Three kinetics models including Pseudo First-order, Pseudo-second-order and Intraparticle diffusion kinetics model were used to check the fitting of the models to nitrate adsorption experimental data.

Pseudo-first-order kinetics model

This model was suggested by Lagergren (1898) for the sorption of solid/liquid systems. It can be expressed as:

*K*

(2.9.2)

Pseudo-second-order kinetics model can be expressed as:

(2.9.3)



1. Determination of thermodynamic parameters

In order to understand the effect of temperature on the adsorption of nitrate, the experiments were carried out at 15, 25, 35, 45 and 550C on the as-synthesized magnetic adsorbent Al2O3/Fe3O4/ZrO2. In order to decide the mechanism involved in the adsorption process, thermodynamic parameters including Gibbs free energy change (AG°), enthalpy change (AH°) and entropy change (AS°) were calculated using equations (2.10.1-2.10.4).

(2.10.1)

*-MR* J5: *RT R*



(2.10.2)

AG° = -RT ln Kd (2.10.3)

AG° = AH - TAS° (2.10.4)

where Kd (L mol-1) is distribution coefficient; R is the gas constant (8.314 J mol-1 K-1); T is the temperature in Kelvin, V is volume of sample solution (in L) and m is mass of adsorbent (in g). AH° and AS° were calculated from the intercept and slope of the linear plot of InKjvs 1/T respectively (Aghaii et al, 2013).

1. Results and Discussion
   1. Quality Control

All nitrate determination experiments in this study were performed initially by calibrating the UV-Vis instrument baseline by measuring the absorbance of a series of standard solutions of NO3~ ions after determining the cuvette efficiency at three wave lengths (200, 220 and 240 cm-1) for which %T were recorded to be 89.3, 96.8 and 98.2 respectively where the expected minimum values were 82.6, 84.9 and 85.6 successively indicating that it was highly transparent. All slopes and intercepts of the linear plots were tested at 95% confidence limit by applying t-test. Limit of detection (LOD) of the UV- Vis and limit of quantification (LOQ) were determined by blank (matrix blank) analyses which were calculated from yb+3Sb and yb + 10Sb respectively where yb and Sb are mean values of blank signal and standard deviation of the blank respectively. Accordingly, LOD of the UV-Vis was found to be 0.007 mg L-1 and the LOQ was 0.021 mg L-1.

* 1. Characterization of Al-Fe-Zr oxide Nanocomposites
     1. FTIR Analysis

The surface functional groups of the adsorbent were determined by the FT-IR spectrometry and the results were shown in Figure 1. As can be seen from the spectra, the predominant bands appearing in the range between 3683-2999 cm-1 represent stretching and bending vibrations of the OH groups (attribute presence of hydroxyl groups and interlayer water molecules) and the peaks at 2923 and 2853 cm-1 represent anti-symmetrical and symmetrical H—O—H stretching vibrational modes (Marcel et al, 2003; Fei et al., 2011; Felora and Reza, 2011). The peak observed at 1384 cm-1 corresponds to presence of nitrate ion in the adsorbent and the appearance of increasing and sharp peak of this intensity in the spectra after adsorption was due to adsorption of large amount of nitrate intercalated in the interlayer space that signify the adsorption of nitrate has been taking place (Haiou et al, 2013; Sanna et al, 2014).

It was reported that, the absorption band of alumina (Al2O3) could be expected at 1620 cm-1. But this absorption peak is not visible due to the overlapping of the Zr-OH bending vibration appearing at 1629 cm-1. Another peak appearing at 1163 cm-1, may be assigned as additional confirmation for the presence of Zr—OH band (Taavoni-Gilan eta/., 2010). However, the peak observed at 1065 cm-1 may still correspond to Al-O stretching (Eva et al, 2010; Fei et al, 2011; Taavoni-Gilan et al, 2010). The second predominant broad band at 579 cm-1 may be assigned to Fe-O stretching vibration for magnetite the fact that the frequency of this peak was slightly reduced to 578 cm-1 which may be considered as indicative of involvement of Fe-O band in the nitrate adsorption process (Taavoni-Gilan et al, 2010). The peak observed at 475 cm-1 may attribute to Zr- O stretching vibration which is characteristic of ZrO2 (Herrera et al, 2012).

The O-H stretching and bending band peaks generally showed a slight decrease in frequencies after nitrate adsorption, which may evidently suggest involvement of the O­H groups on the adsorbent in the adsorption process. However, the intensities of peaks at 3411, 1628 and 578 cm-1 increased after adsorption of nitrate. The increasing intensity of the peak at 3411 cm-1 indicates the increased adsorption of interlayer water molecule and formation of hydrogen bonds between OH and NO3- groups during nitrate adsorption (Biamino et al, 2006; Haiou et al, 2013). The intensity of peaks at 1628 and 578 cm-1 increased also due to OH bending modes of vibrational frequencies of adsorbed intermolecular water (Sanna et al, 2014).

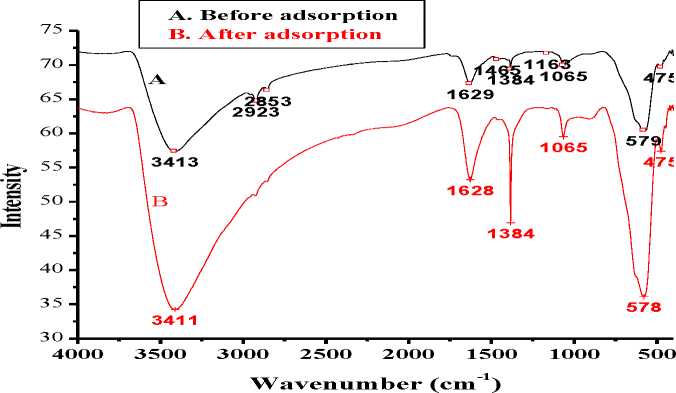


Figure 1. FT-IR spectra of Al2O3/Fe3O4/ZrO2 before (A) and after (B), respectively.

* + 1. AAS Analysis

To determine the amount of each metal by weight ratio present in the adsorbent and to compare with the theoretical weight ratio values, flame atomic absorption spectrophotometric analysis (AAS) was made by using air-acetylene gas as oxidant. The result is presented in Table 1. The percent recovery test measured for Fe was 101.64±0.00 and for Zr was 97.63±0.01%. The recovery result ensures that the analytical system does not change in any significant way that would invalidate the generated analytical data.

Table 1. AAS result of Fe and Zr.

|  |  |  |
| --- | --- | --- |
| Element | % by weight ratio theoretical | % by weight ratio from AAS result |
| Al | X | X |
| Fe | 98.75% | 98.81% |
| Zr | 1.25% | 1.18% |

Thus, the results in Table 1, depict that percent by weight ratios for Fe with respect to Zr was found to be 98.81% (Fe) and 1.18% (Zr), respectively, which is in agreement with the values of these metals present in the theoretical values. This showed that, the synthesis method was efficient.

* + 1. Optimum pH of Adsorption

The removal of nitrate ion from aqueous solutions by adsorption depends on the solution pH, because it affects the adsorbent’s surface charge, the degree of ionization and the speciation of adsorbate (Adhena Ayaliew et al, 2015). Dependence of pH on adsorption of NO3~ by Al-Fe-Zr adsorbent was studied at pH ranges set from 1 to 6. The effect of initial pH for adsorption is presented in Figure 2. The results illustrated

that the NO3-removal levels of 63.33, 92.60, 98.75, 92.87, 86.40 and 56.23% were measured at pH 1, 2, 3, 4, 5 and 6, respectively.

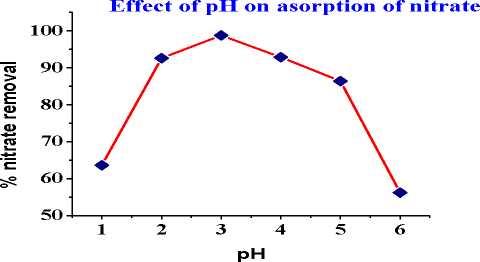


Figure 2. pH dependence, 25 mg adsorbent, 250C, adjusted pH 1-12.

The result showed that maximum absorption was observed at pH 3, with percentage absorption of 98.75 and as pH value increases the surface adsorption cites decreases. The maximum increase in percentage adsorption at pH 3 was due to creation of an acidic surface with the maximum adsorption being at pH 3.

1. Effect of the amount of Adsorbent

The effect of adsorbent dose on the uptake of nitrate by Al-Fe-Zr ternary oxides was investigated using different amounts of adsorbents, while other experimental conditions remained constant. To this effect, 50 mL of 15 mg L-1 of KNO3 was mixed with each of 5, 15, 25, 50, 75 and 100 mg of the adsorbent in a polyethylene flask placed for 24 hr on a shaker at initial pH of 3. Effect of adsorbent dose is presented in Figure 3. The results provided percentage adsorption values of 29.78±0.93, 76.95±0.19, 97.81±0.50, 96.91±0.50, 96.44±0.17 and 96.52±0.32, respectively. The maximum nitrate removal was observed at the 25 mg dose. The highest nitrate adsorption at 25mg adsorbent dose may be accounted for the presence of largest number of active adsorption cites on the adsorbent surface. With further increase in the adsorbent dose, a plateau is formed indicating that no significant increase in adsorption was taking place. This might be explained: as surface adsorption cites became more saturated in the first rapid step and no more surface adsorption cites remained, thus the nitrate ions might have started to diffuse into the bulk matrix (Taddesse et al, 2015) due to two distinct pools of nitrate— adsorbent interfaces, one with rapid adsorption kinetics and the other with slower adsorption kinetics.

Effect of adsorbent dose

O

Z

"CT5

>

O

E

o

100­

80­

60­

40

20

0

**/**

A

**/**

0

20 40 60 80

Adsorbent dose(mg)

100

Figure 3. Effect of adsorbent dose at 5, 15, 25, 50, 75 and 100 mg adsorbent, pH 3, nitrate conc. 15 mg L-1, 250C, 24 h constant shaking.

1. Batch Adsorption Studies

Adsorption of nitrate onto Al-Fe-Zr ternary oxides nano adsorbent was studied by batch experiments. It was found that maximum percentage of nitrate adsorption by the Al-Fe- Zr oxides nano adsorbent value was measured to be 97.64±1.07. This value represents 28.83 ±0.21 mg g-1 and this result was not reported for as such binary or ternary oxide nanocomposite systems. Thus, the result showed high adsorption capacity of the adsorbent and therefore it is efficient and suitable for nitrate removal from aqueous solution. Different metal oxides or hydroxide adsorbent systems were presented in Table 2 for comparison.

Table 2. Surface area, equilibrium pH and nitrate removal capacities of different adsorbents.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Types of adsorbent | Surface  area  K g-1) | Equilibrium  pH | Nitrate removal Capacity (mg g-1) | Ref. |
| Mg-Al LDH | 64.40 | 7 | 23.56 | [ Halajnia ] |
| ARO3 | 151.70 | 4.4 | 4.00 | [ Halajnia ] |
| SO2-FeOH-Fe | - | 3 | 15.97 | [Bekhradinassab] |
| Fe/Fe3O4 | - | 6.7 | 19.30 | [ Jiang ] |
| ARO3/Fe3O4/ZrO2 | 296.47 | 3 | 28.83 | [present] |

The adsorbent under this study has also maximum surface area and adsorption capacity as compared to the other adsorbents used for nitrate removal.

1. Nitrate Adsorption Isotherms

The distribution of nitrate betweenthe adsorbent and solution at equilibrium state was investigated using Langmuir, Freundlich, and Dubinin—Redushkevich (D—R) isotherm models which have been extensively used for evaluation of adsorption behaviors for different solid—liquid systems. In order to evaluate the adsorption capacity of the

adsorbent under investigation, the equilibrium adsorption of nitrate was studied as a function of nitrate concentration and the adsorption isotherms. A plot of Langmuir and Freundlich isotherm are given in Figure 4.

Langmuir parameters calculated from the Langmuir isotherm plotted as log Ce/qe vs log Ce and is shown in Table 3. From the lists the value of Kl related to the enthalpy of adsorption, Qo represents the maximum adsorption capacity of the monolayer coverage of sorbent with sorbate and from Freundlich isotherm plot (log qe vs log Ce), the constant Kf represents maximum adsorption capacity; n represents an empirical parameter related to the intensity of adsorption, which varies with the heterogeneity of the adsorbent, were calculated from the slope and intercept of the linear plots.

The correlation coefficients R2 was directly obtained from the linear equation. From Table 3, it could be seen that the values of experimental qe and the calculated Qo values were in highly agreement, 25.445 mg L-1. This showed that, Langmuir isotherm model is in better agreement with the adsorption experiment than the Freundlich isotherm for which the maximum adsorption capacity Kf value was only 19.227 mg L-1 nitrate. These facts suggest that nitrate is sorbed in the form of monolayer coverage (physisorption) on the surface of the sorbent (Amit et al, 2010)] and multilayer sorption (chemisorption) as the Kf value, 19.227 mg g-1 is significant.

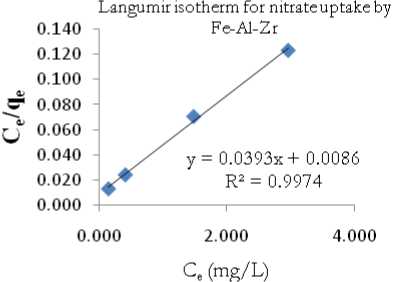


Figure 4. Langmuir and Freundlich Isotherm plots for nitrate uptake at 6, 9, 12 and 15 mg L-1 initial concentrations, 25 mg adsorbent, pH 3, 250C and with 24 h shaking.

To determine whether the adsorption is favorable or not at the studied conditions, a dimensionless constant separation factor (Rl) was also computed. The Rl parameter is considered as a more reliable indicator of the adsorption.

Table 3. Isotherm constants on nitrate adsorption onto Al-Fe-Zr adsorbent at 250C, adsorbent dose of 25 mg and pH 3.

|  |  |  |
| --- | --- | --- |
| Lngumir isotherm |  | Freundlich isotherm |
| Adsorbent Qo Kl (l mg-1) (mg g-1) | qe R2 dose(mg (mg g-1) | Kf (mg g-1) n R2 |
| 25 25.45 4.57 | 25.45 0.9974 | 19.23 4.27 0.9575 |

The value of Rl indicates the type of isotherm: to be irreversible if (Rl= 0), favorable if (0 < Rl< 1), linear if (Rl= 1), or unfavorable for (Rl> 1) (Saeed et al, 2014). Thus, the calculated values of Rl for nitrate adsorption by nano Al-Fe-Zr ternary oxide was laid in the value (0 < Rl<1) which attributes the reaction was favorable at standard room temperature for all Rl values between zero and one.

Table 4. Values of (Rl) parameter for nitrate sorption onto Al-Fe-Zr.

|  |  |  |
| --- | --- | --- |
| Co (mg L-1) | B | Rl |
| 6.000 | 0.0086 | 0.951 |
| 9.000 | 0.0086 | 0.928 |
| 12.000 | 0.0086 | 0.906 |
| 15.000 | 0.0086 | 0.886 |

The Rl values in this study range from 0.951 to 0.886, showing decreasing order with increasing nitrate concentration, suggesting that increased affinity between nitrate and Al2O3/Fe3O4/ZrO2nanocomposite. This may be explained as there is diffusion of nitrate particles into the matrix even after the mono surface sorption has been completed (Yanhui et al, 2011).

In addition, the n value obtained from the Freundlich equation can also indicate the favorability of the adsorption process: values of n between two to ten are good, values of one to two denote moderate difficulty, and values less than one are poor (Ili et al., 2013). Based on our result the values of n for nitrate adsorption onto Al-Fe-Zr at studied temperatures was in the range of two to ten, indicating a favorable adsorption process and thus in consistent with the Rl values obtained from the Langmuir equation. Furthermore, value of 1/n (or 1/4.270 = 0.234) is ranging between 0 and 1 (i.e. n is between 1 and 10) is a measure of surface heterogeneity and becoming more heterogeneous as this value gets closer to zero (Ili et al, 2013). As the value of 1/n is below unity (0.234), it implies that the adsorption process was of a chemical reaction type.

Langmuir isotherm best fit to the monolayer adsorption (physisorption) whereas Freundlich isotherm is more pronounced to describe chemisorption. From the three isotherm models Langmuir, Freundlich and D-R, parameter values: R2, Rl, 1/n, n, and E, it was observed that, the adsorption of nitrate by Al-Fe-Zr ternary oxide nano composite undergoes both physisorption and chemisorption processes. In addition, the FT-IR spectral analysis assured that, the disappearance of adsorption frequencies of peaks at 2923, 2853 cm-1, a slight decrease in frequencies of peaks at 3413, 1629 and 579 cm-1 might be due to exchange of OH functional groups with NO3-1 in the chemical reaction.

1. Adsorption kinetics

The adsorption kinetics of nitrate was investigated through batch experiments at initial concentrations of 5, 10 and 15 mg L-1 over 1, 2, 4, 8, 12 and 24 h at standard room temperature (250C), optimum adsorbent dose and pH. As kinetic parameters, values of pseudo first order and pseudo second order rate parameters are indicated in Table 5.

The best-fit model was selected based on the match between experimental qe (exp) and theoretical qe (cal) uptake values and linear correlation coefficient (R2) values at the studied conditions. The linear plot is given in Figure 5. Comparing their correlation coefficient, R2 values, qe (exp) and qe (cal) of Pseudo first order and Pseudo second order rate reactions, pseudo second order best fit to the experimental adsorption process than pseudo for the studied initial concentrations.

Table 5. Kinetic parameters for nitrate adsorption by ARO3/Fe3O4/ZrO2 (15 mg L-1) initial NO3- concentration, pH 3, 25 mg adsorbent, 24 h shaking.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Time | Pseudo 1st order | |  |  | Pseudo 2nd order | |
| (hr) | Co | Qe | Qe cal | R2 | Qe cal | R2 |
|  | (mg L-1) | (mg g-1) | (mg g-1) |  | (mg g-1) |  |
| 1 | 5 | 4.988 | 2.978 | 0.672 | 4.168 | 0.991 |
| 2 |  | 6.597 | 5.957 |  | 6.087 |  |
| 4 |  | 6.901 | 6.295 |  | 6.631 |  |
| 8 |  | 6.964 | 5.943 |  | 6.826 |  |
| 12 |  | 6.970 | 5.508 |  | 6.877 |  |
| 24 |  | 6.975 | 4.375 |  | 6.928 |  |
| 1 | 10 | 10.532 | 6.950 | 0.451 | 10.209 | 0.997 |
| 2 |  | 12.988 | 11.590 |  | 13.157 |  |
| 4 |  | 13.584 | 12.359 |  | 13.668 |  |
| 8 |  | 13.736 | 11.858 |  | 13.777 |  |
| 12 |  | 13.768 | 11.169 |  | 13.795 |  |
| 24 |  | 13.797 | 11.268 |  | 13.811 |  |
| 1 | 15 | 17.704 | 14.388 | 0.681 | 15.506 | 0.998 |
| 2 |  | 19.833 | 18.578 |  | 18.653 |  |
| 4 |  | 20.180 | 19.231 |  | 19.571 |  |
| 8 |  | 20.266 | 19.275 |  | 19.957 |  |
| 12 |  | 20.281 | 19.143 |  | 20.074 |  |
| 24 |  | 20.363 | 18.880 |  | 20.259 |  |

The assumption behind the pseudo-second-order kinetic model was that the rate- limiting step might be chemisorptions involving valence forces through sharing or exchange of electrons between the adsorbent and adsorbate (Pahlavanzadeh and Mohammadi, 2012). This result is in agreement with the adsorption kinetics of nitrate removal from aqueous solutions by: nano-alumina (Amit et al, 2010), nitrate and

nitrite from aqueous solution onto calcinned (Mg—Al) hydrotalcite (Dongjin et al, 2012), nitrate and perchlorate by organoclay (Saeed et al, 2014).

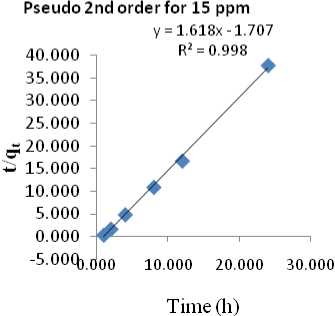
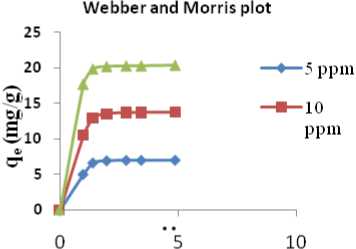
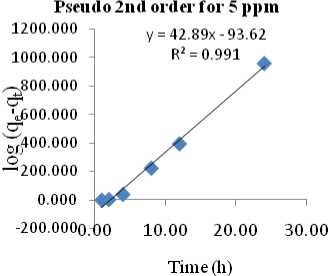
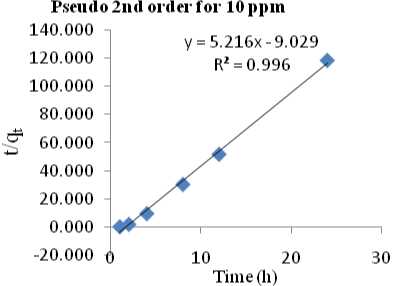


Figure 5. Linear plots of Pseudo second order kinetics and Weber and Moris plot for different nitrate concentrations at pH 3, adsorbent dose of 25 mg and a temperature of 250C.

1. Thermodynamics Parameters

The effect of temperature on adsorption of nitrate by Al-Fe-Zr nanoadsorbent was also studied. As it is observed from Table 6, adsorption of nitrate decreased with increasing temperature. These results indicated the exothermic nature of nitrate adsorption by the magnetic adsorbent under study.

From values of experimental qe, calculated qe (mg g-1) and correlation coefficients (R2) for Langmuir and Freundlich isotherm models, it was observed that Langmuir isotherm best fit to the experimental data than the Freundlich isotherm. Further, from values of Freundlich model, it is also observed that nitrate adsorption is not limited only by monolayer coverage. In addition, it can also be seen that multilayer adsorption on heterogeneous surfaces was taking place (Foo and Hameed, 2010). These results depict

that higher adsorption capacity of the adsorbent for nitrate removal might be attributed also due to higher nitrate adsorption onto the internal surfaces (chemisorption).

The calculated values of qe showed a decreasing trend as temperature increases which attribute a decreasing trend of removal capacity of the adsorbent. This showed that nitrate adsorption by ARO3/Fe3O4/ZrO2 decreases at higher temperature which might be explained as, nitrate adsorption by the adsorbent is more favored at low temperature than at high temperature that is an indicative of the occurrence of exothermic process. This result is in agreement with sorption study of nitrate on Mg—Al layered double hydroxide reported by (Halajnia et al., 2013). From the comparisons of R2 and correlation between experimental qe and calculated qe values, Table 5, it can be concluded that, both models (pseudo first order and pseudo second order) fit to the experimental adsorption process.

Table 6. Effect of temperature on removal of nitrate (Conditions: Temp. 15, 25, 35, 45 and 550C, pH 3, adsorbent dose 25 mg and 24 h shaking).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Temp  (K) | Conc. | Langmuir |  |  | Freundlich |  |
| (mg  L-1) | Qe (mg g-1) | Qe calc  (mg g-1) | R2 | Qe calc  (mg g-1) | R2 |
| 288 | 5 | 5.585 | 7.756 | 0.9986 | 5.546 | 0.9535 |
| 298 |  | 5.286 | 4.520 |  | 4.732 |  |
| 308 |  | 3.126 | 3.039 |  | 3.750 |  |
| 318 |  | 2.171 | 2.061 |  | 2.213 |  |
| 324 |  | 1.960 | 1.958 |  | 1.866 |  |
| 288 | 10 | 12.580 | 13.514 | 0.9991 | 12.190 | 0.9621 |
| 298 |  | 11.549 | 10.896 |  | 10.093 |  |
| 308 |  | 8.833 | 8.652 |  | 8.260 |  |
| 318 |  | 8.040 | 8.040 |  | 6.934 |  |
| 324 |  | 7.915 | 7.967 |  | 6.855 |  |
| 288 | 15 | 19.556 | 27.082 | 0.9958 | 20.370 | 0.9786 |
| 298 |  | 18.239 | 17.230 |  | 17.701 |  |
| 308 |  | 15.136 | 14.580 |  | 15.031 |  |
| 318 |  | 14.655 | 14.329 |  | 14.521 |  |
| 324 |  | 13.677 | 14.131 |  | 14.028 |  |

Nitrate adsorption—desorption isotherm at 288, 298, 301, 318 and 328 °K was done to determine the apparent distribution coefficient (IK), a factor related to distribution of ion between solid and aqueous phases. This parameter could be calculated from the following expression (eqn. 4.5):

(3.9.1)



where qe is the amount of ion adsorbed per unit mass of the adsorbent and Ce is the ion concentration per unit volume of solution. The values of IK are summarized in Table 7.

For all the three different concentrations, decreasing in apparent distribution coefficient (Kd) values with increasing ion concentration in equilibrium solution at increased temperature. Table 7 indicated that the Al-Fe-Zr affinity for the studied anions was greater in lower concentrations, probably due to the saturation of adsorbate at higher concentration. In other words, the Kd values were almost independent of the surface coverage, probably due to the nitrate adsorption into the interlayer spaces also. Further, the greater Kd values for nitrate at initial lower temperature indicated that there is remarkable affinity of nitrate for the synthesized Al2O3/Fe3O4/ZrO2nano adsorbent at low temperature.

Table 7. Kd values of nitrate adsorption by AbO3/Fe3O4/ZrO2 nanoadsorbent at different temperatures, and 5, 10 and 15 mg L-1 initial nitrate concentrations at optimum conditions.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Temperature (K) | 288 | 298 | 301 | 318 | 328 |
| Kd (L g-1) for 5 mg L-1 | 5.58 | 4.95 | 2.96 | 0.95 | 0.41 |
| Kd (L g-1) for 10 mg L-1 | 12.41 | 7.90 | 3.25 | 1.52 | 1.29 |
| Kd (L g-1) for 15 mg L-1 | 18.96 | 7.82 | 2.24 | 1.60 | 1.08 |

Further, to decide the mechanism involved in the adsorption process, thermodynamic parameters including Gibbs free energy change (AG°), enthalpy change (AH°) and entropy change (AS°) were also calculated using equations 3.9.2—3.9.4 from linear plots indicated in Figure 6.

(3.9.2)



*-Mi\**

RT

Alternatively,

***lnKD*** =



AG° = -RT In Kd

AG = AH - TAS

(3.9.3)

(3.9.4)

where Kd (L mol-1) is distribution coefficient; R is the gas constant (8.314 J mol-1 K-1); and T is the temperature in Kelvin. Alternatively, AH° and AS° could be calculated from the intercept and slope of linear plot of IuKd vs 1/T respectively (Pahlavanzadeh and Mohammadi, 2012; Christianah et al, 2010).

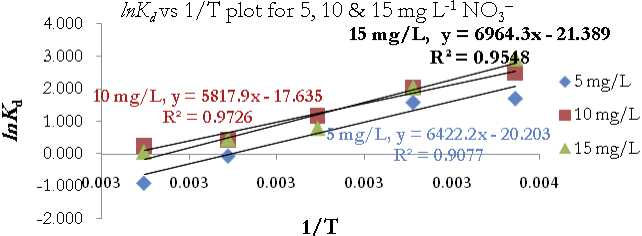
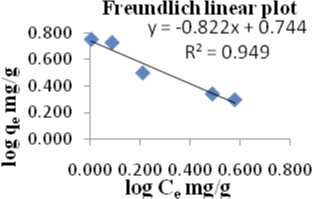
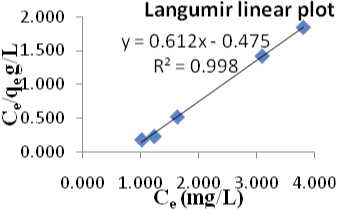


Figure 6. Linear plots of InKj vs 1/T for different nitrate concentrations at different temperatures.

Figure 7. Linear plots of Langmuir and Freundlich models at different temperature, conc. 5 mg L-1 (A, B), 10 mg L-1 (C, D) and 15 mg L-1 (E, F), dose 25 mg, pH 3).

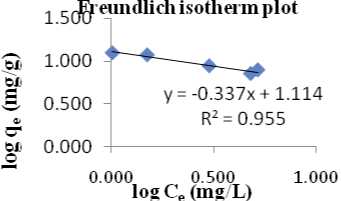
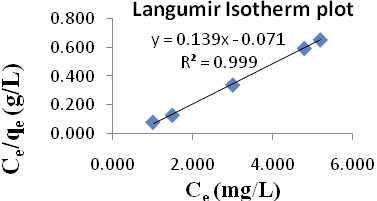
A

B



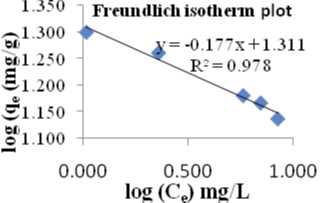
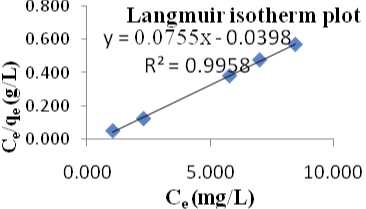
C

D



E

F



The thermodynamic parameter results (AH °, AS ^and AG a) Table 8, calculated from linear equations of the plots in Figure 7 for the studied concentrations showed that standard free energy (AG °) values during the sorption process at the studied temperatures were negative, indicating that the adsorption of nitrate ions onto the adsorbent was thermodynamically feasible and spontaneous in nature.

Table 8. Values of thermodynamic parameters calculated from lnKd vs 1/T for nitrate adsorption by ARO3/Fe3O4/ZrO2 at different temperatures.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Conc. (mg L-1) | Temp (K) | AHO  (KJ mol-1 IK-1) | ASO  (KJ mol-1 IK-1) | AG0t  (KJ/mol) |
| 5 | 288 | -53.39 | -0.17 | -5.01 |
|  | 298 |  |  | -3.33 |
|  | 305 |  |  | -2.15 |
|  | 318 |  |  | 0.03 |
|  | 328 |  |  | 1.71 |
| 10 | 288 | -48.37 | -0.15 | -6.03 |
|  | 298 |  |  | -4.56 |
|  | 305 |  |  | -3.54 |
|  | 318 |  |  | -1.62 |
|  | 328 |  |  | -0.15 |
| 15 | 288 | -57.90 | -0.18 | -6.64 |
|  | 298 |  |  | -4.86 |
|  | 305 |  |  | -3.61 |
|  | 318 |  |  | -1.30 |
|  | 328 |  |  | 0.48 |

In addition, the negative values of the standard enthalpy change AH Showed that the adsorption of nitrate was exothermic. Furthermore, the standard entropy change AS0 was also negative, indicating a decreased randomness existed at the adsorbent-solution interface during the adsorption of nitrate.

1. Effect of competitive ions

The impact of various anions including Cl-, F-, SO42-, HCO3- and QO4- on nitrate removal by nano Al-Fe-Zr was investigated at 15 mg L-1 of initial nitrate concentration and 25 mg of the adsorbent. The summarized result is given in Figure 13. It was observed that nitrate adsorption was mainly influenced by the presence of Cl-, F-, SO42-, HCO3- and ClO4- ions. Presence of these anions in the nitrate solutions is likely to limit the nitrate removal efficiency by the studied adsorbent. F- ion is more likely less competing with nitrate for adsorption than the rest. The effect of these co-existing anions on nitrate adsorption decreased in the order: ClO4-> SO42- ~ HCO3-> Cl-> F-. In the presence of nitrate ion, the affinity sequence for adsorption for example (SO42-> Cl-) is consistent with the results previously reported by (Haiou et al, 2013). For example, the hydration energy of SO42- (AGO, 1103 kJ mol-1) is higher than Cl- (AGO, 363 kJ mol-1).

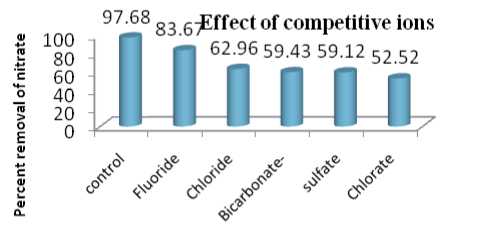


Figure 8. Effect of competitive ions on nitrate removal capacity by Al2O3/Fe3O4/ZrO2 at pH 3, adsorbent dose of 25 mg, 25 0C and 15 mg/L of initial nitrate concentration.

1. Conclusions

The results from the present study exhibited the potential of Al2O3/Fe3O4/ZrO2 ternary oxides NP for nitrate removal from aqueous solutions. The study showed that the adsorbent has surface area of 296.5 m2 g-1. The sorption of nitrate on Al-Fe-Zr oxides was found to be pH dependent with maximum nitrate removal occurring at pH 3. Kinetic analyses indicate that the sorption process followed pseudo-second-order kinetics. Both the Langmuir and Freundlich Isotherm models could be used to describe nitrate removal satisfactorily. Comparing Freundlich and Langmuir isotherm models, the Langmuir model gave a better fit to the adsorption isotherm equilibrium data. The sorption capacity of Al2O3/Fe3O4/ZrO2 adsorbent for nitrate was found to be ca. 28.83 mg g-1 at 25 0C. Nitrate sorption was affected by the presence of chloride, bicarbonate, sulphate, chlorate and fluoride anions. The effect of these co-existing anions on nitrate adsorption decreased in the order: F- < Cl- < HCO3- ~ SO42- < QO4-. The results of the present study suggest that Al2O3/Fe3O4/ZrO2 can be used for the removal of excess nitrates from water with better recycling.

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1. Removal of 2, 4-D, Atrazine and Major Metabolites of Atrazine from Aqueous Solution by Fe-Zr-Mn Nanocomposite

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Abstract: Current agricultural practices involve the use of different kinds of herbicides and other agrochemicals. Thus, the intensive use of these herbicides leads to diffuse contamination of non-target environments. For instance the contamination of groundwater and surface water threatens human health and the environment, due to the toxic properties of these compounds. For this purpose Fe-Zr-Mn nanosorbent was prepared to remove the herbicides from aqueous solution. The objective of this study was to synthesize Fe-Zr-Mn ternary mixed oxide and to investigate its sorption and desorption efficiency for the removal of selected pesticides including 2,4-D, atrazine (ATZN) and major metabolites of atrazine; diethylatrazine (DEA), deisopropylatrazine (DIA) and hydoxyatrazine (ATOH)) from aqueous solution. For this purpose, the adsorbent was synthesized by impregnation method. The optimum percentage compositions of Fe, Zr, Mn were 50, 35 and 15, respectively. The adsorbent was characterized by FT-IR and FAAS and its potential for the removal of selected pesticides was investigated. Adsorption study was carried out by batch experiment. The effects of different experimental parameters, namely, solution pH, adsorbent dose, contact time, speed of agitation and initial pesticides concentration were determined. The isotherm experiment showed that equilibrium data were well fitted to the Langmuir model. The kinetic study demonstrates the pseudo-second-order model gives a best fitting to the adsorption of pesticides on the adsorbent.

Keywords: Adsorption; Desorption; Pesticides; Nanocomposite; Ternary oxides

1. Introduction

Modern agricultural practices often include the extensive use of a wide range of pesticides.Environmental contamination due to the excessive use of pesticides has become a great concern to the public and to environmental regulatory authorities. In 1995, conventional pesticide use in USA amounted to about 1.22 billion pounds, which was one fifth of the world’s use of such chemicals (Ghosh and Philip, 2006). Herbicides are the pesticides used to remove weeds that would otherwise compete with the crop.

Pesticides are an important group of synthetic organic chemicals (SOCs), not only because of their abundance, but also because of their toxicity to aquatic life and to humans. The routes that pesticides follow to enter a water body include rainfall runoff, snowmelt runoff and atmospheric processes of wet and dry atmospheric deposition (To et al, 2008).

In agricultural practices, pesticides are used as insecticides, weedcides, fungicides, and herbicides. Part of them is also used to control diseases like: - malaria, filariasis, dengue, cholera, and Japanese encephalitis (Vinay, 2010), yet they are toxic and are potentially hazardous to human, animals, other organisms and the environment. The toxicity of a pesticide is a measure of its capacity or ability to cause injury or illness (Lorenz, 2007).

Among all the pesticides, herbicides production and its use was more than any other pesticides in the world (Ghosh and Philip, 2006). The compounds that belongs to family of herbicides and which have been widely used are Atrazine (ATZN) and its metabolites such as diethylatrazine(DIA), deisopropylatrazine (DEA), hydroxyatrazine (ATOH) and 2,4-D, (2,4- Dichlorophenoxyacetic acid). The extensive uses of herbicides cause a great distribution in the environment and consequently contaminating the soil and water reserves, and gradually find its way to enter into the food chain (Kalkhoff et al, 2003).

Atrazine is a chlorinated herbicide and at present, it has been used in more than 80 countries and probably it is the most commonly used herbicide in the world which exhibits acute, chronic and phytoxicity (Hayes et al, 2002).

It has been proved that atrazine contains mutagenic and carcinogenic agents also. Atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine) is a member of s- triazine group of herbicides and it is almost non-volatile and its half-life in neutral condition is about 200 days but varies from 4-57 weeks depending on various environmental factors like pH, moisture content, temperature and microbial activity (Mc-Cormick and Hiltbold, 1966).

Atrazine is used mainly for pre and post emergence control of annual grass and broad- leafed weeds in Maize, Sorghum, Pineapple, Sugarcane, Macadamia nuts and many other crops and have been sold in different commercial names like Aatrex, Aatratol, Bicep, Gasaprim etc. Its solubility in water is 33 mg/L at a temperature of 20 0C whereas, solubility in methanol, ethylacetate, dichloromethane, and chloroform are 18, 24, 28 and 52 g/L, respectively (Tomlin, 1994).

Due to its excessive usage, high persistence and mobility, atrazine along with its metabolites are transported to surface and subsurface water bodies and had been found in ground water, rivers, high mountain lakes, drinking water supplies, and rain water and even in fog (Glotfelty et al, 1987). As high as 22 mg/L of atrazine residue levels was observed in the water near the mixing or loading sites whereas the permissible limit of atrazine in drinking water is in parts per billion (ppb) level (Habecker, 1989).

Chlorinated aromatic compounds are a major group of chemicals responsible for environmental pollution, being highly toxic and resistant to degradation. Many of these compounds are widely used as herbicides. 2,4- Dichlorophenoxyacetic acid (2, 4-D) is the most commonly preferred herbicide to control broad leaved weeds because of its low cost and good selectivity (Hameed, 2009).

2, 4-D herbicide is an extremely active auxin, changing the normal growth patterns and resulting in death of the plant and it can be considered as a threat to the environment and human health. It has been proved to be toxic to humans and animals and has been classified as a possible human carcinogen and mutagen by the International Agency for Research on Cancer (Derylo-Marczewska et al, 2010). 2,4-D is also one of the well- known endocrine disrupting chemicals which seriously affect the immune and endocrine system (Mantilla et al, 2009)

For these reasons, the World Health Organization has recommended 70 pg/L as its maximum permissible concentration in drinking water (Han et al., 2010).

According to World Health Organization (WHO), the permissible limit of atrazine in drinking water is restricted to 2 pg/L (WHO, 1993). Under safe drinking water act, Environmental Protection Agency (EPA) established Maximum Contaminant Level (MCL) for atrazine as 3 pg/L, which took effect in 1992. As such no guidelines exist till now on the permissible limit of atrazine concentration on effluent discharged into water bodies.

Due to the physicochemical properties of herbicides (solubility in water and low soil sorption coefficient) and to its resistance to biological degradation, they tend to remain primarily in the dissolved phase (surface or ground water) and does not attach to suspended-sediment particles (Gaynor et al, 1995). Pesticides in drinking water can increase cancer risk and can cause damage to the liver and nervous, cardiac, endocrine and reproductive systems. Also, in recent years concern has been expressed over the persistence of these herbicides in the aquatic environment, which may present a risk to water supplies and aquatic ecosystems.

Conventional water treatment practice are largely ineffective at removing dissolved pesticides from water and in many cases concentrations of pesticide in finished drinking water is similar to concentrations in the supply water. Costly alternative treatment systems such as filtration using granular activated carbon (GAC) and/or powdered activated carbon (PAC) or ozonation may be required for water systems to comply with water quality standards (Doulla et al., 2008). Although, GAC and PAC exhibit a high adsorption capacity towards pure solutes, in natural water the competition between pollutants and background organics reduces the adsorption of micropollutants. Consequently, the search for adsorbents with high specific surface areas and high selectivity for specific contaminants is evident.

Today nanoparticles, nanomembranes and nanopowders are used widely for detection and removal of chemical substances including metals (e.g., cadmium, copper, lead, mercury, nickel, zinc), nutrients (e.g., phosphate, ammonia, nitrate and nitrite), cyanide, organics, algae (e.g., cyanobacterial toxins), viruses, bacteria, parasites and antibiotics (Dhermendra et al, 2008).

Most of the pesticides are resistant to biodegradation and are found to be carcinogenic even at parts per billion (ppb) levels. Therefore, it becomes essential to develop new technologies, which are capable of removing pesticides parts per billion (ppb) level.

In the last two decades, nanotechnology has developed with its applications in almost all branches of science and technology. In this series, water treatment is not deprived of nanotechnology. Nanosize adsorbents have been prepared and used for the removal of water pollutants. Some nanoparticles have been prepared and used for water treatment (Ali, 2012).

Nanoparticles have proven themselves as excellent adsorbents due to their unique features. The most important characteristics of these particles; which made them ideal adsorbents are their small size, catalytic potential, high reactivity, large surface area, ease of separation and large number of active sites for interaction with different contaminants. These properties are responsible for high adsorption capacities by increasing the surface area, free active valences and surface energies of nanoparticles (Ali, 2012).

Adsorption by nanoparticles offers flexibility in design and operation and in many cases it can generate high-quality treated effluent. In addition, owing to the reversible nature of most adsorption processes, the adsorbents can be regenerated by suitable desorption processes for multiple use and many desorption processes are of low maintenance cost, high efficiency and ease of operation (Pan et al, 2009). Therefore, the adsorption process has come to the forefront as one of the major techniques for pollutant removal from water/wastewater.

Organic pollutants were removed from water by adsorption technology using nanoparticles. The nanoparticles of aluminum, iron, and titanium oxides and native iron metals are effective for the removal of normal and halogenated hydrocarbons. Research paper is available in the literature on pesticide adsorption from water that is adsorption of atrazine onto nano-SiO2 andnanokaolin particles was reported (Ali, 2012).

Characterization studies of multi-component sorbents indicate that the physico­chemical properties of these solids differ significantly from those of their single­component constituents. These differences in physico-chemical properties are believed to be the primary reason for differences in sorption behavior between multi- and single component solids.

For example, increased Ni adsorption in a Fe-oxide/silica multi-component system (compared to a silica only system) is attributed to increases in surface area, porosity and surface charge distribution (Potter and Young, 1999).

Fe-Mn binary oxide originating from the combination of iron oxide and manganese dioxide investigated as potential for phosphate removal (Zhang et al, 2009). Similarly, Fe-Al-Mn nanocomposite was studied as potential adsorbent for the removal of atrazine and its metabolites from the aqueous solution in a batch system (Endale, 2012).

Therefore, in the present study, Fe-Zr-Mn ternary oxide nanocomposite was synthesized and utilized for the removal of herbicides from aqueous solution due to ZrO2 has been reported as a better catalyst and catalyst support, as a result of its versatile structural and surface chemical properties as well as good thermal stability

compared to metal oxides such as Al2O3, SiO2 and TiO2 (Stichert and Schuth, 1998) and important scavenging properties of Mn. The main purpose of this study was to synthesize and characterize Fe-Zr-Mn nanocomposite using impregnation method (Agulia et al, 2008) and to investigate its removal capacities for 2,4-D, atrazine and major metabolities of atrazine (DIA, DEA and ATOH) from aqueous solution.

1. Materials and Methods
   1. Experimental Site

Synthesis of Fe-Zr-Mn mixed nanocomposite, FAAS study and adsorption experiments for the removal of selected pesticides using the synthesized material were carried out at Haramaya University, Chemistry Department Research laboratory. Infrared spectroscopic study was conducted for identification of functional groups on the adsorbent surface at Addis Ababa University.

* 1. Apparatus and Chemicals
     1. Apparatus

The apparatus that were used in the present work included different sizes of beakers, Erlenmeyer flasks, burettes funnels, graduated cylinders, volumetric flasks, capped test tubes, droppers, glass pipettes, spatula, measuring cylinder, suction filter pump, stirrer, analytical balance, conical flask, round bottom flask, mortar, pestle, filter paper, acid digestion tube and crucible dish.

1. Chemicals and reagents

Iron, manganese and zirconium salts like ferric nitrate nona hydrate (Fe(NO3)3.9H2O, 98 %,BDH chemicals Ltd, England), manganese nitrate nona hydrated (manganese dioxide (MnO2, 98%, 5.03 gcm-3) and zirconium Oxy chloride octa hydrate

(ZrOCl2.8H2O,99.5%) were used for the synthesis of Fe-Zr-Mn nanocomposite. The pH was adjusted during the research using hydrochloric acid (HCl, 36-37%, BDH chemicals Ltd, England) and sodium hydroxide (NaOH, 97.5% BDH chemicals Ltd, England). Concentrated nitric acid (conc. HNO3) and hydrogen peroxide (H2O2) was used for digestion of powders for elemental analysis. Methanol and acetonitrile were used for dissolving the standards pesticide compounds. Stock solution of pesticides; atrazine (ATZN) and its metabolities: diethylatrazine (DEA),

deisopropylatrazine (DIA), hydroxyatrazine (ATOH) and 2,4-D were prepared from their respective standards.

* 1. Experimental Procedures

1. Synthesis of Fe-Zr -Mn nanocomposite

To synthesize nanosized Fe-Zr -Mn ternary mixed oxides impregnation method was used (Agulia et al, 2008). 0.1 mol nano sized Fe-Zr-Mn ternary mixed oxides was prepared by impregnating MnO2 in aqueous solution of Fe(NO3)3’9H2O and ZrOCl2.8H2O salts. Then it was dried at 110oC in an oven for 24 hours and further calcined at 400, 600and 700oC for 3 hours by varying the molar percentage of iron, zirconium and manganese precursors as (70, 25, 5), (60, 30, 10) and (50, 35, 15) %, respectively.

1. Elemental analysis of the nanocomposite

The percentages of iron as iron oxide, zirconium as Zirconium oxide and manganese as manganese oxide in the selected synthesized powders were determined by flame atomic absorption spectrophotometer. For this purpose, 0.5 g of the as-synthesized powder for three replication were digested with a mixture of concentrated nitric acid (7 mL), concentrated hydrochloric acid (4 mL) and hydrogen peroxide (2 mL) using acid digestion tube till clear solution appeared. The samples were transferred to 100 ml volumetric flasks and brought to volume using deionized water. 1 mL of this solution was diluted further to 50 mL and the concentration of iron, zirconium and manganese were read from their solution in 50 ml volumetric flasks. The results were corrected for the dilution factor (Bock, 1978).

* 1. Preparation of the Pesticides Solution

In order to prepare pesticide solution, 2.5mg of each standard pesticide (ATOH, ATZN, DEA, DIA and 2,4-D) was dissolved in acetonitrile. The resulting solutions were diluted to the final volume with reagent water in 25 mL flask. All stock solutions were stored at 4 oC till the time of analysis. A mixed working standard solution of 10 mg/L containing each of the pesticides were prepared every time by mixing appropriate amount of the stock solution and diluting with reagent water to a given volume.

A series of concentrations for calibration were prepared in the concentration range of 500 to 2000 ig/L at six points (500, 750, 1000, 1250, 1500 and 2000 ig/L) and for 2,4- D concentration range of 1000 to 11000 ig/L (1000, 3000, 5000, 7000, 9000, and 11000 Ig/L) (Muggli **et al,** 2001).

* 1. Procedure for Pesticides Removal

Adsorption process was studied by batch experiment. First, 0.1 gram of as synthesized powder sample (adsorbent) was added into measured volume of pesticides stock solution using Erlenmeyer flask under continuous mixing condition with magnetic stirrer at room temperature. The effect of different parameters such as adsorbate concentration, dose of adsorbent, agitation speed, pH, and contact time were studied by varying any one of the parameters and keeping the other parameters constant.

For each trial, a sample was taken periodically out of the flask and shaken on a rotatory shaker for 1 hour, until complete adsorption equilibrium was assumed to occur. After that, samples subject to double filtration on soft filter paper. Then, the concentrations of non- adsorbed analytes in the filtrates were determined using UV-VIS spectrophotometer (Rafiquea and Nsreen, 2011).

* 1. Optimization of Experimental Parameters
     1. Effect of pH

To study the influence of pH on the pesticides [(2,4-D, atrazine (ATZN), diethylattrazine (DEA) deisopopylatrazine (DIA), hydroxyatrazine (ATOH)] adsorption, experiments were carried out by adding 0.1 g of the adsorbent into 25 mL Erlenmeyer flask separately for each pesticide. For atrazine and its metabolites the pH was varied from 3 to 8 before adsorption experiments were carried out while keeping other parameters constant (agitation speed at 150 rpm, contact time at 60 minutes and initial pesticides concentration at 1000 pg/L). For 2,4-D the pH was varied from 3 to 9 while keeping other parameters constant (agitation speed at 150 rpm, contact time at 90 minutes and initial pesticides concentration at 5000 pg/L). The pH of the solutions were adjusted with dilute HCl or/and NaOH solution. Then equilibrium pesticides concentrations were measured after the solutions were agitated for 60 minutes.

* + 1. Effect of agitation speed

To study the effect of agitation speed on pesticides [(atrazine (ATZN), diethyl atrazine (DEA), deisopropylatrazine (DIA), hydroxyatrazine (ATOH) and 2,4-D)] adsorption, the quantity of pesticide adsorbed were determined by varying the agitation speed as, 50, 75,100, 120, 150, 180 and 200 rpm with pH kept at optimized value, while keeping other parameters constant.

* + 1. Effect of contact time

For determining the effect of contact time on pesticides [(atrazine (ATZN), diethylatrazine (DEA), deisopropylatrazine (DIA), hydroxyatrazine (ATOH) and 2,4-D)] adsorption, we varied the contact time as, 30, 60, 90, 120, 150, and 180 minutes keeping the other parameters constant.

* + 1. Effect of initial concentration of pesticides

To study the effect of initial adsorbate concentration, the experiment was carried out using different initial pesticides concentrations. For atrazine (ATZN) and its metabolites (diethyl atrazine (DEA), deisopropylatrazine (DIA), hydroxyatrazine (ATOH) concentrations 500, 750, 1000, 1250, 1500 and 2000 pg/L were employed, and for 2,4- D, initial concentrations of 1000, 3000, 5000, 7000 and 11000 pg/L were used. Each time 0.1g of the adsorbent was loaded into a 50 mL Erlenmeyer flask and 25 mL of each of initial pesticides solution was then added. Each time the pH of the solution was maintained at the optimized value by adding 0.1 M HCl or 0.1 M NaOH solutions. The flask was agitated at 150 rpm keeping pH, contact time and the adsorbent dose constant. At the end of the adsorption period, the pesticides solutions were filtered and then analyzed for pesticides equilibrium concentrations.

1. Effect of adsorbent dose

For determining the effect of adsorbent dose on the pesticides adsorption, the amounts of pesticides adsorbed were determined by varying the dose as, 0.06, 0.08, 0.1, 0.2 0.3 and 0.4 g; the initial pesticides concentrations, agitation speed, contact time and pH were kept at the optimized value.

* 1. Adsorption Isotherms

Freundlich and Langmuir models were employed to describe the experimental results of effect of pesticides adsorption. Pesticides adsorption isotherms were determined by keep ing all a parameters at optimized conditions and initial pesticides concentrations were varied from 500 to 2000 pg/L for atrazine and its metabolites (DEA, DEA and ATOH) and for 2,4-D the initial concentration was varied from 1000 to 11000 pg/L. In separate flask 25 mL of solutions containing different amount initial pesticides concentrations were added. After the reaction period; all samples were filtered and analyzed for the corresponding pesticides equilibrium concentrations.

* 1. Kinetics Study

Effect of adsorption kinetics on pesticides atrazine (ATZN) and its metabolites, and 2,4- D was determined by varying the contact time as, 30, 60, 90, 120, 150, and 180 minutes by keeping all parameters (pH, adsorbent dose, agitation speed and initial pesticides concentrations) at optimized value. It was evaluated by using 0.1g of adsorbent and placed in several 50 mL Erlenmeyer flasks, each containing 25 mL of 1000 pg/L and 500 pg/L for atrazine and its metabolite and 2,4-D respectively. The pH of the solutions was maintained at the optimized value. The flasks were continuously shaken at a speed of 150 rpm. The sample solution was immediately filtered of and then analyzed for pesticides equilibrium concentration.

1. Statistical Analysis

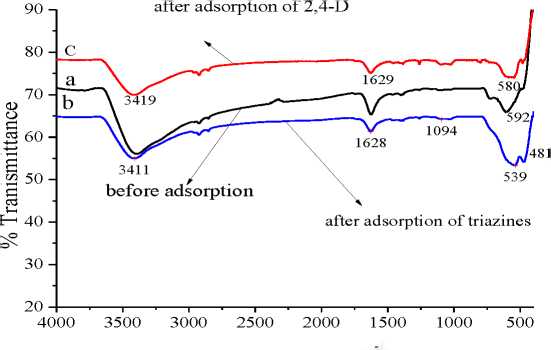
To determine the concentration of each pesticide samples in contaminated aqueous solution, the mean values were calculated from the replicates and expressed with standard deviation. The homogeneity of variance was checked out and analysis of variance (ANOVA) was then performed to assess the significance difference among means of replicate measurements (Panesey and Sukhatm, 1999).

1. Results and Discussion
   1. Elemental Analysis of Synthesized Adsorbent

Elemental content of the selected adsorbent is (M3-400) with percent composition of Fe: Zr: Mn (50: 35: 15)was analyzed through FAAS. The analysis was performed using a standard solution of each analyte prepared at a series of concentrations. The synthesized mixed oxide powder was disolved by acid digestion method, in which 0.5g of the sample was dissolved in 100mL volumetric flasks using a mixture of conc. HNO3, HCl and H2O2 with appropriate concentrations volume ratios. The unknown concentration of each metal ion was determined from its calibration plot prepared from series ofconcentrations of standard versus the corresponding absorbance reading (Appendix Figures 4, 5 and 6). The percentage composition of Fe, Zr and Mn in the sythesiized selected nanosorbent was found to be 47, 31 and 13.6, respectively and this is not far from the theoretical composition.

* + 1. Infrared spectroscopic studies

FTIR measurement was made to study the surface functional groups on the nanocomposite. There are usually occurring metal hydroxyl groups on the surface of many metal oxides (Stumm, 1992) which are the most abundant and active adsorption sites for adsorbate and can be detected by IR spectroscopy. FT-IR spectra of the Fe—Zr —Mn nanocomposite before and after adsorption are shown in Figure 9. A strong and broad band in 3600-3100 cm-1 region (O—H stretching vibration) should be assigned for the presence of hydroxyl of coordinate water molecules (Apte et al, 2007). The broad band in the range of 3411 and 3419 cm-1 is caused by the presence of the OH- (stretching vibration). A band at 1628cm-1 is primarily attributed to the bending vibration of hydroxyl groups of iron hydroxides (Fe—OH) (Zhang et al., 2007). Adsorption band centered at 539 cm-1 show the presence of hematite and the band observed in the region around 481, 580, and 592cm- indicates the presence of mixed metal oxides bond in specific vibration (Zhang et al., 2009). In this study, we noticed no particular change before and after adsorption.



**Wave number (cm')**

Figure 7. FT-IR spectra of Fe—Zr—Mn nanocomposite before adsorption (a), after adsorption of atrazine and its metabolities (b) and after adsorption of 2, 4-D (c).

* 1. Optimum Conditions for Pesticides Removal by the Sorbent
     1. Effect of agitation speed

Agitation speed is an important parameter in sorption phenomena, which has a serious action on the distribution of the solute in the bulk solution and the formation of the external boundary film. The effect of agitation on the uptake of pesticides by Fe-Zr-Mn nanosorbents was studied at different agitation speeds (75- 200 rpm) while otherparameter was at constant value. From Figure 12 (a) and (b), it can be observed that agitation speed significantly affects the sorption of pesticides.

The percent of adsorption was enhanced with increase in agitation speed from 75 rpm to 150 rpm confirming the influence of external diffusion on the sorption kinetic control. This is may be due to increasing the agitation speed; the rate of diffusion of pesticides molecules increase hence percent of adsorption was also increase (Mall et al, 2005). As agitation speed increase from 150 to 200 rpm, the percent removal of pesticides was decreased for all pesticides (DIA, DEA, ATOH and ATZN) (Figure 12 (a)). This decrease in percent removal may be attributed to an increased desorption tendency of pesticides molecules and/or having similar speed of adsorbent particles and adsorbate ions. This desorption tendency may be attributed to high mixing speed which means more energy input and higher shear force causing break of bonds between pesticides and the adsorbent (AbdEl-Latifet al, 2010). This also indicates that a 150rpm agitation speed is sufficient to assure that all the surface binding sites are made readily available for pesticides uptake.

As can be seen in Figure 12 (b), the uptake of 2,4-D on adsorbent increases progressively with an increase in the agitation speed from 75 to 200rpm, and reaches maximum value (78.62%) at the stirring speed of 150rpm. This increase in uptake can be attributed to the decrease in boundary layer thickness around the adsorbent particles being a result of increasing the degree of mixing. Also, it may be due to the fact that severe agitating promotes a certain turbulence which insures an intimate contact between the phases (Demirbas, et al., 2002).

In addition, the increased uptake may be related to reduce adsorbent agglomeration with agitation, thus increasing surface area to volume ratio and in turn removal. However, after the agitation speed is increased to more than 150rpm, the uptake of 2, 4-D on adsorbent has no significant change and remains approximately constant. The result indicates that proceeding with increasing the agitation speed does not nearly affect the adsorption efficiency of 2, 4-D on adsorbent when the agitation speed is above 150rpm. Therefore, it can be concluded that the agitation speed of 150rpm is appropriate to remove 2, 4-D from aqueous solutions by Fe2O3-ZrO2-MnO2 nanocomposite.

Figure 8. (a) Effect of agitation speed on the removal of pesticides (DIA, DEA, ATOH, and ATZN) [At initial pesticides concentration (Co) = 1 mg/L, adsorbent dose = 0.1 g, pH = 4 and contact time =1 hr]. (b) Effect of Agitation speed on the removal 2, 4-D [At initial pesticides concentration (Co) = 5 mg/L, dose = 0.1 g, pH= 4 and contact time = 90 min].

A

B

100

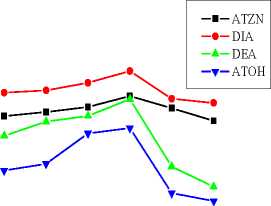
90

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50

60

40

60 80 100 120 140 160 180 200

Agitation speed (rpm)

50

60 80 100 120 140 160 180 200

Agitation speed (rpm)

1. Effect of contact time

Contact time is one of the most important parameters for practical application. Effect of contact time on adsorption of pesticide of atrazine and its metabolites is presented in Figure 13(a). Uptake of pesticides was rapid in first 30-60 minutes and declined after 60 minutes. The pesticides uptake process appears to be rapid in first 30-60 minutes and nearly 60 to 86% of total pesticides uptake appears to have been adsorbed in this duration depending upon the adsorption nature of different pesticides. The initial rapid phase may also be due to the increased number of vacant sites available at the initial stage whereas after 60 minutes decreasing effect is due to vacant surface sites are not easy to be occupied due to repulsive forces. Later on the process becomes relatively slower and equilibrium conditions are reached at 60 minutes.

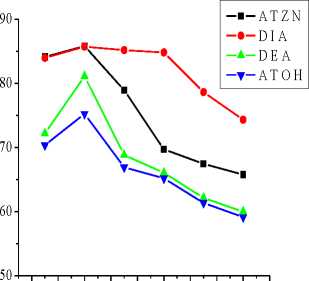
At this point, the amount of the pesticides desorbing from the adsorbent is in a state of dynamic equilibrium with the amount of the pesticides being adsorbed onto the adsorbents. The time required to attain this state of equilibrium is termed the equilibriumtime, and the amount of pesticides adsorbed at theequilibrium time reflects the maximum adsorption capacity of the adsorbent under those operating conditions (Satish et al, 2011). Therefore, further batch experiments were carried out at 60 minutes optimum contact time.

According to Figure 13 (b), 2, 4-D adsorption rate increased quickly with time, and then reached equilibrium. The contact time to reach equilibrium was 90min. The adsorption capacity and percent removal of 2,4-D onto the adsorbent significantly increased during the initial adsorption stage, and then equilibrium was nearly reached. At this time, removal efficiency reached to 72.29 %. Hence, in the present work, 90min waschosen as the equilibrium time. Generally, the removal rate of sorbate is rapid initially, but it gradually decreases with time until it reaches equilibrium.

This phenomenon is attributed to the fact that a large number of vacant surface sites are available for adsorption at the initial stage, and after a lapse of time, the remaining vacant surface sites are not easy to be occupied due to repulsive forces between the solute molecules on the solid and bulk phases. On the other hand, the rate in percent of 2,4-D herbicide removal is higher in the beginning due to the larger surface area of the adsorbent being available for the adsorption of the pollutants. As the surface adsorption sites become exhausted, the rate of uptake is controlled by the rate of transport from the exterior to the interior sites of the adsorbent particles Similar findings were reported by ( Naghizadeh et a**l,** 2011; Calvete **et al,** 2009).

80

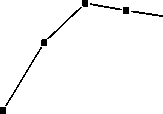
**b**



20 40 60 80 100 120 140 160 180 200

Contact time (min)

**a**



70

60

40

20 40 60 80 100 120 140 160 180 200

Contact time (min)

Figure 9.(a) Effect of contact time on the removal of pesticides (DIA, DEA, ATOH, and ATZN) [At initial pesticides concentration (Co) = 1 mg/L, dose = 0.1 g, agitation speed = 150 rpm and pH = 4]. (b) Effect of Contact time on the removal2,4-D [At initial pesticides concentration (Co) = 5 mg/L, dose = 0.1 g, agitation speed =150 rpm and pH = 3].

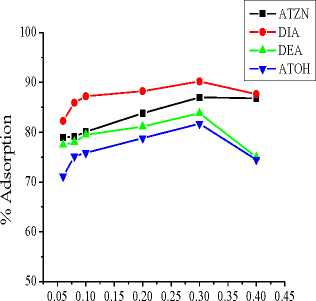
1. Effect of adsorbent dose

The adsorbent dose is an important parameter because this determines the capacity of the adsorbent for a given initial pesticides concentrations. The effect of nanosorbent dosage on pesticides (atrazinne and its metabolites) removal was studied by increasing the dose of nanopowder keeping the initial pesticides concentration (1 mg/L), agitation speed (150 rpm), pH(4) and contact time (1 h) constant at equilibrium time at room temperature. Effect of adsorbent dose of atrazine and its metabolites is presented from Figure 14 (a). It is clear that the percentage adsorption increased with the increase in adsorbent dosage. This can be due to the fact that, the large numbers of active sites could be effectively utilized when the dosage was high (Ponnusami **et al,** 2009).

It is also observed that a further increase of adsorbent dose from 0.3 to 0.4g, the percent adsorption increasing was not observed. Thus, the adsorbent dose was maintained at 0.3g in all the subsequent experiments, which was considered to besufficient for the removal of pesticides. The effect of nanosorbent dosage on 2,4-D removal was carried out by increasing the dose of adsorbent and keeping the initial pesticides concentration (5 mg/L), agitation speed (150 rpm), pH (3) and contact time (90 min.) constant at equilibrium time at room temperature. As can be seen in Figure 14 (b); 2,4-D herbicide removal was dependent on the mass of adsorbent present in the solution, and it increases when the adsorbent dosage increases. On the other hand, the percentage of 2,4-D removal steeply increases with the adsorbent loading up to 0.1g. This result can be explained by the fact that the sorption sites remain unsaturated during the sorption, whereas the number of sites available for sorption site increases by increasing the adsorbent dose. The maximum adsorption efficiency of 2,4-D herbicide onto adsorbent was found to be 75.3%.

b

**a**



Adsorbent dose (g)

90

80



0 cn

'O

£ 60

■

<

50

/

0.1 0.2 0.3 0.4

Adsorbent dose (g)

Figure 10.(a) Effect of adsorbent dose on the removal of pesticides (DIA, DEA, ATOH, and ATZN) [At initial pesticides concentration (Co) = 1 mg/L, contact time = 1 hr, agitation speed = 150 rpm and pH = 4]. (b)Effect of adsorbent dose on the removal2,4-D [At initial pesticides concentration (Co) = 5mg/L, dose = 0.1g, agitation speed = 150 rpm and pH = 3].

1. Effect of initial pesticides concentration

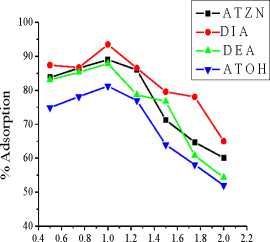
One of the most important and widely studied aspects of sorption of organic pollutants to aqueous solution is the effect of solute concentration on sorption affinity, given that, in theory, this should convey important information about sorption mechanisms. As shown in Figure 15 (a), the removal efficiency of the pesticides increase till 1mg/L but decreased as the initial concentration of pesticides increased beyond 1mg/L for all pesticides (ATZN, DIA, DEA and ATOH).

This can be explained by the fact that in case of low concentrations, the ratio of the initial number of moles of solutes to the available surface area of adsorbent is large and subsequently the fractional adsorption becomes independent of initial concentration and consequently higher adsorption yields were obtained. However, at higher concentrations, most of the adsorption sites could be occupied by ions and the available sites of adsorption would become fewer, hence the percentage removal of pesticideswhich depends up on the initial concentrations could decrease as suggested by Yu **et al** (1990).

The initial concentration of pollutant affects both the adsorption capacity of the adsorbent, and the adsorption rate. Also, the initial concentration provides an important driving force to overcome all mass transfer resistance of the adsorbate between the aqueous and solid phases. In the case of 2,4-D herbicide, the amount sorbed decreased with increase in the initial concentration of the sorbate (Figure 15(b)).

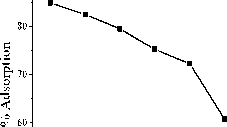
b

**a**



Initial concentration (mg/L)

90



50

0 2 4 6 8 10 12

Initial concentration (mg/L)

Figure 11.(a) Effect of initial concentration of pesticides (ATZN, DIA, DEA and ATOH) on the removal pesticides [At pH = 4, dose = 0.1 g, agitation speed = 150 rpm and contact time = 1 hr]. (b) Effect of initial concentration on the removal2,4-D [At initial pesticides concentration (Co) = 5 mg/L, dose = 0.1 g, agitation speed =150 rpm and pH = 3].

1. Sorption

Due to the complexity and heterogeneity of sorbents, both absorption and adsorption may occur at the same time, and it is often impossible to differentiate between the two. Adsorption specifically refers to sorption of molecules to the surface of solid components, whereas absorption refers to the movement of molecules, or partitioning, into a separate phase (Hassett and Banwart, 2002). Sorption isotherms for the five pesticides at equilibrium studies were conducted with an adsorbent quantity of 0.1 g with concentrations of atrazine and its metabolities 0.05, 0.075, 0.1, 0.125, 1.5, 1.75 and 2 mg/L and 2,4-D concentration 1, 3, 5, 7, 9, and 11 mg/L in identical conical flasks containing 50 ml of distilled water and sorption kinetics studies were conducted at different contact times of 30, 60, 90, 120, 150, and 180 minutes.

1. Equilibrium study

Isotherms correlate the equilibrium adsorption data with different mathematical models to describe how adsorbate interact with adsorbents and is critical in optimizing the use of adsorbent (Bharathi and Ramesh, 2012). Two most common isotherm models were employed for describing the adsorption data, which are Langmuir and Freundlich isotherm.

In order to find the short term behavior of pesticides (ATZN, DIA, DEA, ATOH and 2,4-D) in nanosorbents, adsorption isotherm studies were conducted with an equilibrium time of 1h for atrazine and its metabolites and 90min for 2,4-D. Using Langmuir (1918) and Freundlich (1926) equilibrium models, the isotherm constants and the maximum adsorption capacity of the nanosorbents were calculated for different initial concentrations of pesticides to understand the sorption behavior clearly. Langmuir equation is based on several assumptions such as (i) the adsorbent surface is homogeneous; (ii) there is no interaction between adsorbates in the plane of the surface and (iii) monolayer type of adsorption. The Langmuir equation can be represented in the form of following equations. Also, the adsorption rate is proportional to the number of free sites on the adsorbent and fluid concentration. Once pesticides molecules occupy a site, no further adsorption will take place at the site (Allen et al, 2003). The Langmuir isotherm can be expressed by:

(14)

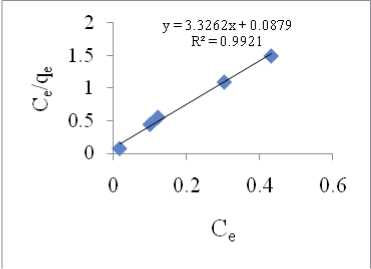


Where Ce is the equilibrium concentration of solution (mg/L), qe is the amount of pesticide adsorbed; Qm and b is Langmuir constants related to adsorption efficiency and energy of adsorption, respectively. The linear plots of Ceq/qe vs. Ce suggest the applicability of the Langmuir isotherms. The values of Qm and b were calculated from slope and intercepts of the plots respectively. The Freundlich equilibrium isotherm (Freundlich, 1906) was also used to describe the experimental adsorption data. This isotherm model assumes a heterogeneous surface with a non-uniform distribution of heat of adsorption over the surface (Pearce et al, 2003). The Freundlich isotherm can be expressed by:

logqe=logKf+ 1/nlogCe (15)

Where Kf is adsorption capacity and n is degree of nonlinearity between solution concentration and adsorption respectively. These constants can be obtained from the plot of logqe versus logCe.

a B



c d

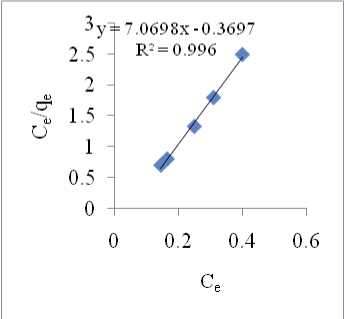
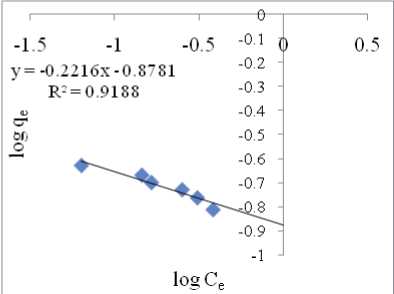
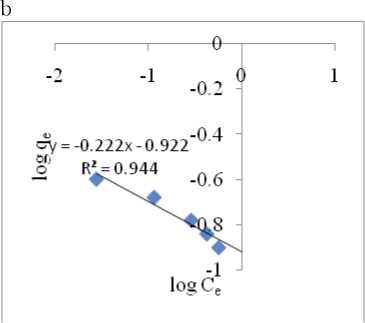
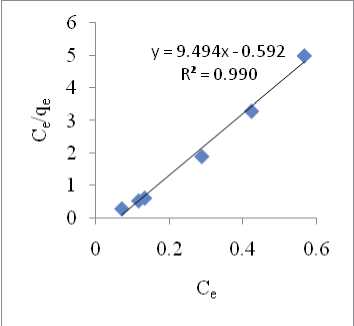


Figure 12. Langmuir (a) and Freundlich (b) adsorption isotherm of ATZN, Langmuir (c) and Freundlich (d) adsorption isotherm of DIA by Fe-Zr-Mn nanocomposite at different initial concentration of pesticides



a



c

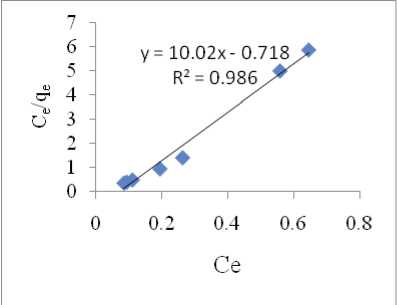
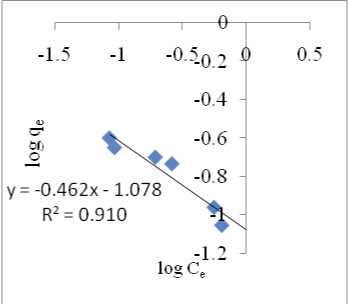
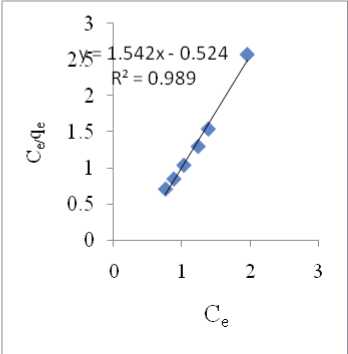


Figure 13. Langmuir (a) and Freundlich (b) adsorption isotherm of ATOH, Langmuir (c) and Freundlich (d) adsorption isotherm of DEA by Fe-Zr-Mn nanocomposite at different initial concentration of pesticides.

d



a



b

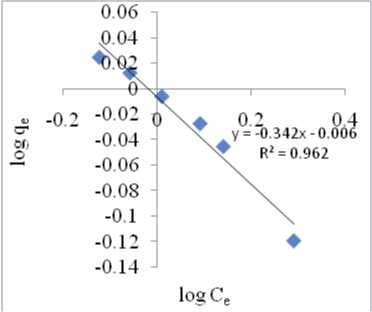


Figure 14.Langmuir (a) and Fredlich (b) adsorption isotherm of 2,4-D by Fe-Zr-Mn nanocomposite at different initial concentration of pesticides.

From the Figures 16, 17 and 18 linear relationships were observed among the plotted parameters at different concentration. Qm and b are Langmuir constants. The values of Qm and b were calculated from slope and intercepts of the plots and listed in Table 6. The values can conclude that the maximum adsorption corresponds to a saturated monolayer of adsorbate molecules on adsorbent surface with constant energy and no diffusion of adsorbate in plane of the adsorbent surface. To confirm the favourability of the adsorption process, the separation factor (RL) was determined and given in Table 6. The values were found to be between 0 and 1 and confirm that the ongoing adsorption process is favorable (Prabakaran and Arivoli, 2012).

Kf and n are Freundlich constants, the factors affecting the adsorption capacity and intensity of adsorption, respectively. The intensity of adsorption is an indication of the bond energies between metal ion and adsorbent, and the possibility of slight chemisorptions rather than physisorption. However, the multilayer adsorption of adsorbate through the percolation process may be possible. The values of n are less than one, indicating the physisorption is much more possible. The equilibrium data fitted well with the Langmuir isotherm for pesticides sorption studied at the different initial concentrations.

From the Table 6; the result of the separation factor (RL) is between 0 and 1 and it confirms that adsorption process is favorable. The R2 values of Langmuir model is

greater than the R2 values of Freundlich model for each pesticide (Table 6), indicating that the Langmuir model is suitable for describing the adsorption equilibrium of pesticides onto Fe-Zr-Mn nanocomposite.

1. Kinetic Studies

Table 4. Langmuir and Freundlich isotherm constants for pesticides (DIA, DEA, ATOH, ATZN, and 2,4-D) adsorption by Fe—Zr—Mn nanocomposite.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Pesticides | Langmuir | |  | Freundlich |  |  | Separation  factor |
| qmax  (mg/g) | b(L/mg) | R2 | Kf(mg/g) | 1/n | R2 | Rl |
| ATZN | 0.30 | 38.0 | 0.9921 | 0.078 | -0.5601 | 0.9603 | 0.03 |
| DIA | 0.14 | 19.3 | 0.996 | 0.13 | -0.2216 | 0.9188 | 0.05 |
| ATOH | 0.105 | 16.08 | 0.9908 | 0.12 | -0.2227 | 0.9448 | 0.06 |
| DEA | 0.099 | 56.5 | 0.9862 | 0.084 | -0.4625 | 0.9106 | 0.017 |
| 2,4-D | 0.65 | 2.93 | 0.9899 | 0.98 | -0.342 | 0.9624 | 0.25 |

A kinetic study of adsorption process is important to describe the controlling mechanism, which is the fundamental factor of mass transfer and pesticide uptake rate as well as the equilibrium time.Adsorption kinetics is mainly to study adsorption reaction rate. Effects of adsorption kinetics on pesticides were studied by varying the contact time as 30, 60, 90, 120, 150, and 180 minutes by keeping all parameters (pH, adsorbent dose, agitation speed and initial pesticides concentrations) at optimized value.

Several kinetic models have been used to investigate the mechanism of process and the potential rate-controlling steps involved in the process of sorption. In this study, the mechanism of sorption was investigated by the kinetic models such as pseudo-first-order and pseudo-second-order. The pseudo-first-order kinetic model can be represented by Equation (12):

log ( qe -qt ) = log (qe ) - h/2.303t (12)

Where qe and qt are amounts of pesticides adsorbed (mg/g) on adsorbent at equilibrium and at time t, respectively and K1 is rate constant of pseudo first order adsorption (min­1). The slope and intercept values of plot log (qe - qt) against t, pseudo first order rate constant (K1) and theoretical amount of pesticides adsorbed per unit mass of adsorbent qt(theoretical) were determined from equation using Figures 19-21. qt (theoretical) were compared with the qe(experimental) values in Table 7. The pseudo-second-order kinetic model can be represented by Equation (13):

(t/qt) = 1/k2 qe2 +1/qe(t)

(13)

Where K2 is rate constant of second order adsorption (g/mg/min). The slopes and intercepts of plot of t/qt against t, Figures 18-20, were used to determine qt (theoretical) and k2 respectively. The pseudo second order parameters, qt (the) and k2 obtained from the plot are represented in Table (7).

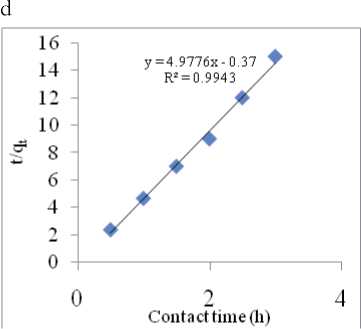
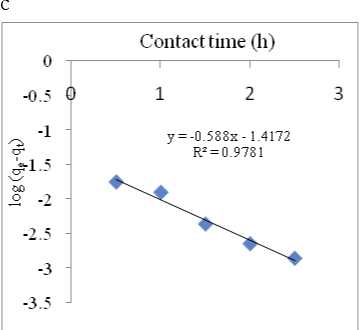
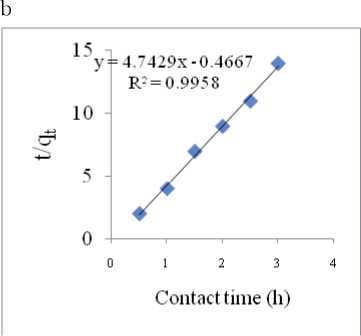
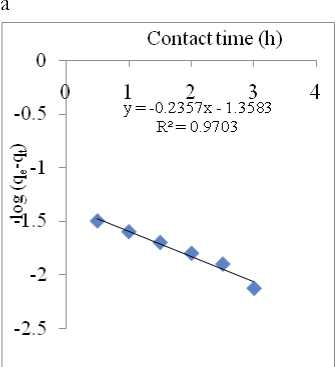
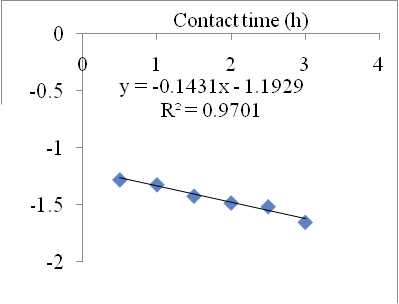


Figure 15. Pseudo-first (a) and pseudo-second (b) order kinetics for ATZN, pseudo-first (c) and pseudo-second (d) kinetics for DIA by Fe-Zr-Mn nanocomposite sorbent at different contact time.

a



lo? (q<Lfit) ^ log (qe-qt)

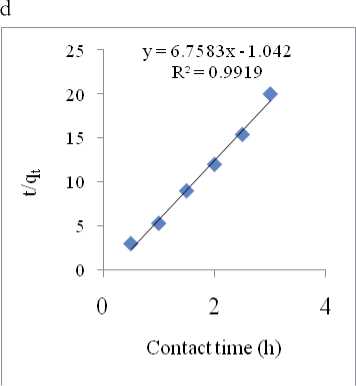
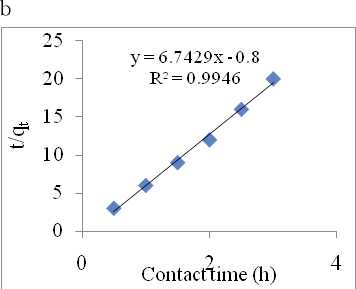
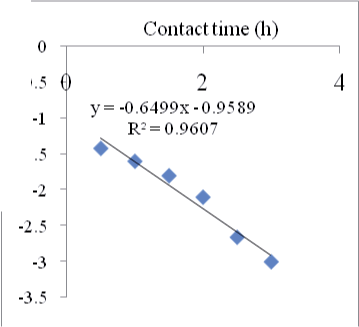
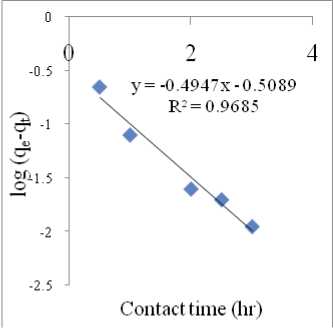


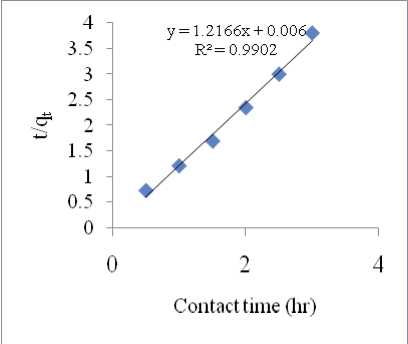
Figure 16. Pseudo-first (a) and pseudo-second (b) order kinetics for DEA, pseudo-first (c) and pseudo- second (d) kinetics for ATOH by Fe-Zr- Mn nanocomposite at different contact time.

a



b

Figure 17. Pseudo-first (a) and pseudo-second (b) order kinetics for 2,4-D by Fe-Zr-Mn nanocomposite at different contact time.



The effect of contact time was investigated to find the best kinetic model. In all the conditions studied, the pseudo- first-order equation did not fit well to the whole range of contact times. The experimental qe values do not agree with the calculated qt from the linear plots. This shows that the sorption of pesticides onto nanosorbent did not follow first-order kinetic indicating that the sorption was not diffusion-controlled and adsorption was not preceded by diffusion through a boundary (Sener, 2008).

The correlation coefficients for the pseudo-second- order-kinetics were closer to unity than that of the pseudo- first-order kinetics.The experimental qe and the calculated qe values of the pseudo-second-order kinetic model were closer to each other and its calculated qe values agree with the experimental qe values. This confirmed that the adsorption data are well represented by the pseudo-second-order kinetic model for the adsorption of pesticides by the nanosorbent. The linear plots of the models are represented in Figure 19, 20 and 21 shown above.The values of parameters and correlation coefficients of kinetic models are shown in Table 7.

Table 5. The values of parameters and correlation coefficients of kinetic models.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pesticide | pseudo | - first |  |  |  | pseudo-second- | | order |  |
| s | Initi | qe(exp) | qe(cal | K1 | R2 | qe(exp) | K2 | qe(cal | R2 |
|  | al | (mg/g) | c.) | h-1 |  | (mg/ | g/mg. | c.) |  |
|  | con. |  | (mg/ |  |  | g) | h | (mg/g |  |
|  | (mg |  | g) |  |  |  |  | ) |  |
|  | /L) |  |  |  |  |  |  |  |  |
| ATZ | 1 | 0.24 | 22.82 | 5.43 | 0.970 | 0.24 | 48.2 | 0.21 | 0.995 |
| N |  |  |  |  |  |  |  |  |  |
| DIA | 1 | 0.21 | 26.13 | 1.35 | 0.978 | 0.21 | 67.0 | 0.20 | 0.994 |
| DEA | 1 | 0.20 | 15.6 | 0.33 | 0.97 | 0.20 | 56.8 | 0.15 | 0.994 |
| ATO | 1 | 0.18 | 9.09 | 1.50 | 0.96 | 0.18 | 43.83 | 0.148 | 0.991 |
| H |  |  |  |  |  |  |  |  |  |
| 2,4-D | 5 | 0.90 | 3.23 | 1.14 | 0.968 | 0.90 | 8.82 | 0.77 | 0.993 |

1. Statistical Analysis

Analysis of variance (ANOVA) was done to determine means of replicate measurements are significantly differing or not (appendix Table 23-27). ANOVA explains any variation in the statistically derived model and significance of the model parameters. The model parameters, usually indicated in ANOVA are the main effects, interaction effects and error terms, and their significance in the model is represented by Fischer (F) and associated probability (p-values).

ANOVA was done by using SAS 9.1 software and the value of Fcalculated,the degrees of freedom (DF), sum of squares (SS) and mean squares (MS) were also found. A larger F, small value of coefficient variance and lower P value of a model term in ANOVA indicates good significance of the term over others i.e., if the value of Fcalculated is greater than the value of Fcritical (which is found using degree of freedom from table in the literature or book), then the means from different replicate measurements are significantly different (Sudamalla et al, 2012).

Mean results from ANOVA for all parameters (pH, contact time, dosage, initial concentration and agitation speed of all compounds (2,4-D, DIA, DEA, ATOH and ATZN) are given in appendix Table 23-27. In all pesticide, the ANOVA result indicates that the means for each parameter are not significantly different. From appendix table, ANOVA results indicates that the value of Fcalculated is less than the value of Fcnticall, for all case, therefore data are not significantly different and the replicate measurements for all compounds (2,4-D, DIA, DEA, ATOH and ATZN) have homogeneity of variance at a significance level (P > 0.05).

1. Conclusions

Fe-Zr-Mn nanocomposite was synthesized by impregnation method. The adsorption of pesticides onto nanoadsorbent was proven to be an efficient process. The amounts of pesticides adsorbed were found to vary with contact time, adsorbent dosage, pH, initial concentration, and agitation speed. The adsorption of pesticides increased with increasing adsorbent dose but decreases with increasing initial concentration of

pesticides. The maximum uptake of pesticides by nanoadsorbent occurred at a pH 4 for atrazine and its metabolites and pH 3 for 2,4-D and the optimum agitation speed for the maximum uptake for all pesticide occurred at 150 rpm. The equilibrium adsorption for atrazine and its metabolites and 2,4-D were attained at 60min. and 90min. respectively. The Langmuir and Freundlich isotherm models were used for the mathematical description of the sorption equilibrium of pesticides onto nanoadsorbent. The Langmuir isotherm model was found to provide the best fit of the experimental data in the different initial concentrations range studied.The pseudo-second-order kinetic model agrees well with the dynamical behavior for the adsorption of pesticides onto the nanoadsorbent under several different contact times.

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1. Construction of Novel Natural Pigment Sensitized Solar Cells Based on Fe2O3/ZnO Nanocomposite and Sensitizer Extracted from Tomato **(Lycopersicon esuientum)** Peel

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Abstract: A total of five nanocomposites of iron-zinc oxide with different ratios of precursor salts were prepared by co-precipitation method to use as semiconductors for dye sensitized solar cell. The method of UV- vis spectroscopy was employed to estimate bandgap energies of prepared nanopowders. A quasi-solid state photoelectochemical cell based on the five semiconductors and a natural pigment extracted from tomato peel was constructed and characterized. The current density-voltage characteristics in the dark and under white light illumination and action spectra under monochromatic illuminations were studied. The Natural pigment was extracted using ethanol and water as solvents. Absorption spectrum of the natural dye was measured and ethanol extracts of the natural sensitizer absorbs in the visible region. The following best device parameter was achieved by the ethanol extract of tomato peel and FZ3 nanocomposite semiconductor when the potential is scanned: a Voc of 540 mV, Jsc of 1.641 mAcm-2 at light intensity of 100 mWcm-2; the IPCE % obtained were 25.657% for the tomato peel sensitizers.

Keywords: Co-precipitation method; semiconductor; dye sensitized solar cell; natural pigment; conversion efficiency; nanocomposite

1. Introduction

The increasing demand for fossil fuels and the environmental impact of their use are continuing to exert pressure on an already-stretched world energy infrastructure. Significant progress has been made in the development of renewable-energy technologies, such as solar cells, fuel cells, and biofuels. Solar energy is considered to be the ultimate solution to the energy and environmental challenge as a carbon-neutral energy source (Zhang et al, 2009).

The conversion from solar energy to electricity is fulfilled by solar-cell devices based on the photovoltaic effect. Many photovoltaic devices have already been developed over the past five decades (Goetzberger et al, 2003). However, wide-spread use is still limited by two significant challenges, namely conversion efficiency and cost (Bagnall and Boreland, 2008).

Solar cell is an electricity generator that converts directly solar light to electricity. Active material comprising solar cell absorbs light, which leads to electron excitation from valence band (or ground state) to conduction band (or excited state). Electron-hole charge is separated and then collected at transparent conductive or metallic charge collector. This consecutive process is the basic working principle of solar cell (Park, 2010).

To aim at further lowering the production costs, dye-sensitized solar cells (DSSCs) based on oxide semiconductors and organic dyes or metallorganic-complex dyes have recently emerged as promising approach to efficient solar-energy conversion. The DSSCs are a photoelectrochemical system, which incorporate a porous-structured oxide film with adsorbed dye molecules as the photosensitized anode. A platinized fluorine- doped tin oxide (FTO) glass acts as the counter electrode (i.e., cathode), and a liquid electrolyte that traditionally contains I-/I3- redox couples serves as a conductor to electrically connect the two electrodes (Kroon et al, 2007).

Almost two decades ago, dye sensitized solar cells (DSSCs) were proposed as low cost alternatives to the conventional amorphous silicon solar cells (O’Regan and Gratzel, 1991), owing to the simplicity of their fabrication procedures, practically under ambient conditions with mild chemical processes. The overall efficiency of 10.4% placed DSSCs as potential inexpensive alternatives to solid state devices (Nazeeruddin et al, 2001).

For the successful commercialization of DSSCs, two important factors have to be taken into account: a) the low-cost fabrication process, which is approximately 10% of that needed for silicon solar cells, and b) device stability of at least 10 years for outdoor use (Kroon et al, 2007), which is also comparable with that of amorphous silicon. An electrochemical solar cell based on a meso-porous wide bandgap metal oxide sensitized with a dye exhibiting an efficiency of 7.1% was demonstrated by Brian O’Regan and Michael Gratzel in 1991 (O’Reganand Gratzel, 1991). And it reaches high conversion efficiency of about 12% (Agarwala et al, 2012).

Dye-sensitized TiO2 solar cells, DSSC, are a promising alternative for the development of a new generation of photovoltaic devices. DSSC are a successful combination of materials, consisting of a transparent electrode coated with a dye-sensitized mesoporous film of nanocrystalline particles of TiO2, an electrolyte containing a suitable redox- couple and a Pt or PEDOT coated counter-electrode. In general, Ru bipyridyl complexes are used as the dye sensitizers. The light-to-energy conversion performance of the cell depends on the relative energy levels of the semiconductor and dye and on the kinetics of the electron-transfer processes at the sensitized semiconductor jelectrolyte interface. The rate of these processes depends on the properties of its components (Longo and De Paoli., 2003).

One of the main merits of the DSSC over other organic photovoltaic technologies is that the photo-excited state is formed at the interface where the charge separation takes place, eliminating the need for an excitation diffusion step. But, since this charge separation interface is only a single molecule layer thick there has to be a very large surface area to ensure that most photons are being harvested by the sensitizer dye. It was this limitation which was overcome, by O’Regan and Gratzel in 1991, by introducing a meso-porous network of TiO2 particles, effectively increasing the surface area by several orders of magnitude (O’Reganand Gratzel, 1991).

As a key component of DSSCs, the nanoporous electrode shows high surface area, which enables both efficient electron injection and light harvesting. Unfortunately, the nanoporous electrode also introduces the charge recombination which mainly occurs at the electrode/electrolyte interface due to the absence of energy barrier layer (Wang et al, 2006).

Dye-sensitized solar cells based on nanoporous films of metal oxides have gained much attention as alternative approach to the silicon solar cells because of their prospect for the low cost photovoltaic energy conversion (O’Reganand Gratzel, 1991). In this contest, promising solar energy into electrical energy conversion efficiencies of more than 10% have been achieved for DSSCs based on TiO2 (Nazeeruddin et al, 2001). However, the efficiency of DSSCs constructed with other candidates of metal oxides such as ZnO, SnO2 etc., lies much more behind (Keis et al, 2002).

Dye-sensitized solar cells have extensively employed TiO2 semiconductor for efficiency development. Towards next evolution, however, design of new semiconductor material is the key for developing higher performance of DSSCs. Zinc oxide has a bandgap and energy level of the conduction band edge close to titanium dioxide (TiO2) and its electron diffusion coefficient is higher than that of TiO2. As photoelectrode, however, ZnO has such drawbacks that it is chemically unstable and is easily dissolved in the acidic and basic solutions and the amount of dye loadings is less than that on TiO2 (Sakai et al, 2011).

This study is, therefore, to evaluate and compare the cell performance of Fe2O3 semiconductor using a binary system i.e. Fe2O3/ZnOnanocomposite and natural dye extracted from tomato peel. To the knowledge of the researcher, there has been a research gap till date on the synthesis, characterization and evaluation of such semiconductors and extraction of natural pigments for dye sensitized solar cells.

1. Materials and Methods
   1. Experimental Site

Fresh tomato peel samples were collected from Haramaya University staff residence and lounge. Synthesis of the nanocomposites, preparation of the tomato peel sample and Uv-vis measurements were carried out at Chemistry Department research laboratory, Haramaya University. Fabrication and measurement of solar cell performance was carried out at Chemistry Department, Addis Ababa University.

* + 1. Chemicals and reagents

(CH3COO)2 Zn.2H2O (98%, BDH Chemicals Ltd, England) and Fe(NO3)3.9H2O (98%, BDH Chemicals Ltd, England) were used along with NH4OH (25%, Abron Chemicals) for synthesis of the nanocomposite. PEG (Aldrich) solution and ethanol (96%, Abron Chemicals) were used as solvents for the preparation of the paste (semiconductors) from the nanocomposite. Absolute ethanol (99.9%, Lab Tech Chemicals) was used for the extraction of natural pigments. Acetone (98%, Aldrich), isopropanol (96%, Riedle-de Hean) and ethanol (96%, Abron Chemicals) were used to clean the ITO glass substrates. NaI (98%, BDH Chemicals Ltd, England), iodine (Aldrich) and PVP (Aldrich) were used for the preparation of the quasi-solid electrolyte. EDOT (Aldrich) as monomer, (C2H5)4NBF4 (98%, Aldrich)and acetonitrile (98%, Aldrich) were used to coat the counter electrode with PEDOT.

* 1. Experimental procedure
     1. Synthesis of oxide nanocomposites

Synthesis of nanocomposites was performed according to the procedure developed by Singh et al, 2012 as follows: Nanocomposites of iron-zinc oxide were prepared by co­precipitation using, precurssors, iron (III) nitrate nonahydrate, Fe(NO3)3.9H2O, zinc acetate dihydrate (CH3COO)2 Zn.2H2O by varying the content of zinc and using iron as host. Ammonium hydroxide, NH4OH, was used for precipitation and ethyl alcohol was employed to wash the precipitate. For this synthesis, appropriate amount of (CH3COO)2 Zn.2H2O and Fe(NO3)3.9H2O was used as a salt precursors, starting with the pure iron oxide at one end and terminating at pure zinc oxide at the other end. Aqueous solutions of precursor salts were mixed and stirred for 30 minutes along with slow addition of NH4OH solution till pH was raised to 7 at which precipitation occurs. Stirring was continued for another 30 minutes, after which the precipitate was aged for 24 hrs, after drying for 1 hr at 80oC the content was vacuum filtered and the precipitate was calcined in three stages: Stage I: 30 min at 250oC, stage II: 30 min at 600oC and stage III: 1 hr at 800oC, step calcining was aimed to avoid thermal shock to samples. The resulted powders were subjected to UV-Vis spectrophotometer characterization. The as synthesized samples were designated as shown in Table 1.

Table 1. Designation of the as-synthesized powders.

|  |  |  |
| --- | --- | --- |
|  | Sample Name | Experimental Condition |
| FZ1 |  | 100% Fe |
| FZ2 |  | 90% Fe and 10% Zn, |
| FZ3 |  | 80% Fe and 20% Zn |
| FZ4 |  | 70% Fe and 30% Zn |
| FZ4 |  | 60% Fe and 40% Zn |

* + 1. Sample collection and preparation

Fresh tomato peel was collected (Figure 1). The collected peel was dried at room temperature in a shade to prevent pigment degradation. After drying for about 2

months the sample was crushed with Micro Plant Grinding machine to produce the powder of the respective plant material.



Figure 1. Fresh flower samples.

* + 1. Extraction of natural pigment

The dye extraction from the powder was performed as follows: 2g of powder sample was taken and soaked in 50mL of ethanol for extracting using ethanol. The same amount of powder was soaked in 50mL water for extracting with water in separate bottle. The solution was stored at room temperature for about 6 hours to dissolve the powder completely. Then the solution was filtered with glass filter to separate the solid from the pure liquid (Figure 2). Optical absorption of each extracts was measured by taking small amounts of the filtered samples. The following spectra were obtained and observed that the ethanol extract of the tomato peel shows a distinct peak at the visible region this in turn assures it’s a best to use as a low cost sensitizer during the construction and characterization of the solar cells.



Figure 2. Samples of extracted natural pigments.

* + 1. Characterization

For the estimation of absorption edge of the as synthesized powders, UV — vis absorption was measured using SANYO, SP65 spectrophotometer at Haramaya University research laboratory, scanning over 200-800 nm.

* + 1. Construction of dye sensitized solar cells

The method that was employed for the fabrication of dye-sensitized solar cells based on Fe2O3/ZnO nanocomposite involves the following steps:

* + - 1. Preparation of the substrate for deposition

TCO glass substrates were thoroughly cleaned before film deposition. The glass cleaning protocol was first cleaned with acetone then with isopropanol finally with ethanol. In all case the cleaning process was done in ultrasonic bath for about 20 minutes in each solvent.

1. Fe2O3/ZnO paste preparation

For paste preparation, 30mg of a dispersing agent, polyethylene glycol (PEG) and 10ml of distilled water were mixed. Next, 1.8 g of Fe2O3/ZnO powder was continuously grounded by using porcelain mortar to break down the aggregated particle. Then, 2ml of the PEG solution was slowly added to the powder and completely mixed by using the mortar. Finally the paste was ready for deposition. The same procedure was used to prepare the pastes for Fe2O3 semiconductor.

2.2.53. Deposition of Fe2O3/ZnO films

The simplest and most widely used method for depositing Fe2O3 paste on a substrate is the so-called doctor-blade method. It uses a hard squeegee, or doctor blade, to spread a portion of nanoparticle paste onto the glass.

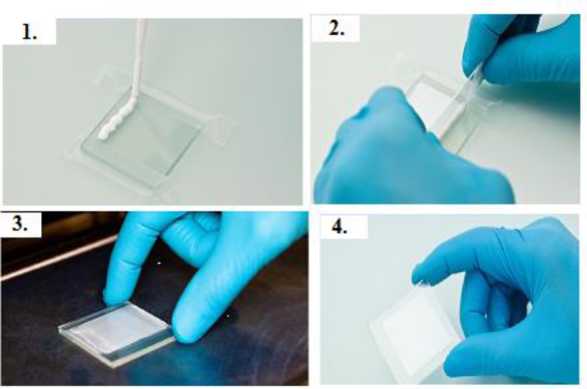


Figure 3. Deposition of paste.

With the conductive side facing up, four parallel strips of tape on the edges of the glass plate were applied, covering small portion of glass. After making the paste ready for deposition the portion of paste was applied near the top edge of the TCO glass between the two pieces of tape with the help of a glass rod, then, the paste spread across the plate with the support of the tape on all sides.

The preparation of electrode was completed by firing the deposited layer. The organic solvent burns away, leaving the Fe2O3 nanoparticles sintered together. This process ensures electrical contact between particles and good adhesion to the TCO glass substrate. Sintering was performed in furnace at 400oC (Figure 3).

2.2.5.4. Electrode sensitization

Natural dyes were used for electrode sensitization. Before immersion in the dye solution, films were warmed up to higher temperature (80oC) to minimize the water vapour content inside the porous of the semiconductor electrode. The sensitization was performed at room temperature. The best method of adsorbing a natural sensitizer to the oxide layer is by dipping the electrode in a solution of the dye already prepared. After sensitization, the films were rinsed in the same solvent (ethanol) as employed in the dye solution.

1. Preparation ofquasi - solid state electrolyte

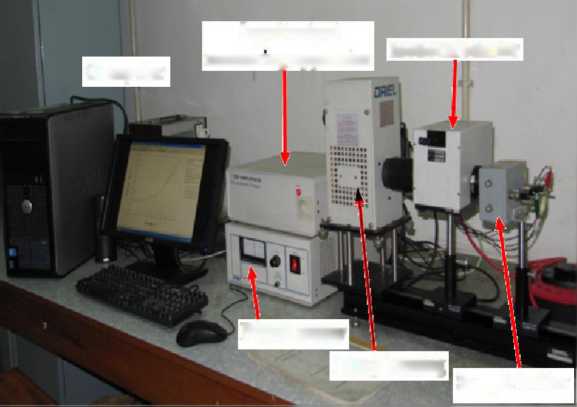
The polymer gel electrolyte was prepared according to the method described below:

0.9 M of 1-ethylene-3-methyl immidazolium iodide was added into acetonitrile under stirring to form a homogeneous liquid electrolyte. In order to obtain a better conductivity, 0.5 M of sodium iodide was dissolved in the above homogeneous liquid electrolyte, and then 0.12 M iodine and 35% (w/w) of PVP were added. Then, the resulting mixture was heated at 70 — 80oC under vigorous stirring to dissolve the PVP polymer, followed by cooling down to room temperature to form a gel electrolyte.

1. Coating counter electrodes

A CHI630 Electrochemical Analyzer and a three-electrode electrochemical cell were used for polymerization of EDOT. The poly (3, 4 - ethylenedioxythiophene) (PEDOT) film for the counter electrode was formed by electrochemical polymerization of 3, 4- ethylenedioxythiophene (EDOT), in a three electrode one-compartment electrochemical cell. The electrochemical cell consisted of a pre cleaned ITO-coated glass working electrode, platinum foil counter electrode and quasi-Ag/AgCl reference electrode dipped in (C2H)4NBF4 acetonitrile solution. The solution used for the polymerization contained 0.1 M EDOT and 0.1 M (C2H)4NBF4 in acetonitrile. The monomer was used as received. The polymerization was carried out potentiostatically at +1.8 V for 20 seconds. At this potential, the electrode surface becomes covered with blue-doped PEDOT film. Then the film was rinsed with acetonitrile and was dried in air (Figure 4).

1. Assembly of DSSCs for characterization



Device assembly is the final step for characteristics measurement. Here the sensitized electrode was washed by the solvent of the dye followed by ethanol and dried using hair dryer to dry the electrode, and then the uncovered part of the film by the paste was covered by a tape spacer in all side by leaving some place for electrical contact. By facing the active sides of the photoanode and the cathode, the two electrodes were pressed together after putting the quasi - solid electrolyte on the photoanode. Then the devices were ready for characterization (Figure 4).

Input/output

**Computer**

measuring apparatus

Monochromator

Power supply

**Lamp housing**

**Sample**

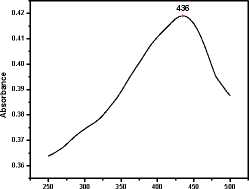
**holder**

Figure 4. Experimental set-up for photoelectrochemical characterization.

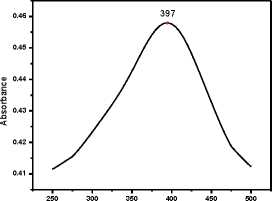
1. Results and Discussion
   1. Characterization of the as-synthesized Powders
      1. UV-Vis absorption spectra analysis

The optical absorption spectra of as-synthesized were determined using UV-Vis spectrophotometer. UV-Vis absorption spectra for the selected as- synthesized powders are shown in the following figures.

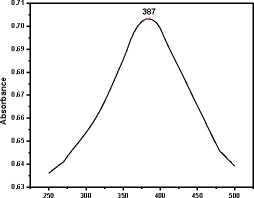
Figure 5. Absorption spectrum of FZ1. Figure 6 Absorption spectrum of FZ2.



Wavelength (nm)

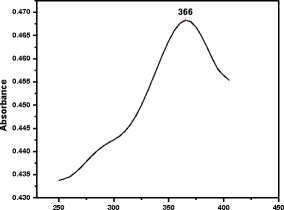


Wavelength (nm)



Wavelength (nm)

**Figure 7. Absorption spectrum of FZ3.**



Wavelength (nm)

**Figure 8. Absorption spectrum of FZ4.**

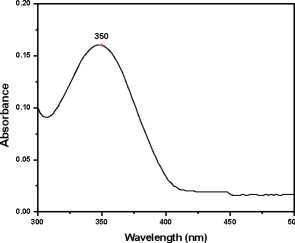


Figure 9. Absorption spectrum of FZ5.

As evident from Figures 5-9 the absorption edges of the binary oxides of FZ2 — FZ5 shifted remarkably to the UV range relative to the pure Fe2O3. This shift depends on the amount of ZnO incorporated. The observed absorptions were not attributed to the Fe2O3 or ZnO bandgap absorption but rather to the additional sub bandgap absorptions.These sub bandgap absorption may arise from surface states of the ZnO- Fe2O3 materials. The surface states are surface localized electronic states within the material bandgap, involving complex species such as dangling bonds, defects and atoms adsorbed on the surface (Laxmi and Chakrabarty, 2013).

Band gap energy (Eg) of the as-synthesized powders were calculated using Equation (11) (El-Kemary et al, 2010).

**1240 el**

(11)

"HI

Where, Eg is bandgap energy in electron volts and Xmix is wavelength (nm) corresponding to absorption edge.

Table 2. Maximum wavelength and energy bandgap of the as-synthesized nanocomposites

|  |  |  |
| --- | --- | --- |
| Samples | Maximum  wavelength (nm) | Bandgap (Eg) (eV) |
| FZ1 | 436 | 2.84 |
| FZ2 | 397 | 3.12 |
| FZ3 | 387 | 3.20 |
| FZ4 | 366 | 3.39 |
| FZ5 | 350 | 3.54 |

Critical comparison of the results in Table 2 depicts that the values obtained for the samples having Zn in their composition are remarkably large. The bandgap of pure Fe2O3 and ZnO were 2.1 eV and 3.2 eV, respectively whereas the calculated bandgap of Fe2O3-ZnO mixed oxide varies from 2.84 eV to 3.54 eV. The energy level of Fe2O3 both for the valance band and conduction band correspond well within bandgap of ZnO. When the electrons are excited, most of the electron from the conduction band of ZnO can easily transfer to the conduction band of Fe2O3 this accounts for the reason why the bandgap decreased while we observe from the highest ratio (FZ5) of the Zn to the lowest (FZ2).

1. Optical Absorption Measurements of the Natural Dyes

The absorption spectra of the extracted natural dyes were measured by UV-vis spectrophotometer.

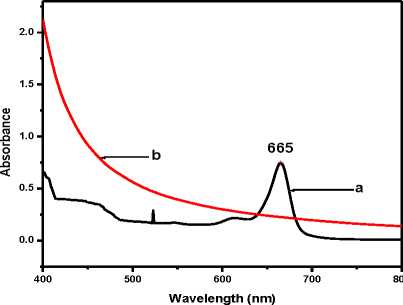
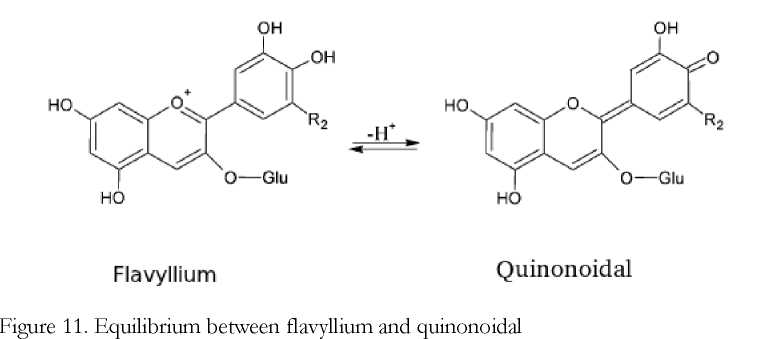


Figure 10. Absorption spectra of Tomato (Lycopersicon esuientum) Peel extracted with a) ethanol b) water.

The ethanol extracts of the natural pigments exhibit an absorption peak of about 666nm. These absorption peaks indicated that chlorophyll are present, a group of natural photosynthetic component. As shown in Figure 10, water extract of tomato peel doesn’t show any absorption peak, this does not mean that there is no associated pigment. This could be explained based on the fact that the anthocyanin exists in two forms (flavylium cation and quinonoidal), when the quinonoidal forms (Figure 11) are dominant the pigment did not show absorption maxima.



When this sample is acidified an absorption band which is a typical characteristics of anthocyanins starts to be observed due to the shift in equilibrium from quinonoidal to flavylium form. In this pigment, the aqueous environment, available in large quantity, adds to the flavyllium form at pH values above 1.5 - 2.0, resulting in a loss of color owing to the formation of the colorless pigment through a slow acid-base equilibrium. This loss of color can be reversed by a simple re-acidification with complete recovery of the colored flavyllium cation. So that for the water extract of all the flowers the quinonoidal form of the anthocyanin is present in larger amount than the flavyilum

cation form. Therefore, the colorless quinonoidal form of the anthocyanin is largely present in the water extract of all flowers compared to the flavyllium cation form, hence could not show absorption peak for the qualification of the associated pigments.

* 1. Current density-voltage characteristics

The current density-voltage characteristics of DSSCs constructed based on the five semiconductors sensitized with tomato peel pigment are shown in Figure 12. The device based on FZ3 showed relatively higher current density than the others. This may be attributed to the high surface area and stability of the semiconductor in dye solution.

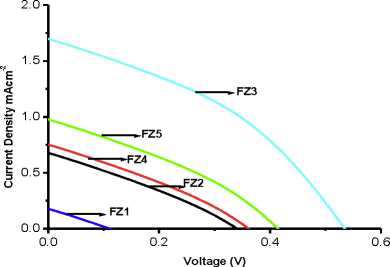


Figure 12. The J-V characteristics of ethanol extracted tomato peel dye based on of FZ1, FZ2, FZ3, FZ4 and FZ5.

Table 3. Photovoltaic performance of DSSCs based on of FZ1, FZ2, FZ3, FZ4 and FZ5 sensitized with ethanol extracted tomato peel dye.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sensitizer | Semiconductor | Jsc (mA.cm-2) | Voc (V) | FF % | n |
|  | FZ1 | 0.201 | 0.11 | 27.31 | 0.0061 |
| N719 | FZ2 | 0.6936 | 0.34 | 30.70 | 0.007 |
|  | FZ3 | 1.7738 | 0.59 | 39.14 | 0.401 |
|  | FZ4 | 0.6814 | 0.35 | 34.65 | 0.082 |
|  | FZ5 | 0.9981 | 0.44 | 36.38 | 0.160 |

Critical comparison of the values in the Table 3 shows that conversion efficiency of the as-synthesized semiconductors is in the order of FZ1 < FZ2 < FZ4 < FZ5<FZ3.

1. Photocurrent Action Spectra

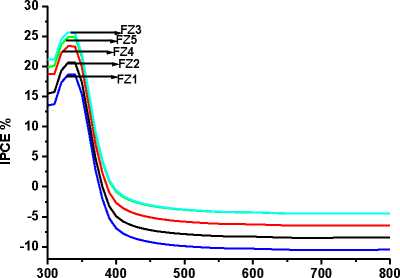
The incident monochromatic photon to current conversion efficiency (IPCE) defined as the number of electrons generated by light in the external circuit divided by the number of incident photons at each wavelength was also studied.

**IPCE%**

**\_ 1240kJec [uA.cm--;**

**A- [nm]xl L n [W. m — 2 ]**

Photoaction spectra provided further insights on the photoelectrochemical behavior of sensitizers. The following Figure (Figure 13) shows the incident photon to current conversion efficiency (IPCE) spectra of FZ1, FZ2, FZ3, FZ4 and FZ5 semiconductors sensitized with tomato peel pigment as a function of wavelength.



Wavelength (nm)

Figure 13. Photocurrent action spectra of based on FZ1, FZ2, FZ3, FZ4 and FZ5 sensitized with ethanol extracted of tomato peel dye.

Critical observations of the photocurrent action spectra above the tomato peel natural pigment show very low sensitization and conversion behavior at the visible region. This may attributed to the low adsorption capacity of Iron Oxide based semiconductors which in turn results in low concentration of the natural pigments adsorbed on the surface of the films.

1. Conclusion

In this study, a new semiconductor using Fe2O3-ZnOnanocomposite was synthesized, characterized and its property as semiconductor for DSSC was studied in DSSCs. Natural pigments were also extracted from peel of tomato to use as sensitizer pigment for DSSCs constructed based on the new semiconductors. For the natural pigment extracted from tomato peel best conversion efficiency and IPCE percentage of Salvia was obtained from the devices constructed based on the binary oxide (FZ3) semiconductor. The obtained conversion efficiencies for the ethanol extracts of tomato peelwas 0.401%. Though the performances of DSSCs under the present experimental conditions were low, the results indicated that it is possible to use Fe2O3- ZnOnanocomposite semiconductor for DSSCs which is sensitized by pigments extracted from tomato peel.

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1. Landfill Site Suitability Evaluation for Harar City, Eastern Ethiopia

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Abstract: Solid waste dumping is a serious problem in urban areas as most solid wastes are not dumped in the suitable areas. Similar situation is observed in Harar town. The objective of this study was, therefore, to select potential suitable sites for solid waste dumping for the city ofHarar.

The study involves multi criteria evaluation method of weighted linear combination using GIS as a practical instrument to evaluate the suitability of landfill in the city. For the purpose of making decisions in landfill site selection, a hierarchy structural was formed and different parameters have been identified, including slope, distance from water body, developed areas, sensitive areas, and roads and land use land cover. Initially, the rating method was used to evaluate each criterion individually. Then, the relative importance of criteria to each other was determined by an analytic hierarchy process. Simple Additive Weighting method was applied to evaluate the overall suitability. The result showed that 16.7% of the study area is highly suitable, 20.5% is moderately suitable and 33.2% and29.6% ,respectively were least suitable and unsuitable for the purpose. Five candidate sites were identified and with more field investigation, one best suitable site was selected.

Keywords: Analytic Hierarchy Process; Geographic Information System; Landfill; Multi criteria evaluation; Remote Sensing.

1. Introduction

In developing countries, the ever increasing human population and the associated anthropogenic activities have accelerated the phenomenon of urbanization. As a result, there has been an enormous increase in the quantity and diversity of the solid waste being generated (Kabte, 2011). The problem of solid waste has assumed significant dimension especially in the urban centers. In urban centers throughout African regions, less than half of the solid waste produced is collected, and 95 percent of that amount is either indiscriminately thrown away at various dumping sites on the periphery of urban centers, or at a number of so-called temporary sites, typically empty lots scattered throughout the city. Domestic, industrial and other wastes, whether these are of low or medium level, have become a perennial problem as they continue to cause environmental pollution and degradation. Khan and Ranjan (2014) described that generation of solid waste has become an increasing environmental and public health problem everywhere in the world, particularly in developing countries. Fast expansion of urban, agricultural and industrial activities spurred by rapid population growthhas produced vast amounts of solid and liquid wastes that pollute the environment.

According to Kumel (2014), the insufficient handling of solid waste represents a source of water, land and air pollution affecting the urban environment and the health of the people living in the cities and is one of the most critical environmental problems that cities in Africa are facing today. Therefore, solid waste management is becoming a major public health and environmental concern in urban areas of many African countries like in Ethiopia.For sustainable environmental and public health protection, solid waste should be disposed in environmentally sound and socially acceptable sites.

The population of Harar is growing due to both natural increase and immigration of people from rural areas to the town (PEDB, 2006). This increases household by products. Moreover, in the last decade, different development activities, such as construction and service deliveries, have also been growing. As a consequence of population growth and development activities, high amounts of household and other external solid wastes are generated. It is a very common distributed here and there in the outskirts of Harar. High rate of wastes are facing problem of their disposal and have very high potential effect to pollute environment such as land and air. Public health is also highly affected by the uncontrolled solid waste generation and disposal. The solid waste disposal system should be in an environmentally sound and socially acceptable way so as to protect the environment and safeguard public health (Adefris, 2015). However, the traditional and manual method used to select suitable landfill site is time consuming and costly. Therefore, it is necessary to select solid waste landfill sites for the town by considering ecological, environmental and social factors so as to manage solid wastes in an environmentally sound manner. Choudhury (2012) described that GIS and remote sensing techniques provide appropriate information about geographic data to assist in selecting potential solid waste disposal site using different factors. GIS is capable of integrating geospatial data from different sources and thus helps decision makers in environmental and public health protection.

The general objective of this study was to evaluate and model suitable landfill sites using Remote Sensing (RS) and GIS.The specific objectives were (a) to study land use/land cover of Harar town from solid waste landfill suitability angle, (b) to examine factors that are necessary for selecting landfill and for preparing suitability maps.

1. Research Methods
   1. Description of the Study Area
      1. Location of the Study Area

Harari People's National Regional State is one of the nine Regions in the country and is located in the eastern part of the country. Astronomically, it is located between 90 11’ 49” North Latitude and 420 03' 30’’ and 420 16’ 24’’ East Longitude. According to the Harari Planning and Economic Development Bureau (2000), the region has an area of about 343.2 sq.km in which the rural area constitutes 323.7sq.km while the urban area has about 19.1 sq. km. Administratively, the region is divided into nine administrative

Woredas- three rural kebeles and six urban local administrations. The region shares common boundaries with Eastern zone of OromiaWoreda, Jarsso in the North and Babile in the East; Fedis in the South and HaramayaWoreda in the West.Hararis the capital of Harari people’s regional state; which is located in East at a distance of 525 km from Addis Ababa. The elevation above sea level of the city varies from 1600 to 1900 masl.

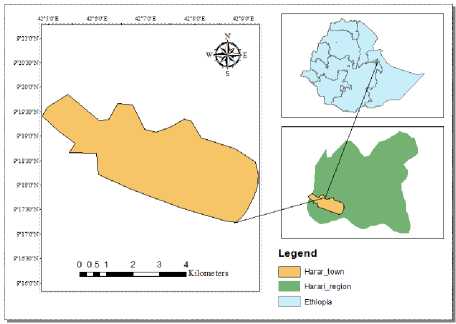


Figure 18. Map of the Study area.

Source: CSA, 2007.

* + 1. Climate

In Harari region the mean annual temperature varies from 100C in high lands and 260C in low lands. Generally, the temperate of the region has a little variation among seasons, as the metrological data of 1997—2000 E.C indicates. The mean annual maximum temperature of the region ranges from 280C in high land and 220C in the low lands. The mean annual minimum temperature is 100C in high lands and 150C in low lands. The precipitation of the Region is recorded as a mean monthly rainfall of 67.1mm and mean annual rainfall of 804.7 mm. The coldest months are November, December and January. The duration and intensity of rainfall in the region vary considerably. Generally, it decreases from west and North West to south east wards. The last four years record of rainfall showsvariation that ranges from 700m.m in the south east and over 900m.m in the western part of the region. On the other hand, the highest amount is recorded in Dire Tayarakebele and the lowest amount is recorded in Ererkebele. Regarding reliability of rain fall for crop production and duration of growing periods, the pattern of rainfall in the region is treated in three seasons, i.e., Kiremt, Bega and Belg. However, in each of the seasons the rain may begin earlier and lasts before the usual time.

* + 1. Topography

The altitude of the Region ranges from 1300 m.a.s.l. in Kille peasant association in Erer Valley to 2200 m.a.s.l. in Hakim Mountain. Large part of the Region’s topography is covered by an altitude which ranges from 1800 to 2000 m.a.s.l.

* + 1. Soil

The major soil types which occur in the Harari region are Nitisols, Luvisols, Arnosols, and Aerosols. Nitisols (distinguished by their shiny pad surface) occupy 2792.5 hectare and luvisols (soils which has a cat ion exchange capacity equal to or greater than 24 mol clay) occupy 2440 hectare.Regosols (medium and fine textured) occupy 6,017.5 hectare and Aerosols (coarse textured with weak pedogenetic characteristics in the B horizon) occupy 4575 hectare. The wet land found in eastern boundary of the region following the Erer river occupy about 487.5 hectare which is poorly drained and partially used locally for sugar cane production. The ridge tops which are marginal for arable agriculture occupy about 815 hectare (Hakim gara).

* + 1. Drainage basin

The drainage system of the region can be classified into Hamaressa basin, Bisidimo basin and Erer basin. The drainage system of the Region falls under Wabi-Shebele basin. These three major rivers (Hamaresa, Bisidimo and Erer rivers) together with streams flow to Wabe Shebelle River in Somali Region.

* + 1. Demographic and socio-economic characteristics

Harari peoples regional state has a population of 183,344 of which 92,258 are male and 91,023 are female (CSA, 2007). The size of urban dwellers are 99,321 and 84,023 are rural. The growth rate according to (CSA, 2007 report) is 2.6 percent. In terms of age distribution, about 37.2% are under 15 years old, 58.8% 16—60 years, 4% above 60 years. The region has an estimated density of 534 people per square kilometer. For the entire region, 46,815 households were counted, which results in an average for the region of 3.9 % persons to a household, with urban households, having an average 3.4 and rural household 4.6 people.

2.2 Data Collection

1. Data sources

Collecting accurate and reliable data is the most determinant factor as it determines the quality of the research. The first step was to identify the environmental, social, and economic variables to be considered for siting landfills followed by setting criterion based on international and local rules. Accordingly, the necessary data were collected from different sources.

Table.6. Data sources.

|  |  |  |  |
| --- | --- | --- | --- |
| No | Type | Description | Source |
| 1 | Maps | Aerial photo | EMA(Ethiopian mapping Agency) |
|  |  | Topographic Map (1:50,000) | EMA |
|  |  | Digital Soil Map | Ministry of Water and Energy |
|  |  | City shape file data | CSA, |
|  |  | Harar cadaster | Harar municipality |
| 2 | Row data | Borehole data | HWASA |
|  |  | ETM+ images and SPOT5 | USGS and vendors |
|  |  | SRTM (20\*20m resolution) | USGS |
| 3 | Equipment | GPS and Digital Camera | Market/rent |

1. Interview, meeting and discussion

One of the primary data collection activities were accomplished using a survey questionnaire. The discussions were held with urban planning experts. Direct and indirect unstructured interviews were conducted with the experts during the field surveys to gather more information .The information derived from this study was used to identify and develop priority criteria and factors for the selection of landfill site. It was also used to identify problem in the study area and prioritize the potential landfill sites.

2.3. Data Analysis

Solid waste landfill site selection is complex and costly process which needs to consider many conflicting criteria (Basak, 2004). GIS based multi criteria evaluation methodology was used to combine land use/land cover, slopes, elevation, proximity from road, sensitive sites, and water body as landfill siting factors. All the factors were internally classified into four classes (highly suitable, moderate suitable, less suitable and Unsuitable) with values ranging from1 to 4. Higher value 4 was given to the most suitable and value 1 to the least suitable for all factors considered. Weights for each class of criteria were derived in IDRISI software using AHP methods.

1. GIS-based-multi criteria evaluation methodology

GIS-based multi-criteria decision analysis involves the utilization of geographical data, the decision maker’s preferences and the combination of the data and preferences according to specified decision rules (Malczewski, 2006). Multi-criteria approaches have the potential to reduce the costs and time involved in siting landfills by narrowing down the potential choices based on predefined criteria and weights (Issa^ al, 2012). Weighted Linear Combination and Analytic Hierarchy Processes (AHP) are the two most known Multi-Criteria Analysis methods that were used for this study.

1. Analytic hierarchy processes (AHP)

The Analytic Hierarchy Process is a decision making method for prioritizing alternatives when multiple criteria must be considered. It is a powerful and flexible decision-making process to help people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered. It provides a hierarchical structure by reducing multiple variable decisions into a series of pair comparisons and develops subjective priorities based upon user judgment (Kubde, 2012). AHP was used in this study to derive weights for each criterion.

Table 7. The rating scale method (Saaty, 2008).

|  |  |
| --- | --- |
| Intensity of importance | Definition |
| 1 | Equal importance |
| 2 | Equal to moderately importance |
| 3 | Moderate importance |
| 4 | Moderate to strong importance |
| 5 | Strong importance |
| 6 | Strong to very strong importance |
| 7 | Very strong importance |
| 8 | Very to extremely strong importance |
| 9 | Extreme importance |

Table 3. Factor values and their weights based on Saaty (2008)and expert opinion.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Factor | Class | Rate | Weight | Level of suitability | Influenc  e (%) |
| Slope | <10 | 4 | 0.4700 | Highly suitable | 0.1 |
|  | 10-15 | 3 | 0.2599 | Moderate Suitable |  |
|  | 15-30 | 2 | 0.1983 | Less suitable |  |
|  | >30 | 1 | 0.0718 | Unsuitable |  |
| Elevation | <1800 | 4 | 0.0718 | Unsuitable | 0.07 |
|  | 1800-1850 | 3 | 0.1983 | Less suitable |  |
|  | 1850-1900 | 2 | 0.2599 | Moderate Suitable |  |
|  | 1900-2000 | 1 | 0.4700 | Highly suitable |  |
| Distance to | 100-700 | 1 | 0.0718 | Unsuitable | 0.15 |
| road | 700-15000 | 2 | 0.1983 | Less suitable |  |
|  | 1500-2000 | 3 | 0.2599 | Moderate Suitable |  |
|  | >2000 | 4 | 0.4700 | Highly suitable |  |
| Distance to | 0-1000 | 1 | 0.0718 | Unsuitable | 0.05 |
| water body | 1000-1500 | 2 | 0.1983 | Less suitable |  |
|  | 1500-2000 | 3 | 0.2599 | Moderate Suitable |  |
|  | >2000 | 4 | 0.4700 | Highly suitable |  |
| Distance to | 0-1000 | 1 | 0.0718 | Unsuitable | 0.16.94 |
| sensitive | 1000-2000 | 2 | 0.1983 | Less suitable |  |
| area | 2000-3000 | 3 | 0.2599 | Moderate Suitable |  |
|  | >3000 | 4 | 0.4700 | Highly suitable |  |
| Land | Developed | 1 | 0.0718 | Unsuitable | 0.275 |
| use/cover | area |  |  |  |  |
|  | Agricultural/F | 2 | 0.1983 | Less suitable |  |

* 1. Developing Criterion Maps

|  |  |  |
| --- | --- | --- |
|  | orest  Bush/Grass | 3 |
|  | land  Bare/open | 4 |
| Distance to | land 0-500 m | 1 |
| developed | 500-1000 m | 2 |
| area | 1000-1500 m | 3 |
|  | >2000 m | 4 |

|  |  |
| --- | --- |
| 0.2599 | Moderate Suitable |
| 0.4700 | Highly suitable |
| 0.0718 | Unsuitable |
| 0.1983 | Less suitable |
| 0.2599 | Medium suitable |
| 0.4700 | Highly suitable |

* + 1. Suitability analysis to developed area

The factor of the developed areas includes residential areas, government buildings, schools, hospitals and other types of build up areas and associated infrastructure in the study area.

Table 4. Reclassified distance from developed area.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Distance from  developed  area(m) | Level of suitability | Rate | Weight | Area  (ha) | Percent of the total area (%) |
| 0-500 | Unsuitable | 1 | 0.0718 | 1650 | 30 |
| 500-1000 | Less suitable | 2 | 0.1983 | 1100 | 20 |
| 1000-1500 | Medium suitable | 3 | 0.2599 | 1650 | 30 |
| >2000 | Highly suitable | 4 | 0.4700 | 1100 | 20 |

In relation to developed area, Wangg et al (2009), suggested that a minimum distance of 1km from the landfill site is necessary for the flow of wastes to and from the site and the developed areas. Areas that are selected for such purpose must be at an optimum distance from the developed areas. Very near places are disregarded as this may pollute the developed areas. Very far areas are also not recommended as it incurs cost of distance. As described above in table (4), areas that lie 3 km away from the developed areas are at optimum distance.

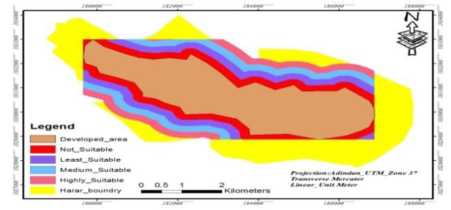


Figure 19. Suitability distance from developed areaSource: Researchers.

* + 1. Slope suitability

Slope refers to the measures of the rate of change of elevation at a surface location and normally expressed in percent or degree slope. Slope is one of the key criteria to be considered in landfill site selection. This is because site topography can reduce or increase adverse effects of landfill on the environment. Flat land and depression topography are not recommended for landfill due to water logging problem and downstream surface and ground water pollution. Moreover, steep slope is not best option for solid disposal because of the difficulty posed in construction or leveling. In addition, high topography areas reduce the stability of the side slopes and increase leachate movement. Therefore, the best slope for solid landfill should be modest slopes, which enable easier leachate control and site stability measures. Different researchers set different slope criteria for landfill site selection. Kirimiet al (2012) considered lower slopes more highly suitable than the land with higher slope. As indicated in the table below, areas which are with slopes >30% were excluded as it is unsuitable for landfill and the rest of the slope classes were ranked from very highly suitable to low suitable.

Table 5. Slope ranges.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Slope  (%) | Level of suitability | Rate | Weight | Area(he) | Percent of total area (%) |
| <10 | Highly suitable | 4 | 0.4700 | 2200 | 40 |
| 10-15 | Moderate suitable | 3 | 0.2599 | 1650 | 30 |
| 15-20 | Less suitable | 2 | 0.1983 | 550 | 10 |
| >30 | Unsuitable | 1 | 0.0718 | 1375 | 25 |

As can be seen from the above table <10% slope was ranked in the first place. Areas with 8-15% slope were the second option for landfill while 15-20% slope class was ranked as the third option. This is because as steepness increases, operation will be difficult and construction cost will be increased. Therefore, <10% slope class was used as very highly suitable for landfill while slope >30% is unsuitable. In the figure shown below areas represented by the blue color are highly suitable for putting landfills as they are relatively flat lands.

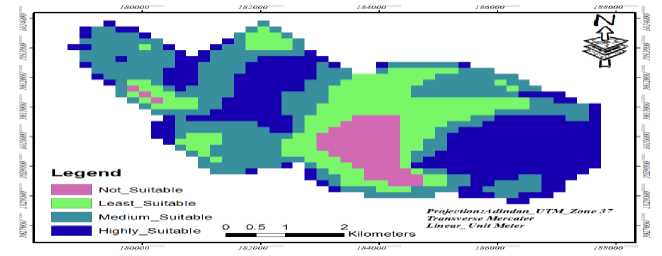


Figure.20. Reclassified slope map. Source: Researchers.

* + 1. Suitability distance to road proximity

The road network map delineating the major roads in the city were digitized from SPOT5 (Satellite Pour observation de la Terre) for Satellite for observation of Earth image. Proximity from roads is one of the criteria that should be considered from economic and social point of views during solid waste landfill site selection processes. This is because siting landfill very close to roads may have public health problem as landfill pose hazardous effect to health. Moreover, landfill site very far from road network is also not recommended due to high transportation cost. Minimum and maximum distance from road network of the study area was set after summarizing different literatures. Chang et al. (2007) used 500-700 m buffer from road as a minimum distance within which landfill should not be located.

Table 6. Reclassfied distance to road.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Distance from road(m) | Level of Suitability | Rate | Weight | Area(ha) | Percent of total area |
| 500-700 | Unsuitable | 1 | 0.0718 | 1925 | 35 |
| 700-15000 | Less suitable | 2 | 0.1983 | 1133 | 20.6 |
| 1500-2000 | Moderate suitable | 3 | 0.2599 | 737 | 13.4 |
| >2000 | Highly Suitable | 4 | 0.4700 | 1683 | 30.6 |

As can be seen from the above table areas within 2km away from roads were analyzed as best site for landfill.

Therefore, Euclidian distance was used to create buffer classes around the roads with 500-700m, 700-1500m, 1500m-2000, 2000-3000m, distance ranges. Then they were classified using classify tools in four classes of suitability of highly, moderate, least and unsuitable. See figure below.

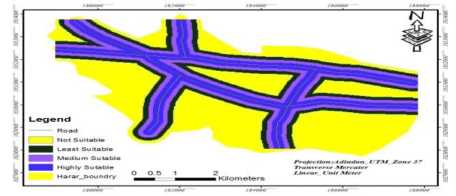


Figure 21. Reclassified road network map. Source: Researchers.

* + 1. Proximity distance from water body

To protect surface water from pollution, landfill should not be located near streams and rivers. To minimize pollution, different researchers set minimum buffer distance for landfill site selection. For example, Owoeyeet al. (2015) used 400m buffer distance. Accordingly, Multiple Ring Buffer from Analysis Tools was used to prepare multiple polygons around each streams and rivers within the following distances given in the table below. As can be observed from table (7) and figure (5) more weight was given to areas beyond 2000m based on experts opinion. To minimize the effect of landfill leachate on surface water pollution, 0-500 m buffer area were excluded from siting process.

Table 7. Reclassified distance from water body.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Distance from  water body | Level of  suitability | Rate | Weight | Area(he) | Percent of total area (%) |
| 0-500 | Unsuitable | 1 | 0.0718 | 2200 | 40 |
| 500-100 | Less suitable | 2 | 0.1983 | 1100 | 20 |
| 1500-2000 | Moderate  suitable | 3 | 0.2599 | 1375 | 25 |
| >2000 | Highly Suitable | 4 | 0.4700 | 825 | 15 |

The proximity map was standardized and reclassified into four classes. Weights were calculated for the classes based on their preference using AHP modular in IDRISI software. Accordingly, more weight was assigned for more suitable areas (0.4700) while least weight (0.0718) was given to areas in the vicinity of the rivers and streams (the gray color in the figure below shows areas with high suitability). Generally, weights and suitability level increases with distance from surface water.

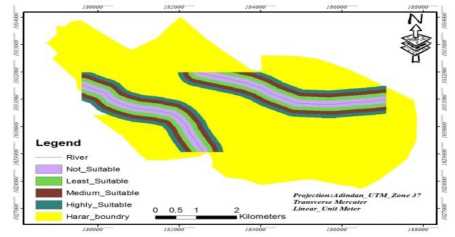


Figure 22. Reclassified distance to water body. Source: Researchers.

* + 1. Land use /land cover analysis

The land use/cover map displays the land utilized by the human and the natural cover in the study area. It is the basic map of the study which helps to generate many thematic maps required for overlay analysis.

Land use/land cover should also be considered as one of landfill site selection criteria. This is due to the fact that, adjacent landfill may affect land use/land cover of the area and lower economic values of the land. Therefore, current land use/land cover of the study area should be studied and high value land must be excluded from landfill siting. According to MoeinaddinL/ al. (2010),a site with potential for higher value uses such as nature conservation, agriculture and residential development should not be used for

landfill. Hence, areas with low economic advantages for people should be considered for landfill.

LANDSAT ETM+ of recent time and cadaster images were used to produce the current land use/land cover of the study area. Images used to identify main land use types were processed, and classified using Erdas Imagine2014.Preprocessing techniques such as spatial, radiometric, and spectral enhancements were done using interpreter module of Erdas imagine. Then supervised classification was done to identify the available land use/land cover.

Table 8.Classified land use/cover.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Land use/cover | Level of  Suitability | Value | Weight | Area(ha) | Percent of  total area |
| Developed area | Unsuitable | 1 | 0.0718 | 2073.5 | 37.7 |
| Agricultural/Forest | Less suitable | 2 | 0.1983 | 1463 | 26.6 |
| Bush/Grass land | Moderate suitable | 3 | 0.2599 | 1122 | 20.4 |
| Open/bare land | Highly Suitable | 4 | 0.4700 | 841.5 | 15.3 |

Major land cover classes were developed areas, agricultural/forest fields, bare/open land etc. Hence, the highest value was given for suitable land class types to waste disposal site selection. In addition landfill should not be sited in built up areas and forestlands as they are high value lands and thus excluded from siting processes. The land which is covered by bare and grass lands account for about 23.9% from the total area. The open/bare lands indicated by the yellow color were the most suitable area for solid waste dumping site. Then, land use/land cover of the study area was reclassified into four classes of unsuitable, least suitable, marginally suitable and highly suitable levels as depicted in the following figure.

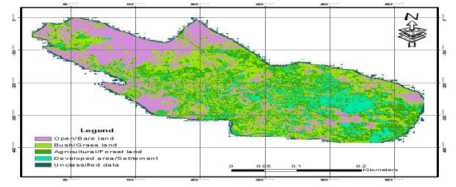


Figure 23.Classified Land use/cover. Source: Researchers.

1. Distance from sensitive sites

A sensitive sites map refers to the major cultural, archaeological, ecological and historical sites in the study area.It may also include churches, mosques, parks and others. The areas in and around the historical wall of the city should be restricted from such activity. These sites are restricted from the development of landfill. Thus landfill should not be located in close proximity to sensitive areas listed above. When the distance increases

the suitability also increases. Siddiqui (1996) showed that the area located at the distance greater than 3000m from environmentally sensitive area were selected as highly suitable for solid waste dumping site. In the present study, about 29.8% from the total areawere located at distance of 3000m fromenvironmentally sensitive area. The table below shows the level of suitability, the rate given and the weight assigned. The most suitable area for solid waste dumping site was given higher weight of 0.4700 as can be seen below.

Table 9. Reclassified distance to sensitive area.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Distance from sensitive | Level of  suitability | Rate | Weight | Area(ha) | Percent of total area (%) |
| 0-500 | Unsuitable | 1 | 0.0718 | 973.5 | 17.7 |
| 500-1000m | Less suitable | 2 | 0.1983 | 1463 | 26.6 |
| 1000-2000 | Medium suitable | 3 | 0.2599 | 1424.5 | 25.9 |
| >3000 | Highly suitable | 4 | 0.4700 | 1639 | 29.8 |

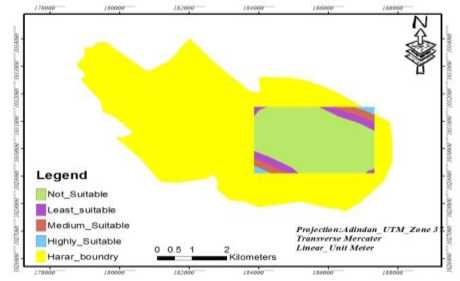


Figure 24. Reclassified distance to sensitive area.

Source: Researchers.

1. Elevation

Elevation is an important parameter in the identification of landfill site(Kumar, 2013). SRTM (Shuttle Radar Topography Mission) image was used to drive elevation map of the study area. The elevation of the study area generally ranges between 1776 and 2016 meters. Lower and higher altitudes were ignored as they are not good for siting landfills. Lowest and higher weight values were given to areas at >1,800 m above sea level and areas at <2016m above sea level respectively. The rating, suitability and weights assigned is given in the following table and the figure illustrates the level of suitability.

Table 10. Reclassified elevation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Elevation(meters) | Level of suitability | Rate | Weight | Area(ha) | Percent of total area (%) |
| <1800 | Unsuitable | 1 | 0.0718 | 973.5 | 17.7 |
| 1800-1850m | Less suitable | 2 | 0.1983 | 1463 | 26.6 |
| 1850m -1900m | Medium suitable | 3 | 0.2599 | 1424.5 | 25.9 |
| 1900m -2000m | Highly suitable | 4 | 0.4700 | 1439 | 29.8 |

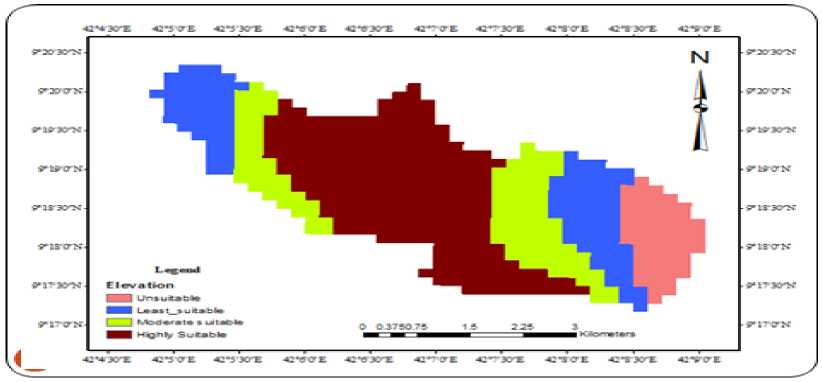


Figure 25. Reclassififedelevation. Source: Researchers.

1. Assigning Criteria Weights and Standardize Factor Maps

One of the components of GIS-Based MCE methodology is assigning criteria weights for each factor maps to express the importance or preference of each factor relative to other factor effecting landfill siting. A number of criterion-weighting procedures based on the judgments of decision makers have been proposed in the multi-criteria decision literature (Eskandarb/ «/. 2009). One of the most promising is pair-wise comparison developed in context of a decision making process is known as AHP. In multi criteria evaluation using a weighted linear Combination, it is necessary that the weights should sum to 1.Weight was derived by taking the principal eigenvector of a square reciprocal matrix of pair-wise comparisons between the criteria.

Table 11. Pair wise comparison based on Saaty rating scale and expert’s opinion.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Less important |  |  | More | important |  |  |  |
|  | Land | Developed | Sensitive Road | | Slope | Elevation | Water |
|  | cover | area | area |  |  |  | body |
|  | type |  |  |  |  |  |  |
| Land | 1 |  |  |  |  |  |  |
| use/cover type |  |  |  |  |  |  |  |
| Developed area | A | 1 |  |  |  |  |  |
| Sensitive area | 1/3 | 1/2 | 1 |  |  |  |  |
| Road | 1/4 | 1/3 | 1/2 | 1 |  |  |  |
| Slope | 1/5 | 1/4 | 1/3 | 1/2 | 1 |  |  |
| Elevation | 1/6 | 1/5 | 1/4 | 1/3 | 1/2 | 1 |  |
| Water body | 1/7 | 1/6 | 1/5 | 1/4 | 1/3 | A | 1 |

Table 12. Weights derived from Pair wise comparison

|  |  |  |
| --- | --- | --- |
| Factor | Eigen vector | Weight percentage (%) |
| Land use/cover type | 0.275 | 27.5 |
| Developed area | 0.1946 | 19.46 |
| Sensitive area | 0.1604 | 16.04 |
| Road | 0.15 | 15 |
| Slope | 0.1 | 10 |
| Elevation | 0.07 | 7 |
| Water body | 0.05 | 5 |
| Total | 1 | 100 |

The above table shows that land use/cover and developed area are more important than other factors for landfill site selection.

1. Aggregating the Criteria Weights

The distinguishing feature of GIS is its capacity for integration and spatial analysis of multisource datasets. The data are manipulated and analyzed to obtain information useful for a particular application such as suitability analysis. Landfill site selection involves aggregation of factors in a systematic way. Once the factor maps are prepared, the last step in suitability analysis is to evaluate the criterion so as to combine the information from the various factors. Weighted linear combination one of the multi criteria evaluation techniques to use for factors aggregation (Malczewski, 2006).With a weighted linear combination, factors were combined by applying a weight to each followed by a summation and final landfill suitability map that shows suitable sites for landfill. The overall suitability index was calculated using the following formula SI=E?=1 WiXi

Where SI refers to Suitability index,

W refers to weight and X refers to the variables used

SI =Y^ (Land use/land cover\* 0.275 + Developed area \* 0.1946+ Sensitive area\* 0.16.94 + Road proximity\*0.15 + Slope \* o.1 + Elevation \* 0.07+ Water body \* 0.05)

1. Results and Discussions
   1. Landfill Suitability Analysis

The final step in the process of suitable site assessment was the development of suitability model, showing the sites suitability in four different levels. For this purpose the percentages of influence was multiplied by the value of each raster cell in the factor considerations and then were summed up all together using raster Calculator. A model with six possible suitability classes was then turned for which it was examined by the six individual factors. This was done repeatedly until it enabled to get reasonable and acceptable suitability model of the study area.

As can be seen both in the table and figure/model below the solar yellow shades represent highly suitable areas (suitability class four).The yellow color represents areas with high suitability. Areas represented by red sheds are with suitability value of three and shows least suitable sites and the fourth class which is highlighted by black colour shows places which are restricted from any landfill site since they are occupied by other land uses.

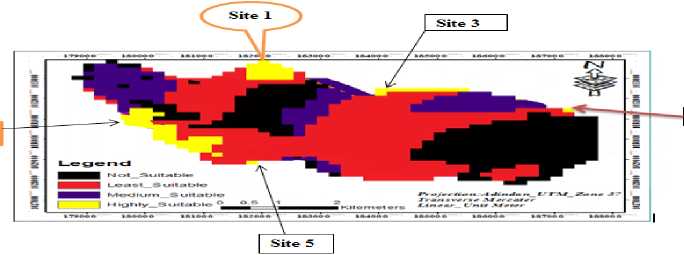


Figure 26.Overall suitability model. Source: Researchers.

Table.13. Overall suitability model/map.

|  |  |  |
| --- | --- | --- |
| Level of suitability | Area(ha) | Percent of total area |
| Unsuitable | 1628 | 29.6 |
| Less suitable | 1826 | 33.2 |
| Medium suitable | 1127.5 | 20.5 |
| Highly suitable | 918.5 | 16.7 |

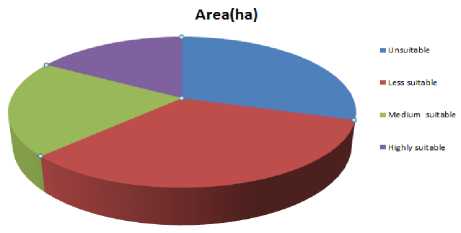


Figure 27. Chart showing overall suitability. Source: Researchers.

* 1. Evaluating Candidate Landfill Sites

Size of landfill is one of the determinant criteria for sustainable solid waste management as size of land selected for landfill determines the number of years for which the landfill will be used as waste disposal site. From sustainability and economical point of views, larger size of land that will serve for at least ten years are more preferable than small size. This is because selecting large sized landfill site can minimize the cost of site selection, design and closure. The analysis shows that, sites with area less than 0.5km2 are economically not feasible and hence considered not suitable. Considering the overall criteria’s, the socio economic criteria, available land uses, the infrastructure on the ground from the alternatives identified site 1 is chosen as the best suitable site for planting the landfill in the study area. It also confirms to one of the candidate sites being studied and identified areas for landfilling.



Figure 28. Most suitable site (Source: Researchers).



Figure 29. Site on the ground.

Source: Researchers.

1. Conclusion and Recomendation
   1. Conclusion

This article examined an approach for identifying the optimum site for the development of a landfill in a growing town. A multi-criteria approach was employed in conjunction with GIS-based overlay analysis to identify the most suitable site for landfill development in the town. The study was based on a set of key criteria, which were selected on the basis of the already available knowledge from research literature as well as criteria’s set by the ministry of construction and urban development. The criteria’s considered were very crucial for landfill site suitability as many literatures reveal and

were considered advantageous for easy access of construction and management and movement of wastes from the urban environment to the dumping site. Generally, this study provided a final suitability map and a model showing the potentially suitable sites on which landfill sites can be established for the city of Harar.During the study, it is proved that GIS is a powerful tool in handling large amounts of data and narrowing areas of interest for potential landfill sites.

1. Recommendation

Detailed social and geological study for the selected landfill sites should be done in order to further enhance the landfill sites and predict the effects that will result from the landfill. To protect air, environment and water, pollution must not flow into and out of the landfill. The selected landfill site should serve at least for two decades to reduce the cost of landfill site selection, construction and closure. Hazardous wastes from industries, health institutions and from households should be separated from non- hazardous solid waste before disposal. Hence, separate landfill should be selected for such hazardous solid waste as siting parameters and construction of landfill for hazardous solid waste is quite different from that of non-hazardous waste.

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1. Institutional Open Access Repository Development and Proposed Indicators of Success: Experience from Haramaya University

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Abstract: Institutional repositories are increasingly becoming an essential component of academic institutions as Universities are mandated to produce ample amount of research outputs such as thesis, dissertations, and experiment bulletins. In Ethiopian Universities particularly in Haramaya University, research outputs were found in poor state and also inaccessible to students, researchers and the outside world. Hence, the Universities web ranking is very low. Institutional Repository project hosted at Haramaya University builds Institutional Repository (IR) which manually derived descriptors for the scanned materials are used for indexing and segmenting the contents using DSPace. During implementation, we learned that the success of IR greatly depends on the presence of clearly defined mandate, physical, availability of technical and knowledge infrastructure, integration with institutional planning, interoperability, promotion and preservation strategy. It also requires involvement of Librarians, ICT professionals, University top management, researchers & graduate school directors. Above all, drafting institutional open access policy that manage the issue of intellectual property right, embargo period etc should precede the technical implementation of the Institutional Repository.

Keywords: Repository; Open Source Software; DSapce, Ethiopia

1. Introduction

As centers for intellectual and scholarly research, academic and research institutions are expected to take initiative in the creation, dissemination as well as preservation of knowledge. In any given society, this is a very complex process. This is more so in developing countries such as Ethiopia where the economic, technological, and institutional structures necessary to achieve the process are not well established (Christian 2008).

Ethiopian academic institutions have been grappling with how to manage the digital intellectual output they produce including journal articles, conference papers, reports, theses & dissertation, teaching materials, artwork, research notes, and research data.

Haramaya University is not an exception; its more than six decades of academic exercises and research practices were basically aimed at addressing the pressing socio­economic problems of the country particularly, in agriculture. To this end, it has produced ample research outputs

The University is pioneers of scientific researches in agriculture and other sciences in Ethiopia. Particularly, research has been one of the pillars of the university’s founding missions. Accordingly, the university has spent large amount of public and donors money to fund these research projects. Its faculty members have also dedicated their time and expertise to resolve the pressing social and academic issues.

The above mentioned research output of the university namely, old publication, journal articles, data sets, technical reports, theses,& dissertations are given less attention. They are not easily accessible (some are dumped in library stores, few are still accessible in the library, others are in the hands of individuals, some are missed). This has undermined the positive role that the availability and accessibility of organized institutional knowledge and experiences can play in enhancing quality, relevance and originality of both the academic & research works of the university. To address the glaring gap, IR project was initiated at September 2015 and completed early 2016. During the implementation of the project many lessons were drawn.

1. Research Methodology

Our research design draws upon qualitative methods to examine each phase of institutional repository project implementation based on the authors experience and reviewing of related literature.

1. Review of Related Literature
   1. Institutional repository

An institutional repository is an accessible collection of scholarly work that represents the intellectual capital of the university. It is digital archive of the intellectual product created by the faculty, research staff, and students of an institution and accessible to end-users both within and outside of the institution with few if any barriers to access (Westell 2006).

Institutional repository showcases scholarly and research output to the wider community, and significantly helps in institutional advancement and outreach. It has the benefit of sharing and marketing research with others. It also provides an opportunity to raise profile and brand awareness of an institution, faculty and students to the global community. Building an effective and successful institutional repository for an academic institution requires careful planning and enthusiasm from the institution’s community(Nagra, 2016).

Building institutional repository in Ethiopian Universities is expected to:

* enhance visibility of the university to the world as web presence is among key criteria in ranking universities worldwide in line with (Rauhvargers 2013).
* seamlessly access to local researches and experiences hence, reduce time and effort through easily learning from local research experience.
* long term preservation of knowledge for the next generation.
* prevents plagiarism.
* Contributes towards ensuring quality of research. As the thesis and the dissertations of the university became more accessible, it is highly unlikely that student would plagiarize. This is because everyone potentially knows about prior research works in their specific
* improves the dissemination, retrieval and impact of the thesis in the scientific community.
* helps to develop a project on previous research findings (e.g. subject analysis).

1. Open Access

Developments in information and communication technology especially the World Wide Web has made possible an unprecedented collaboration in the production, dissemination and exchange of information by people all over the world irrespective of their geographical location. This development has also given rise to various movements aimed at enabling free and open access to information by people irrespective of their economic, social, or geographical background. One of such movement associated with this concept is the open access movement.

The open access movement emerged in response to increasing legal and economic barriers by commercial scholarly publishers which made access to research output and information difficult especially to people in developing countries. Thus, the movement seeks to promote free and open access to research output devoid of any permission barriers and unnecessary legal restraints. The open access movement therefore seeks to use the internet - a product of the n‘networked information economy’ to provide free access to research and scholarly output to people irrespective of their physical or geographical location, or their social and economic means.

The concept of open access is characterized by free availability of research output on the public internet granting a user the license to make legal and non-commercial use of such material subject to proper acknowledgment of the rights of the original owner. Hence the open access initiative makes it possible for researchers to make their research output like scholarly articles freely available to the public by means of any open access instruments such as open access journals or open access repositories. The result according to Lawrence (year) is that “scientist now have almost instant access to a large and rapidly increasing amount of information that previously required trips to the library, interlibrary loan delays, or substantial effort in locating the source”(Weston 2002).

1. Open Source IR Software’s (OSS)

The term Open Source software refers to a computer program that is distributed under one of a number of licensing arrangements. The OSS scheme requires the specific software’s source code to be availed and accessed. It also permits the receiver of the program to modify the source code freely and align it with their own needs provided that, if they distribute the software modifications they create, they do so under an open source license (Myeza 2010). The open source model helped to develop software’s in many industries and business. It also offers librarians the capability to create the software that is standards compliant, interoperable, extensible and scalable. Many of this software’s help customers to find information quickly, conveniently, no matter where that information resides, it also gives the freedom to use, change or distribute the way you want(Hasan 2009).

Open source software has been commonly used for building digital libraries in many academic and research institutions(Oak et al. 2013). It presents a system for the construction and presentation of information collections. More importantly, it helps in building collections with searching and metadata-bases browsing facilities and easily maintained, augmented and rebuilt automatically (Tramboo 2012).

1. Reasons for selecting Open Source Software

Castagne (2013) outlined five aspects of open source software as political, economic, social, technical and legal. On the political aspect, open source software allows everyone to use, study, modify and distribute the software, regardless of person’s status, wealth, social background etc (Vimal 1998). From the economical perspective, upfront costs of commercial software’s is not included in the open source software cost users get full version of the product, no time limited trials(Pankaja & Raj 2013). Commercial software’s require huge investment at the initial stage and additional payment needs if the user wishes to update the software and users have no ownership on the software, it only allows work with the application.

Open source software has also social and technical influence(Singh & Phelps 2009). The social influence is vivid in its development and maintenance process where people collaborate and work together, anybody can also join and contribute in the group. Through this, open source software projects encourage innovation and collaboration of community members. On the technical perspective, it is becoming more reliable and it has proved that open source software is increasingly competitive from its proprietary software counterpart(August et al. 2013). In addition open source software is interoperable, customizable according to the needs and fulfills the software industry standards. From legal point of view, open source software licenses are copyright protected, they strictly ensure the users freedom to use, modify and distribute the programs.

Eprint

EPrint is a free and open source software package originally developed by researchers at the University of Southampton School of Electronics and Computer Science in 2000 (making it the oldest of the platforms in this report)(Andersson, S., Svensson 2013). It was designed specifically for archiving research papers, theses and teaching materials, though it can accept any content. As of July 2013, ROAR has recorded 500 implementations, making it the second most popular platform.

Like DSpace, EPrint follows a “turnkey” approach and some institutions have reported that the installation process is fairly straightforward (Beazley, 2010). The administrative backend provides access to configuration options. EPrint’s Bazaar Store is an interesting concept, aiming to allow repository managers to install extensions with a single click.EPrint is capable of using a controlled vocabulary and authority lists, which can help ensure high metadata quality. It provides native support for Dublin Core with the possibility of exporting to a number of formats (e.g., METS, MODS and DIDL). Qualified Dublin Core and MARC are not supported (Castagne 2013).

Greenstone

Greenstone is an open source digital library building and distributing software. It is a popular software particularly, the software’s ability to redistribute digital collections on self-installing DVD/CD-ROMs made it more popular in developing countries such as Ethiopia with very limited Internet bandwidth (Ian H et al, 2000).

Greenstone is designed and developed using Java, making it ideal for many platforms including Linux and Windows. The current version, Greenstone3, is redesigned to improve the dynamic nature of the Greenstone toolkit and decrease the potential overhead incurred by collection developers. Moreover, it is distributed and can thus be spread across different servers. Furthermore, the new architecture is module based, using independent agent modules that communicate using single message calls.

Greenstone uses XML to encode resource metadata records. XLinks are used to represent relationships between other documents. Using this strategy, resources and documents are retrievable through XML communication. Furthermore, indexing documents enables effective searching and browsing of resources. The software operates within an Apache Tomcat Servlet Engine.

Dspace

DSpace was jointly developed by Massachusetts Institute of Technology and Hewlett- packard in 2002, is an open source software which can be freely downloaded (Castagne 2013)(Andersson, S., Svensson 2013). DSpace is the software of choice for academic, non-profit, and commercial organizations building open digital repositories. It is free and customizable to fit the needs of any organization(Castagne 2013). DSpace preserves and enables easy and open access to all types of digital contents including text, images, moving images, mpegs and datasets. With an ever-growing community of developers committed to continuously expanding and improving the software, each DSpace

installation benefits from the next (Biradar & Banateppanavar 2013). This project compared E-print, Greenstone Digital Library Software and Dspace. DSpace is selected due to its robust search and preservation capability.

1. Result and Discussion
   1. IR building Process

The IR building process we followed involves three phases namely, planning, digitalization process, and post digitalization process. The three phases followed in the project are summarized on the table hereunder.

|  |  |
| --- | --- |
| Steps | Key Activities |
| Planning | Identified major collection to be digitized in agriculture and other colleges of the University  Assessed the required Human and Physical resources to populate and digitalize the materials Decided on the metadata standards. |
|  | Defined methods and timing of quality control. |
| Digitalization  Process | Availed required equipment  Team Formed (5-calatogers were trained on data enriching)  Scan documents with quality control  Configuring DSpace for individual catalogers (collection creation, plugin, populating materials)  Selected materials to be digitized.  Classified items in line with meta data standard  Quality control of the materials (conditions of the material  including cleaness, filesize etc)  Troubleshooting errors |
| Post-digitization  processes. | Migrating collection from catalogers computer to main server Design user Interface for communities Assessment and evaluation of the project.  Official Inauguration |

Quality control and review process was conducted by a person other than the ones doing the original digitizing work. This is in line with the recommendation from previous literatures (Jenn Riley & Kurt Whitse, 2005).

* 1. Proposed Indicators of Successful Institutional Repository

During the implementation of the project, many lessons were drawn from the technical and administration aspects of the project. Hence, future similar projects in the developing countries context should consider the under mentioned points.

* + 1. Mandate

A clearly defined mandate for the repository is key to its success. Repository that is “all things to all people” lacks focus and priorities and is difficult to populate on a sustained

basis. As these projects begin, it is often tempting to embrace a broadly defined mandate to allow for seeding the content. While this can be effective in populating the repository initially, it will be important to get a clear vision of the repository as early as possible. Institutions need to determine the nature of the repository (multi-purpose, mandated, discipline specific, faculty centric, format-specific) and to present the repository to users (Westell, 2006).

* + 1. Interoperability

Interoperability with other repositories indicates an ability and openness on behalf of the institution or library to contribute to national and international scholarship. Opening the repository to cross repository searching tools (OAI and other harvesters as well as the generic indexing intools like Google Scholar and opendoar registration) exposes scholarship in a new way and puts it in an international context. This is particularly important if the institutional repository is purely “institutional” in the sense that it collects institutionally created content, rather than a subject-based repository, which, by definition may cross institutional boundaries.

* + 1. Technical, physical and knowledge infrastructures

It is learned that successful digitization project requires considering various aspect of the project during its planning phases. These essential aspects of the project can be summarized in to four major categories.

The technical infrastructures are the human resource particularly, technical skills required for digitalization software selection, installation, configuration, troubleshooting and training. This IT skill is very important in light of the technical difficulties in customizing and deploying most open source softwares. Hence, prior to initiating IR project, it is crucial to empower technical staff trained to do software selection, installation, configuration, troubleshooting and training considering the local context.

The Physical Infrastructure include the necessary electric power supply, server computer, desktops, scanners, network infrastructure and physical space required to implement the project. The required size of physical infrastructure correlates with the size of the collection and the quantities of the physical infrastructure should be aligned with the time and budget of the project. At this stage you can start by considering the bare minimum requirement to run the adopted Open Source software. For example, in Dspace the bare minimum is 2GB RAM server.

The organizational infrastructure encompasses the availability of rules and regulations, incentives, commitment of management, support from the university top management. For example, the adoption of institutional open access policy will allow making the local content of the university accessible to the public. This is similar with findings of (Biradar & Banateppanavar 2013). Accordingly, we strongly recommend that institutions should draft and adopt open access policy ahead of launching IR.

The knowledge infrastructure is concerned with the availability of content. It also deals with ensuring selection of relevant documentsand the depth and width of the entire collection. Successful knowledge infrastructure incorporates contents that are relevant to the targeted users. On another note, the issue of sustaining content gathering should be well taught. For example, students should be obliged to deposit theses and dissertation in the library.

* + 1. Promotion

Promoting the repository with faculty is an additional crucial factor. It requires that librarians tirelessly promote the IR. Changing the culture of scholarly communications is not an easy job and uptake remains slow in the academy. Many repositories are using the “if you build it, they will come” philosophy. Through developing the infrastructure and encouraging early adopters, a critical mass of content will attract other researchers and illustrate to administration how the repository will meet institutional needs.

1. Conclusion

Building IR is a complex process with many crucial dependencies between different stages over time. Particularly, building large size digital collections using open source software requires dedicated team members, physical resources and more importantly, understanding the nature of the software and devise techniques to effectively utilize it. After the completion of this project, major lessons were learnt.

Availability of clearly defined mandate, physical, availability of technical and knowledge infrastructure, integration with institutional planning, interoperability, promotion and preservation strategy should be encouraged Future same or similar projects can also learn from the experience of building IR in Haramaya University.

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1. Investigation into the Possibility of Blending Taro Root with Selected

Wheat Varieties for Bread Production

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Abstract: A study was conducted to assess the potential of taro (Colocasia esculenta) root for bread production by combining it with flour of different local wheat (Triticum aestivum) varieties. The experiment was planned with two factors, wheat varieties (Hidase, Hogolcha and Ogana) and blending ratios (0, 30, 40 and 50% taro). Fresh taro root, obtained from the south, was washed, peeled, sliced to 6mm thickness, dried in hot air dryer at 60oC for 24hr and milled to pass through 70pm. The wheat grains were cleaned and milled into flour to pass 0.425mm screen. The composite flours were mixed with ingredients in proportion of 50g dry yeast, 200mg salt, spice% tsp, dilute milk A tsp, 50g sugar for 400g flour, using a dough mixer until a homogeneous mixture was attained. The dough was passed through the normal bread making procedures and baked at 180°C for 30 minutes. The flours and breads were evaluated for proximate composition, mineral contents, anit-nutritional factors, functional properties and sensory quality attributes as deemed necessary. Accordingly, the three wheat varieties had significant differences in their proximate composition particularly the protein content with values of 14.85, 10.98 and 8.22% (db) for Ogana, Hidase and Hogolcha, respectively. The taro flour had 5.27, 2.53, 6.98, 1.86 and 85.89% (db) ash, crude fiber, crude protein, crude fat and utilizable carbohydrate, respectively. The three wheat varieties exhibited 51.50, 50.60 and 49.85 mg/100g calcium; 0.73, 0.53 and 0.33 mg/100g zinc; 10.05, 9.15 and 8.87 mg/100g iron and 353.91, 379.60 and 326.06 mg/100g phosphorus, respectively. Likewise the taro flour exhibited 24.50, 10.40, 7.46 and 7.75 mg/100g of the same minerals, respectively. The tannin and phytic acid contents in mg/100g were 0.40 and 13.08 for Ogana; 0.45 and 13.45 for Hidase; and 0.37 and 12.79 for Hogolcha wheat varieties, respectively, while taro showed 38.64 and 100.50 mg/100g, respectively. The ^- carotene was not detected in the wheat samples while it was 0.27 mg/100g for taro. Regarding the composite breads, increasing taro proportion through 0, 30, 40 and 50% showed reduction in fat content from 1.99 to 1.52, 1.20 and 0.96%, in crude protein from 11.35 to 10.42, 9.87, and 8.60%, and increase in crude fiber from 1.04 to 1.39, 1.45 and 1.72%, in ash content from 1.59 to 2.84, 2.92, and 3.13%; with significant (P < 0.05) differences among them. Iron, zinc and phosphorus of the breads increased as the ratio of taro increased. With increase in taro content, the beta carotene increased from 0.00 to 0.09, 0.13, and 0.15 mg/100g, the tannin from o.43 to 0.61, 0.89 and 1.04 mg/100g and the phytic acid from 13.11 to 14.54, 16.08 and 17.62 mg/100g, respectively. The sensory results showed that all the composite breads secured various degrees of liking with scores varying from 4.02 for color and taste to 5.77 for texture, in a scale of 7, for the 50% taro blend showing high acceptance even at the highest taro ratio. No score was given at all in the range of dislike.Generally the results showed that breads of acceptable sensory attributes and improved mineral contents can be produced by mixing taro with wheat flour.

Keywords: taro; wheat varieties; composite bread; blending ratio

1. Introduction

Leavened bread is an important wheat based product with very high popularity in the world as well as in Ethiopia. Wheat is largely grown in the central, east and northern highland regions of the country for both domestic consumption and commercial purposes. Different varieties of wheat, both locally breed and imported, are widely grown for production of bread. However, wheat production in the southern and western regions is very much less and the population depends on wheat flour brought in from other regions for bread consumption which makes it relatively expensive. On the other hand the southern and western regions are rich in root and tuberous crops which are often consumed in limited forms, mainly after boiling. Starchy root crops like cassava, yam, taro and sweet potato are easily available all year round and can be considered among the staple food of the areas. The forms of consumption of these root-crops need to be widened by varying the processing techniques and/or combining them with other crops such as grains.

The high cost of producing leavened bread from wheat might be lowered by incorporating it with some of these high potential root crops. For instance, taro (Colocasia esculenta), which has been found to be important source of calorie for the people in the area can be a good candidate for the purpose. It has been cultivated mainly and extensivelyin the densely populated and high rainfall areas of south, southwest and western parts of the country. Its importance as a potential food security crop in Ethiopians has increased since the1984 famine (Amsalu, 2003). In some areas, it is used to fill seasonal foodgaps when other crops are not in the field (Tewodros, 2011). The protein of taro is well supplied with essential amino acids though is low in histidine and lysine. Taro is fairly rich in carotene, ascorbic acid, thiamine, riboflavin and nicotinic acid. The small size of the starch granules makes taro highly digestible, and is used in preparation of infant foods in Hawaii and other Pacific islands, as well as in Chad.

Given these characteristics, taro flour has much potential for use in food formulations. For example taro flour combined with other products is used extensively for infant formulae in the United States, particularly for children who are sensitive to milk and has formed an important constituent of baby foods (Lee, 1999). Besides, this taro is especially useful to people who are allergic to cereals.

Traditionally in the Ethiopian south, taro is consumed on its own in boiled form and is thought to have an inferior taste to other root crops as a result of which it is considered as a stand-by crop worth eating only during periods of seasonal food shortage. Consumption of taro as reach source of starch (70 — 80%; Howeler et.al, 1993) can be enhanced by blending it with more likable cereals like wheat grains. In fact, the high cost of wheat flour for bread making can be tackled by blending it with this chip starchy root crop available in large quantity in the region. This might increase the consumption of taro on one hand and lower the cost of making leavened bread for the local population on the other. Furthermore, the high potential of taro in some specific nutrients indicated above could be exploited by increasing its consumption in form of bread. This research has, thus, been initiated with the intention of assessing the possibilities of combining taro flour with flour of locally available wheat varieties for the production of bread for local consumption.

* 1. Statement of the Problem

Wheat bread has been consumed all over the globe for long time and it is consumed very widely even in Ethiopia, particularly in wheat growing areas of the country. With the spread of wheat flour processing plants in the country, its use has become more widespread and frequent in areas where wheat is not grown traditionally. However, the wheat grain used for processing of flour for bread production is largely imported from overseas at very high price or purchased from the local market of wheat growing areas. The price of bread for most people living in the countryside of non-wheat growing regions has become expensive. In Ethiopia, particularly in the southern, western and south western regions, use of root crops such as cassava, yam, taro, sweet potato and anchote for human food is common with limited forms of use. These root crops, most of which are rich sources of starch, are largely consumed after boiling or roasting in open fire. This has contributed to limited and domestic consumption of the root crops and has become a hindrance to long term storage and industrial scale use of the crops. The use of root crops after drying and grinding into flour for the production of different food items is becoming more common in many developing countries in Africa. As a starchy food taro can be one of the candidates to be used in flour form and be used in combination with wheat for the production of leavened bread. This might reduce the cost making breads from wheat thus enabling the poor in the countryside to enjoy bread. Furthermore, its use for bread could increase the diversification of the forms of its consumption into more attractive and enjoyable products. This work was initiated with the aim of investigating incorporation of taro flour into wheat flour to reduce cost of bread in taro growing areas and increase its consumption by diversifying the products.

* 1. Objectives of the Study

The general objective of this study was to assess the potential of taro root flour for bread production by combining it with flours of different local wheat varieties. The specificobjectives were to:

* improve the nutritional quality of wheat breads particularly the mineral contents and ^-carotenes by blending it with Taro powder; and
* evaluate the effect of blending ratios of wheat and taro on bread quality and sensory acceptability.

1. Materials and Methods
2. Experimental Materials

All experimental activities were conducted at Food Science laboratories of Haramaya University. The experimental materials, i.e. three wheat varieties (Hidase, Hogolcha and Ogana) and one taro variety were obtained from Holeta agricultural research center and a local market in the southern region, respectively. The corms of the taro were cleaned, washed and stored in cool dry area in the laboratory processed into flour. The wheat grains were cleaned manually to remove any foreign matter.

1. Experimental Design

The experiment was planned with two factors, wheat variety of three types and blending ratios of taro flour with four different levels. The wheat varieties were selected based on availability and suitability for bread according to the existing records in agricultural research centers. The blending ratios were selected based on literature findings. Whole wheat breads of each variety were used as control.

Table 1. Experimental plan.

|  |  |  |  |
| --- | --- | --- | --- |
| Factor-2 (Blending ratio) | Factor-1 (Variety) | |  |
| V1 | V2 | V3 |
| B1 | V1 B1 | V2 B1 | V3 B1 |
| B2 | V1 B2 | V2 B2 | V3 B2 |
| B3 | V1 B3 | V2 B3 | V3 B3 |
| C | CV1 | CV2 | CV3 |

Where:

B1 = Blending ratio (70% Wheat flour and 30% Taro root powder) B2 = Blending ratio (60% Wheat flour and 40% Taro root powder) B3 = Blending ratio (50% Wheat flour and 50% Taro root powder) V1 = Wheat variety one V2 = Wheat variety two V3 = wheat variety three

C = Control (100% of the respective wheat varieties)

1. Sample Preparation
2. Taro root flour production

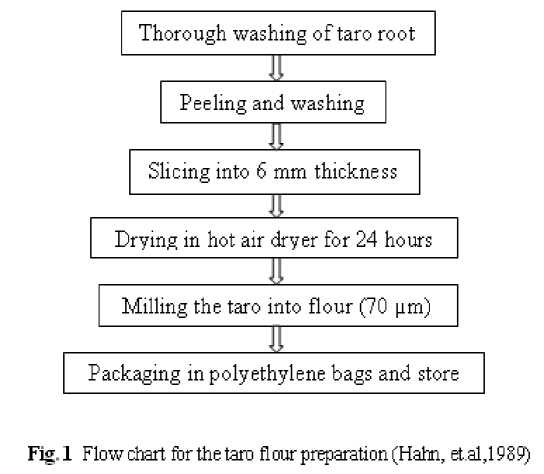
Taro flour was prepared by peeling and slicing the corms and cornels and washing the slices thoroughly in potable tap water in order to remove as much mucilaginous material as possible. The slices were then dried to a brittle texture in a hot air oven at 60°C for 24 hours. Dried slices were milled into flour using an attrition mill. The flour thus produced was packaged in polyethylene bags and stored in air tight containers until required for use. A summary of the preparation of the taro flour is presented in a flow chart in Fig 1.

1. Sample preparation of wheat

Wheat grains were cleaned manually from foreign materials and ground by disc mill at the university cafeteria. The flour was sieved by 0.425mm aperture sieve size and kept, under ambient temperature, inside air tight sealed plastic bag until used.

1. Wheat-taro composite dough preparation

Four samples of required taro-wheat mixture were prepared by mixing taro flour with wheat flour in the proportions indicated in Table 1, with appropriate ingredients (water, salt, sugar,yeast milk, etc) using a Kenwood food mixer KN 201, England for 5 minutes. The amount of ingredients in the mixture is indicated in Table 2 .The mixing was done to ensure a homogeneous mixture of the samples. The four sample formulations were baked using the straight dough method (Ceserani, V. and R. Kinton, 2008), (Fig. 2). The dough was left in bowls at room temperature (29°C), covered with damp clean muslin cloth, for approximately 55 minutes to proof. It was then knocked and molded into a loaf, placed in a loaf tin and further proofed in a proving cabinet for 90 minutes at 30°C, 85% relative humidity. That was followed by baking at temperature at 180°C for approximately 30 minutes (Giami, et al., 2004). It was then removed and placed on a cooling rack and packaged in a transparent polyethylene bag with and stored in a cool dry place until needed.

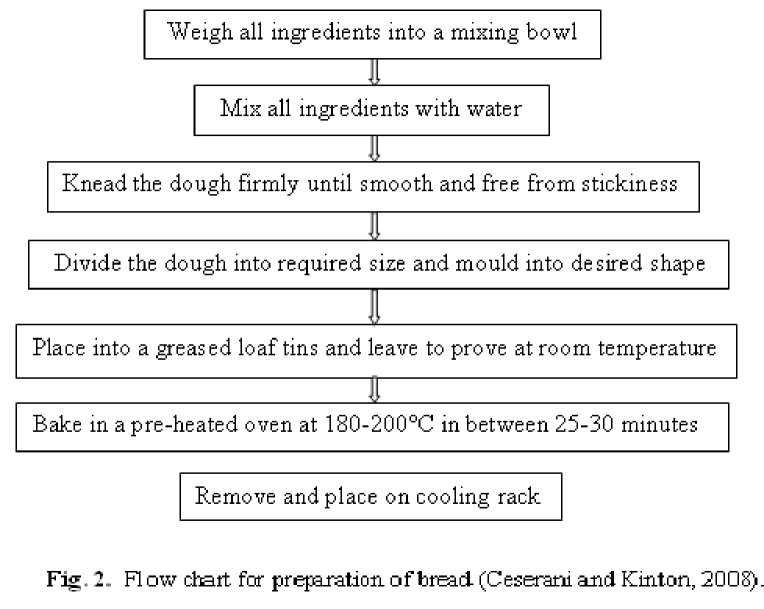


1. Appropriate ingredients needed to make bread

The ingredients used for bread per 400g flour were, 50g dry yeast, 200mg salt, % tsp spice, A tsp dilute milk, 50g sugar, and water. All dry ingredients were weighed and placed in the mixer. The required time for baking was 30 minute and the oven temperature 180oC.

1. Evaluation of chemical composition

Proximate composition, mineral contents, anti-nutritional factors, and ^-carotene contents of wheat flours, taro root powder and breads were analyzed following the standard procedures.



1. Bread characterization

Bread loaf weight and volume were determined using digital balance and solid displacement procedures, respectively.

1. Sensory evaluation

Sensory evaluation of bread samples was carried out using fifty students and staffs of the Food Science Department with adequate experience in sensory evaluation of food samples products. The panelists were provided with adequate samples of the breads to test and bottled water at room temperature to rinse their mouth after each sample test.

A 7-point hedonic scale which consisted of 7(Like very much), 6 (Like moderately), 5(Like slightly), 4(Neither like nor dislike), 3(Dislike slightly), 2(Dislike moderately) and 1(Dislike very much)was used to evaluate acceptability of the sensory attributes which included color, taste, flavor, texture and overall acceptability of the breads.

1. Results and Discussions
   1. Proximate Composition

Proximate compositions of the wheat flours and of the taro powder expressed in dry basis are presented in Table 2. The ash contents of the Hidase, Hogolcha and Ogana wheat varieties exhibited significant (P < 0.05) differences with values of 1.08, 0.72, and 0.93%, respectively while that of taro 5.27%, was greater than twice the values in the wheat.

The crude fiber content of the three wheat varieties were 1.70, 0.84 and 1.97% for Hidase, Hogolcha and Ogana, respectively, also less than the 2.53% of the taro root and with statistically significant (P < 0.05) difference among the four of them.

The crude protein contents of the Hidase, Hogolcha, and Ogana wheat varieties as shown in Table 2 amounted to 10.98, 8.22 and 14.85%, respectively, with significant (P<0.05) statistical difference among them and significantly higher than the 6.98% of the taro root. The protein content of taro in this study is much higher than the 1.4-3.0% recorded by Onwueme, (1999).

The crude fat content of the wheat flours and of the taro root were all in the range between 1.67% of Hogolcha wheat and 2.40% of Ogana wheat, even though statistically significant (P<0.05) differences were observed among all the four samples. Again the crude fat content of the taro root in this work, (1.86%) was very much higher as compared to that reported by Onwueme, (1999).

The utilizable carbohydrate content of the three wheat varieties significantly (P<0.05) varied with the lowest values (80.82%) belonging to Ogana and the highest (89.39%) being of variety Hogolcha.

In energy content, the taro root was found with relatively the lowest value with 388.22 Kcal/100 g. Even though the values appear to be close those of the three wheat varieties exhibited significant differences in energy content.

Table 2. Proximate composition and energy content of wheat flours and taro root powder.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | Moisture | Ash | Crude Fibre | Crude Protein | Crude Fat | Utilizable | Energy |
|  | Content  (%) | (%) | (%) | (%) | (%) | Carbohydrate  (%) | (Kcal/100g) |
| Hidase | 12.68±0.01b | 1.08±0.06b | 1.70±0.01c | 10.98±0.05b | 1.88±0.22b | 86.06±0.03b | 405.08±0.04b |
| Hogolcha | 14.33±0.00a | 0.72±0.17d | 0.84±0.20d | 8.22±0.09c | 1.67±0.11d | 89.39±0.06a | 405.47±0.27a |
| Ogana | 11.28±0.54c | 1.93±0.09C | 1.97±0.52b | 14.85±0.16a | 2.40±0.21a | 80.82±0.09d | 404.28±0.19c |
| Taro | 7.06±0.45d | 5.27±0.01a | 2.53±0.08a | 6.98±0.17d | 1.86±0.14c | 85.89±0.01c | 388.22±0.07d |
| CV % | 0.11 | 0.44 | 0.57 | 0.09 | 0.51 | 0.03 | 0.05 |
| LSD | 0.02 | 0.01 | 0.02 | 0.02 | 0.01 | 0.04 | 0.09 |
| Hidase, Hogolcha and Ogana are | | wheat varieties. MC = | moisture content. Means followed by the same | | letter in a column | are not statistically different (P | > 0.05). |

* 1. Mineral contents

The mineral contents of the three wheat varieties and of taro root are presented in the Table 3. The calcium content of Hidase, Hogolcha and Ogana were 51.50, 50.60 and 49.85 mg/100g while that of the root was 24.50%. Likewise, the zinc contents with values of 0.73, 0.53 and 0.33, respectively, were considered significantly different from one another and from that of the 10.40% determined for the root. The iron contents records, 10.05, 9.15, and 8.87 mg/100 g of Hidase, Hogolcha and Ogana wheat varieties were found to have statistical difference among them and were all significantly higher than the 7.46 mg/100g of taro root. In respect of phosphorus the taro root exhibited very much low value (7.75 mg/100 g) whereas the three wheat varieties had over 300 mg/100g., of course with significant (P<0.05) difference among each other.

Table 3. Mineral contents (mg/100g) of wheat grains and taro flour.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | Mineral Contents | |  |  |
| Ca | Zn | Fe | P |
| Hidase | 51.50 ±0.01a | 0.73 ±0.04b | 10.05±0.02a | 353.91±0.56b |
| Hogolcha | 50.60 ±0.02b | 0.53 ±0.03c | 9.15 ±0.01b | 379.60±0.65a |
| Ogana | 49.85 ±0.03c | 0.33±0.02d | 8.87±0.04c | 326.06± 0.73c |
| Taro | 24.50±0.02d | 10.40 ±0.05a | 7.46±0.03d | 7.75 ±0.61d |
| CV % | 0.02 | 0.33 | 0.11 | 0.24 |
| LSD | .01 | 0.02 | 0.02 | 1.18 |

Hidase, Hogolcha and Ogana are wheat varieties. MC — moisture content. Means followed by the same letter in a column are not statistically different (P > 0.05).

* 1. Anti-Nutritional Factors and Beta Carotene Contents

The anti-nutritional factors present in the three wheat varieties and taro root are presented in Table 4. The tannin content of the three wheat varieties did not show statistical difference (P > 0.05) among themselves with values of o.45, 0.37, and 0.40 mg/100 g for Hidase, Hogolcha and Ogana, respectively, while the taro root was shown to have significantly (P < 0.05) higher value of 38.64 mg/100 g. Similarly the phytic acid content of the three wheat varieties were found to be 13.45, 12.79 and 13.08 mg/100 g, respectively, (P >0.05) again with no statistical difference among them. However, the recorded phytic acid content of the taro root was 100.50 mg/100g, significantly (P < 0.05) higher than those of the three varieties of wheat. It is not uncommon to find root crops having relatively higher anti-nutrient components as compared to cereal grains.

Table 4. Anti-nutritional factors and beta carotene contents of wheat grains and taro root

|  |  |  |  |
| --- | --- | --- | --- |
| Sample | ^-carotene  (mg/100g) | Tannin  (mg/100g) | Phytic acid  (mg/100g) |
| Hidase | ND | 0.45± 0.33b | 13.45± 0.16b |
| Hogolcha | ND | 0.37± 0.05b | 12.79± 0.76b |
| Ogana | ND | 0.40± 0.04b | 13.08± 0.31b |
| Taro | 0.27± 0.00 | 38.64± 0.81a | 100.50± 0.37a |
| CV % | 4.33 | 0.50 | 1.30 |
| LSD | 0.01 | 0.09 | 0.86 |

Hidase, Hogolcha and Ogana are wheat varieties. MC = moisture content. Means followed by the same letter in a column are not statistically different (P > 0.05).

Regarding the ^-carotene content, the data in Table 4 showed that the wheat grains did not have detectible amount while the taro root exhibited 0.27 mg/100 g. This was one of the quality of the taro root which attracted attention to be considered for this study.

* 1. Effects of Blending Ratios and Wheat Varieties on Proximate Composition of Wheat-Taro Composite Bread

Proximate composition data of the wheat-taro composite breads are presented in Table

1. The protein contents 10.42, 9.87, and 8.60% of the composite breads with 30, 40 and 50% taro blends, respectively, were significantly (P<0.05) different from each other and lower than that of whole wheat bread which was 11.35%. As the proportion of the taro flour increased the protein content of the bread decreased. This can easily be explained by the fact that taro root has lower protein content (Table 2) than the wheat and as its ratio in the mixture increased the protein content of the bread will drop.

The crude fiber content also showed significant changes increasing from 1.39 to 1.72% as the ratios of the taro root increased from 30 to 50%. This is attributed to the relatively higher (2.53%) fiber content in the taro root as compared to the wheat flours. The control sample of whole wheat bread exhibited average protein content of 1.04%, compatible with values of the wheat grains.

The ash content of the composite breads were significantly (P<0.05) different from each other with values of 2.84, 2.92 and 3.13% for blending ratios of 30, 40 and 50%, respectively, taro flour. All these values were significantly higher than that of the control whole wheat bread, the 1.59%. These differences are due to the high (5.27%) ash content of the taro root as compared to the wheat (Table 3).

The crude fat content of the whole wheat bread was 1.99% whereas those of the composite breads decreased to 1.52, 1.20 and 0.96%, for samples having 30, 40 and 50%, respectively, blends of taro root. All the four values were found to have significant (P<0.05) difference among them.

The utilizable carbohydrate contents of the breads also showed significant differences at 5% level with values 83.83, 84.54, 85.58 and 84.03% for samples of breads with 30, 40, 50 and 0%, respectively, taro root flour mixtures.

Likewise, the energy contents these breads were 389.54, 390.79, 392.25 and 390.89 Kcal/ 100 g, respectively. Again all the four values exhibited significant differences among them. This appears to be the effect of the utilizable carbohydrate which shared the bulk of the weight in content and showed direct relation as can be observed from the data (Table 5).

Table 5. Effect of blending ratios and wheat varieties on proximate composition (%) of wheat-taro composite bread.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Factors | Parameters |  |  |  |  |  |  |
| BR | MC % | CF | CP | CFb | Ash | U.CHO | Energy |
| B1 | 9.91± 1.04b | 1.52± 0.5b | 10.42±2.69b | 1.39± 0.19b | 2.84± 0.46c | 83.83± 3.74c | 389.54±2.87c |
| B2 | 9.24± 0.10c | 1.20± 0.56c | 9.87± 2.53c | 1.45± 0.26b | 2.92± 0.42b | 84.54± 3.57b | 390.79± 3.74b |
| B3 | 8.75± 0.91d | 0.96± 0.42d | 8.60± 2.20d | 1.72± 0.20a | 3.13± 0.34a | 85.58± 3.10a | 392.25± 2.17a |
| CO | 12.76±1.32a | 1.99± 0.32a | 11.35±2.88a | 1.04± 0.20c | 1.59± 0.38d | 84.03± 3.44c | 390.89± 2.32b |
| Variety  Hidase | 10.13±1.61b | 1.25± 0.51b | 9.72± 1.01b | 1.29± 0.22b | 2.43± 0.82b | 85.30± 0.72b | 391.69± 1.63b |
| Hogolcha | 11.41±1.81a | 1.03±0.42c | 7.26± 0.76c | 1.34± 0.27b | 2.33± 0.39c | 88.02± 0.55a | 393.26± 1.51a |
| Ogana | 8.95± 1.45c | 1.98± 0.33a | 13.19±1.35a | 1.58± 0.39a | 3.09± 0.69a | 80.16± 1.01c | 387.66±1.84c |
| CV % | 0.84 | 9.60 | 0.97 | 9.55 | 2.13 | 0.29 | 0.25 |
| LSD | 0.08 | 0.13 | 0.09 | 0.17 | 0.05 | 0.24 | 0.96 |

Breads from the three wheat varieties are characterized by significant (P < 0.05) differences in almost all components of the proximate composition. Breads from Ogana variety had highest average values of crude protein (1.98%), crude fiber (13.19%), crude fat (1.58%) and ash (3.09%) but lowest utilizable carbohydrate (80.16%) and energy (387.66 Kcal/100 g) contents of all the three varieties. Breads from variety Hogolcha exhibited the lowest average values of crude fat (1.03%), crude protein (7.26%) and ash (2.33%) and highest utilizable carbohydrate (88.02%) and energy (393.26 Kcal/100g).

1. Effect of Main Factors on Mineral Contents of Wheat-Taro Composite Bread

The mineral contents of the wheat-taro root composite breads are shown in Table 6. The calcium content of the control — whole wheat bread— was the lowest (50.59 Kcal/100 g) of the four breads with 52.84, 54.74 and 56.36 Kcal/100g calcium in case of the composite breads having 30, 40 and 50%, respectively, taro root flours. All were significantly (P < 0.05) different from one another. Similarly the iron content of the whole wheat bread (9.38 Kcal/100 g) was increased by blending it with taro root. The 30, 40 and 50% mix ratios of the taro flour resulted in breads with iron contents of 10.77, 12.54 and 13.82%, respectively.

Table 6. Effect of blending ratios and wheat variety on mineral contents (mg/100g).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Factors | Parameters |  |  |  |
| BR | Ca | Fe | Zn | P |
| B1 | 52.84±1.24c | 10.77±0.88c | 0.76±0.22c | 358.61±23.64c |
| B2 | 54.74±1.27b | 12.54±0.36b | 1.11±0.27b | 360.35±23.47b |
| B3 | 56.36±0.93a | 13.82±0.20a | 1.43±0.35a | 362.94±24.05a |
| CO | 50.59±0.77d | 9.38±0.59d | 0.54±0.17d | 353.15±23.14d |
| Variety  A | 54.68±2.21a | 12.24±1.49a | 1.09±0.29b | 363.25±5.94b |
| H | 53.77±2.57b | 11.37±1.86b | 1.14±0.50a | 383.38±3.07a |
| O | 52.45±2.06c | 11.27±2.00c | 0.65±0.26c | 329.65±2.56c |
| CV % | 0.17 | 0.33 | 1.37 | 0.14 |
| LSD | 0.09 | 0.04 | 0.01 | 0.49 |

The zinc content of the control — whole wheat bread— was the lowest (0.54 Kcal/100 g) of the four breads with 0.76, 1.11 and 1.43 Kcal/100g in case of the composite breads having 30, 40 and 50%, respectively, taro root flours. All were significantly (P < 0.05) different from one another. Similarly the iron content of the whole wheat bread (9.38 Kcal/100 g) was increased by blending it with taro root. The 30, 40 and 50% mix ratios of the taro flour resulted in breads with iron contents of 10.77, 12.54 and 13.82%, respectively.

The phosphorus contents of the composite breads with values of 358.61, 360.35 and 362.94 mg/100g for breads with 30, 40 and 50% taro blends were statistically different

from each other and from that (353.15 mg/100g) of control whole wheat bread. With increase in the proportion of taro root flour in the mixture the phosphorus content increased significantly (P < 0.05).

The effects of wheat variety on the mineral contents of the breads are shown in the same Table. Significant differences were observed in calcium contents of breads of varieties of Hidase (54.68 mg/100gm), Hogolcha (53.77mg/100gm) and Ogana (52.45 mg/100 gm). Similarly the iron contents were 12.24, 11.37 and 11.27 mg/100 g for Hidase, Hogolcha, Ogana varieties, respectively, with 5% level of significance. The zinc contents of the breads were also significantly (P < 0.05) different from each other showing levels of 1.09, 1.14 and 0.65 mg/100 g, respectively. The phosphorus contents of the breads from Hidase, Hogolcha, Ogana wheat varieties resulted in average values of 363.25, 383.38 and 329.65 mg/100 g, respectively, again with significant difference.

1. Effect of Main Factors on Anti-Nutritional Factors and B-Carotene Content of Composite Breads

The data of ^-carotene content of the wheat-taro root composite breads is presented in Table 7 Those breads with 30, 40 and 50% taro root flour breads showed ^-carotene content of 0.09, 0.13 and 0.15 mg/100 g, respectively, with significant (P<0.05) difference among them while th.e control whole wheat bread had none at all. This indicated that addition of taro root flour improved the ^-carotene content of the wheat breads. This is because the root contains significant amount (0.27 mg/100 g) of this substance (Table 7) to contribute to the composite breads.

The effect of wheat variety on tannin content of the composite breads can be observed using the data in Table 7. Composite breads formed of Hidase and Ogana wheat varieties showed significantly (P < 0.05) higher tannin contents of 0.78 and 0.79 mg/100 g, respectively, (with no statistical difference (P > 0.05) between them) than the 0.67 mg/100 g of the bread formed using Hogolcha wheat variety. There could be no convincing explanation for this difference between the former two and the later breads since all three wheat varieties exhibited no statistical difference in tannin content (Table

7).

Regarding phytic acid content statistical differences were noted due to variety among the composite breads. The values were 15.20, 15.34 and 15.45 mg/100g for breads formed from Hidase, Hogolcha and Ogana varieties, respectively, with statistically significant differences among them.

Likewise significant differences in ^-carotene content were observed among the composite breads with values of 0.08, 0.09 and 0.10 mg/100g for the breads formed from Hidase, Hogolcha and Ogana wheat varieties.

Table 7. Effect of blending ratio and wheat varieties on Beta carotene, tannin and phytic acid contents of wheat-taro composite breads.

|  |  |  |  |
| --- | --- | --- | --- |
| Factors | Parameters |  |  |
| BR | Beta carotene | Tannin | Phytic acid |
| B1 | 0.09±0.01c | 0.61±0.11c | 14.54±0.31c |
| B2 | 0.13±0.02b | 0.89±0.09b | 16.08±0.14b |
| B3 | 0.15±0.02a | 1.04± 0.03a | 17.62±0.35a |
| CO | 0.00±0.00d | 0.43±0.05d | 13.11±0.29d |
| Variety  A | 0.08±0.05c | 0.78±0.24a | 15.20±1.51c |
| H | 0.09±0.06b | 0.67±0.27b | 15.34±2.01b |
| O | 0.10±0.07a | 0.79±0.24a | 15.45±1.79a |
| CV % | 9.09 | 3.48 | 0.15 |
| LSD | 0.01 | 0.04 | 0.02 |

1. Effect of Blending Ratio and Wheat Variety on Sensory Acceptability of Composite Bread

Table 8 presents the sensory acceptability data of the composite breads. Generally, blending ratios showed significant differences in acceptability in respect of the different sensory attributes. Color scores of 4.53, 4.37 and 4.02 in a scale of 7 points were recorded for breads containing 30, 40 and 50% taro root flour indicating a general trend of reduced acceptability as the proportion taro flour increased. The differences between the 30 and 50% taro blending were statistically significant at P < 0.05. The control bread sample with 100% wheat scored average value of 5.94, of course significantly higher than any of the composite breads.

Similar trend was observed regarding taste with scores of 4.67, 4.43 and 4.02 out of a maximum of 7 for breads of 30, 40 and 50% taro blend. Significant difference was noted between the lowest score and the remaining two. The control bread sample with 100% wheat scored average value of 5.98, being significantly the highest.

Regarding the aroma of the bread, the scores recorded were 4.82. 4.73 and 4.29 for breads of the three taro blends in the same order the lowest value being statistically (P < 0.05) different from the rest. Once again the control sample received score of 6.08 in a scale of 7 points.

Texture wise the sensory acceptability scores for breads of 30, 40 and 50% taro flour mix were 6.18, 6.01 and 5.77 out of 7, with significant (P < 0.05) differences among them. Increase in taro proportion resulted in decreased texture acceptability, although the scores were relatively high in the scale showing good level of acceptability. No difference was observed between scores of the control sample (6.15) and that of bread with 30% taro blend.

Overall acceptability scores of the composite breads were 4.95, 4.75 and 4.53 for breads of 30, 40 and 50% taro blends, respectively. The significant difference was only between the highest and the lowest of the three scores. The control sample of the whole wheat bread received an average of 6.01 in a scale of 7 points, being statistically the highest. Generally the overall acceptability decreased with increase in taro blends but remained within the positive acceptability attitudes.

Table 8. Effect of blending ratio and wheat variety on sensory acceptability data of wheat-taro composite breads

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Factors | Parameters |  |  |  |  |
| Blending  Ratio | Color | Taste | Aroma | Texture | Over a all acceptability |
| B1 | 4.53 ±1.99b | 4.67± 1.89b | 4.82 ±1.77b | 6.18 ±0.62a | 4.95± 1.77b |
| B2 | 4.37 ±1.89bc | 4.43 ±1.70b | 4.73 ±1.69b | 6.01± 0.37b | 4.75± 1.62bc |
| B3 | 4.02± 3.67c | 4.02± 1.58c | 4.29 ±1.44c | 5.77± 0.65c | 4.53± 1.48c |
| CO | 5.94 ±0.85a | 5.98± 0.96a | 6.08± 0.79a | 6.15 ±0.66a | 6.01 0.61a |
| Variety  A | 6.09 ±3.03a | 6.05 ±0.98a | 6.02 ±1.00a | 6.18± 0.86a | 6.17 ±0.76a |
| H | 4.33± 1.36b | 4.40 ±1.39b | 4.51± 1.28b | 6.02± 0.39b | 4.74 ±1.25b |
| O | 3.74± 1.95c | 3.90± 1.89c | 4.41± 1.89b | 5.87± 0.41c | 4.26 ±1.76c |
| CV % | 44.15 | 25.69 | 24.71 | 8.95 | 22.47 |
| LSD | 0.47 | 0.28 | 0.28 | 0.12 | 0.26 |

1. Conclusions

Taro has higher contents of ash, crude fiber, ^-carotene and zinc showing the potential to improve some quality attributes of the bread but it also has higher anti-nutrient factors than wheat which hampers nutrient availability.

The study revealed that taro flour can be incorporated into wheat flour to produce breads of acceptable sensory qualities. All the data showed positive attitudes on the consumer side in all sensory attributes including the overall acceptability. Zinc, phosphorus and ^-carotene improved significantly with the incorporation of taro flour. However, the tannin and phytic acid contents of the breads increased relative to whole wheat bread, which might interfere with the availability of the nutrients in the bread unless taken care of by process techniques and other methods. Other quality attributes of the bread were also influenced negatively but remained within acceptable limit.

Blending of taro flour in wheat flour has affected many of the quality attributes of the bread like the volume, color and texture. Increase in taro proportion reduced the positive aspects of these attributes leading to reduced acceptability in relation to the whole wheat breads. However, sensory acceptability scores of all composite breads remained within the scale of positive attitudes. The wheat varieties showed differences in proximate composition, mineral contents, anti-nutritional factors and sensory acceptability with variety Hidase resulting in the highest sensory acceptability rate.

1. Recommendations

The study on the incorporation of taro root flour into wheat flour for bread production was carried out following the procedure established for whole wheat bread and these might not be appropriate for composite wheat-taro flour. It is important to extend the

study in search of most appropriate procedures including fermentation time and temperature, proofing period, baking temperature, etc. that could give wheat-taro composite breads best quality attributes. It is also necessary to study alternative use of taro alone or in combination with other grain crops.

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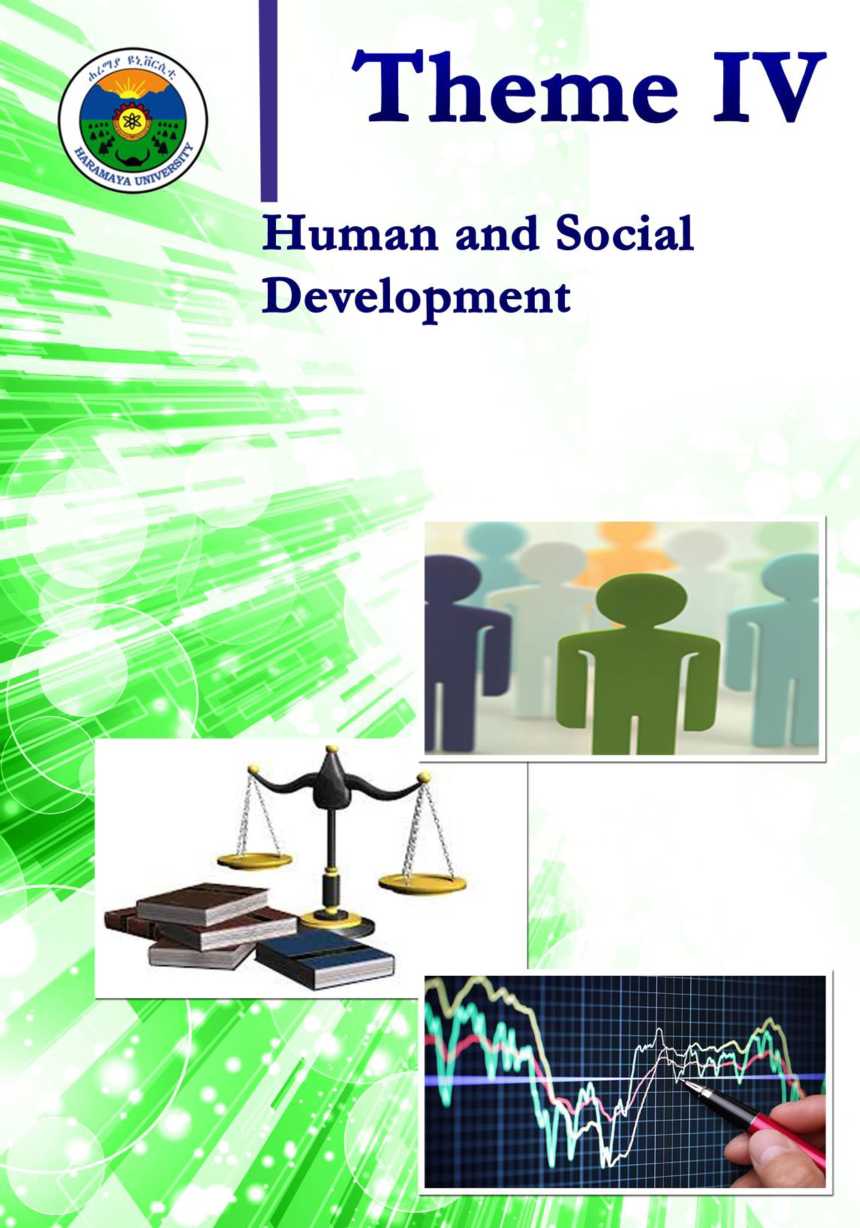
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**Theme IV**

1. Causes for Instructors’ Intensions to Leave Public Universities in Ethiopia

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Abstract: Staff retention has become a difficult task at public universities in Ethiopia. Senior and seasoned teaching and research staff turnover in these universities is high particularly due to better paying jobs in other organizations. Identifying the root causes of staff attrition at public universities in the country is key for ensuring staff retention and to attain sustainable expansion and quality of education and research. This would also enable policy makers to strategize and plan various mechanisms for maintaining the critical mass of teaching and research staff required to ensure quality education and research at public universities in the country.

The objective of the study was to elucidate factors that cause staff attrition at public universities in Ethiopia and suggest remedial measures. This study was undertaken in 2013/14 academic year at13 public (government) universities. The data for the study were generated through self- administered questionnaires and discussions with instructors, students, and university leaders. The data were analyzed using descriptive statistics with the support of some tests of hypothesis where comparisons were found to be necessary.The study revealed the low levels of motivation of staff to continue working at the universities. Accordingly, 63% of the interviewed instructors responded that they had low motivation to work at the universities and 73% revealed their intention to leave their jobs in the near future. Low salaries and dissatisfaction with poor governance systems of the universities were mentioned to be the major reasons for staff to leave their jobs. The interview results also indicated that the salaries to be paid at the universities in the study year should be as follows: 19,641.89 (Nineteen Thousand and six hundred and forty-one and 89 cents) for a person with the academic rank of professor. Recommended solutions include raising

salaries and improving the working environment for the staff, including good governance.

Keywords: Instructors; motivation; Low salary; Poor governance; Staff attrition; Staff retention

1. Introduction

Universities in Ethiopia have the triple mandates of teaching, research, and community engagement. They are also supposed to be the engine of societal transformation through technology and knowledge generation and dissemination. Human power is key for performances of universities in all fields of endeavours. Dedicated and creative work of teaching and research staff members is central to the attainment of the missions of universities. Therefore, the universities in Ethiopia need to establish the critical mass of teaching and research staff members to attain their goals. However, retaining staff particularly those who are experienced has become a major problem at public universities in Ethiopia. Staff are often reported to leave universities in search of better paying jobs in other organizations within the country or abroad.

Staff intention to stay at or leave a university depends on a number of motivating or de-motivating factors. Motivation refers to the process that accounts for an individual’s willingness to exert high levels of efforts to attain an organization’s goals, conditioned by effort’s ability to satisfy some individual needs (Robbins and Coulter, 2005). Theories give different factors for staff motivation. The three-need theory, for example, states that three major motives to work are need for achievement, need for power, and need for affiliation. On the other hand, the goal-setting theory has the proposition that specific goals increase performance and that difficult goal when accepted results in higher performance than easy goals. The expectation theory states that an individual tends to act in a certain way based on the expectation that the act will be followed by a given outcome and on the attractiveness of that outcome to the individual. On the other hand, the equity theory has the proposition that an employee compares his/her job’s input-outcome ratio with that of other relevant job titles and then correct any inequality. Hughes et al. (2006) puts this in a mathematical form as:

personaloutcomes referencegroup outcome personal inputs referencegroup input

Empirical studies give different reasons for employee turnover. Bawa and Jantan (2005), for example, state that staffing process and employee monitoring are effective in reducing voluntary turnover and economic factors such as availability of alternative jobs are the most likely relevant variables in explaining the staff turnover process. Hanna and Lucie (2011) summarizes the factors affecting staff turnover in seven groups without taking into account the personal reasons such as moving, starting a family, illness, retirement or restarting studies. These seven factors are:

1. Low pay (remuneration, benefits, imbalance between performance and reward);
2. Future certainty (trust in the company’s vision, following business ethics, trust in leaders/management, new projects and innovations, speed of employee turnover, a vision of the future);
3. Relationship at work place (co-operation, treatment, fairness, tolerance, helpfulness, the style of assigning and performing tasks);
4. Roles and positions (recognition) in the organization (prestige, opportunities, development, recognition);
5. Communication within the organization and its level ( type, feedback, concealing of information, respecting opinions);
6. Organizational culture (workload, flexible working hours, access to sources, type of culture, focus on quality); and
7. The expectation (imbalance between work and personal life, unclear assignments, expectations),

In this study, these factors were found to be statistically significant in determining employee turnover.

Evidence from the Human Resource Management and Development Office of Haramaya University showed that about 134 academic staff members left the university in the 2012/13 academic year alone. When this attrition is seen in terms of academic rank, 72 were lecturers, 20 were assistant lecturers, 20 were graduate assistants, and 10 were assistant/associate professors. This implies that about 61% of the staff who left the university were the ones on whom the university invested a lot of resources for their education. The turnover of graduate assistants and assistant lecturers (30%) also imply the existence of some problems even in retaining junior and inexperienced staff members. The Institute of Technology, College of Medical and Health Sciences, College of Agriculture and Environmental Sciences, and College of Business and Economics share 38, 32, 16 and 14 of the staff attrition, respectively. Staff attrition in the aforementioned colleges indicates a serious threat to the government’s effort to meet the millennium development goals and its growth and transformation plan.

Except the one year-staff attrition data that we obtained from the Human Resource Management and Development Office of the University, no information was available on staff attrition rate as well its causes. This study was designed to fill such a research gap. In addition, no empirical evidence was available on staff attrition and the reasons thereof at other public universities in the country. Cognizant to this research gap, we selected 13 public universities in the country to conduct the study. The universities were selected purposively considering their varied geographical location in reference to the distance from the capital, Addis Ababa as well as based on their varied years of establishment. The main objective of the study was to elucidate the level of staff retention and mobility and to identify major causes for staff attrition at the universities.

1. Methodology

This study was aimed at investigating the major causes/correlates of staff turnover in purposively selected Ethiopian public universities and come up with possible solutions for the identified problems. Such objectives need both official data and responses from concerned staff. The staff included those who were working at the universities during the study period (active employees) as well as those who left the universities for various reasons. The study design is, therefore, explained as follows.

* 1. Data and the Methods of Data Collection

Based on the literature reviewed in the background, the variables that are supposed to affect staff turnover were university environment which includes administrative support in assigning duties and work load; entry, stay and leave procedures; staff involvement in university affairs and the employee characteristics which include gender, culture, ability and performance in teaching/research/community services; psychological factors, etc. Data were also collected on the demand-supply nature of the specific fields of study. The secondary data included the number of staff who left the particular university by level of education, field of study, type of termination, and years. The data collection questionnaire was designed based on the general scientific literature as well as the contents of the Higher Education Proclamation (No. 650/2009) of the Federal Democratic Republic of Ethiopia.

In article 7 of the Higher Education Proclamation (No. 650/2009), it is stipulated that the guiding values of higher education institutions are 1) pursuit of truth and freedom of expression of truth; 2) institutional reputability based on successful execution of mission; 3) competitiveness in scholarship and cooperation with other institutions; 4) institutional autonomy with accountability; 5) participatory governance and rule of law; 6) justice and fairness; 7) a culture of fighting corruption; 8) quality and speedy service delivery; 9) economical use of resources and effective maintenance of assets; 10) recognition of merit; and 11) democracy and multiculturalism. The same proclamation also clarifies the rights and the responsibilities of academic staff members in its articles 31 and 32. The way these values are exercised directly or indirectly affects university staff retention. Hence, some of the questions in the questionnaire emanated from these values.

The selection of the universities was based on geographical location, years of establishment, distance from the country’s capital, environmental setting (urban/rural). Accordingly, fourteen universities were selected as shown in Table 1.

Vice-Presidents for Academic Affairs and/or directors/heads of Human Resources Management of the respective universities were contacted in order to get the general idea of the colleges/schools from which instructors leave most frequently as well as those from which they leave less frequently, were selected for the study. The colleges/schools helped us in identifying the relevant departments in the same way.

Vice-Presidents for Academic Affairs, directors/heads of Human Resources Management, college/faculty deans, and department/school heads were included in the interview. Graduating class students from the selected department were also interviewed

to share their experiences about staff turnover in the last three to seven years. About 507 instructors filled in the questionnaire that deals with the intention to leave and other issues related to instructor’s turnover and work at the respective university. This paper is based on the findings from 13 universities only since one out of the 14 universities refused to give us permission to conduct the interview. The results and discussions also focused on the responses of the instructors as they are the main stakeholders. It was not possible to interview staff who had already left the universities since we could not trace them easily. The scope of this study is, thus, limited to active staff members who were on duty during the study period.

* 1. Methods of Data Analysis

The data were analyzed using descriptive statistics. Responses were put in percentages and means of quantitative values. Although regression analysis is commonly used in identifying the determinants of an outcome variable, we opted to use descriptive statistics as the instructors themselves told us why they wanted to leave their universities. That means, we may not need probability models in the case the causes are deterministic at least by asking the respondent. Inferential statistics like chi-square test of association and t- test were also applied to test the degree of association between two qualitative variables and to test the significant differences between groups or between observed values and expected values.

Table 1: Selected Universities by region and special characteristics.

|  |  |  |
| --- | --- | --- |
| University | Region | Special characteristics |
| Haramaya | Oromia | Rural, remote, old |
| Jimma | Oromia | Urban, remote, old |
| Maddawalabu | Oromia | Urban, remote, new, cold |
| Wollega | Oromia | Urban, remote, new |
| Adama | Oromia | Urban, old, center |
| Samara | Afar | Rural, remote, new, hot |
| Bahir Dar | Amhara | Urban, remote, old |
| Wollo | Amhara | Urban, remote, new |
| Hawassa | South | Urban, old, hot |
| Arbaminch | South | Urban, remote, old, hot |
| Mekelle | Tigray | Urban, remote, old |
| Adigrat | Tigray | Urban, remote, new |
| Addis Ababa | A.A | Urban, central, old |
| Gondar | Amhara | Urban, remote, old |

1. Results and Discussion.

We collected the filled questionnaire from 507 (male= 474, female=33) university instructors from the 13 universities (see Table 2). About 38% of the instructors reported that they were married whereas 62% reported that they were single. The average family size was three. The average age of the instructors was 29.64 years. About 68.5% of the instructors were Master’s degree holders, 25.5% were first degree holders, 5.8% were

PhD holders, and 0.2% had specialty certificates. Accordingly, 67.7% were lecturers, 8.3% were Assistant Professor and above, and the remaining were either graduate assistants or assistant lecturers. Among the instructors, 43.1% were assigned to work at the universities by the Ministry of Education (MOE), 45.4% were employed directly by the universities, 8.3% were transferred from other universities and others joined the universities from non-teaching organizations. Out of the 507 instructors, 61.4% lived in rented houses while 23.7% lived in university apartments outside the university, and only 11.3% lived in university apartment on the campuses of the universities. Payment of housing allowance was reported to be associated with problems related to staff attrition. The instructors reported that the current housing allowance level did not allow them to rent a decent house let alone a standard one. It was also found that only 2.8% of the instructors lived in their own houses.

Asked about their friends who left their universities, the instructors stated low salaries and lack of other financial incentives, lack of facilities (housing, office, and laboratory facilities), lack of good governance, family problem, and less attractive working environment as causes for leaving their jobs at the universities.

Table 2. Number of instructors interviewed.

|  |  |
| --- | --- |
| Name of university | Number of instructors |
| Addis Ababa University | 32 |
| Bahir Dar University | 35 |
| Gondar University | 53 |
| Mekelle University | 27 |
| Adigrat University | 34 |
| Wollo University | 42 |
| Samara University | 40 |
| Adama University | 28 |
| Jimma University | 36 |
| Maddawalabu University | 34 |
| Hawasa University | 37 |
| Haramaya University | 71 |
| Arba Minch University | 38 |
| Total | 507 |

The instructors were also asked about their own motivation and intention to continue working at the universities. Nearly 63% of them indicated that they were not at all motivated to continue working at the universities. This indicates that attaining the missions of the universities is under threat since more than 60% of the staff are not motivated to continue working. Therefore, a serious attention should be given by policy makers to change this trend.

Considering the way through which the staff joined the universities, only 47% of those directly employed by the universities reported to be motivated to continue working. On the other hand, only 28.6% of staff directly recruited and assigned by

Ministry of Education to work at the universities reported that they were motivated to continue working. Those who were directly recruited by the universities as well as those relocated from other organizations cited disillusionment as the major de­motivating factor to continue working. Instructors who were directly recruited and assigned by the Ministry of Education claimed that the distant location from their birth places as well as unpleasant weather conditions were the major de-motivating factors. In private, some instructors revealed that the desire to study for higher degrees was their only motivation to be employed by public universities. The contractual agreement they enter with the universities as well as the subsequent holding of their degrees until they would serve for the stipulated years of service after a postgraduate study was described to be a demotivating factor according to information obtained from some instructors.

Table 3. Association between the motivation at the current university and the way the instructor joined the university (chi square=21.476, p=0.000).

How did you join at the University? Tot al

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Employed by | Transferred from | Assigned | by | Transferred/left from | Others |  |
|  |  | the University | other University | ministry | of | other non-teaching |  |  |
|  |  |  |  | education |  | organization |  |  |
| Are | you Yes | 105 (47%) | 11 (37.9%) | 61(28.6%) |  | 1 (11.1%) | 4 (57.1%) | 182 |
| motivated | to |  |  |  |  |  |  | (37%) |
| work at | the No | 118 | 29 | 152 |  | 8 | 3 | 310 |
| current |  |  |  |  |  |  |  |  |
| University?  Total |  | 223 | 40 | 213 |  | 9 | 7 | 492 |

Similarly, about 73% of the instructors had the intention to leave their universities at any time in the future. When seen from the perspective of the way instructors joined the universities, about 81% of those who were directly assigned by the Ministry of Education expressed the intention to leave soon while about 66% of those who were directly employed by the universities had also the intention to leave in the near future. In this regard, the majority of the instructors had the intention to leave irrespective of the way they joined the universities although the figure is high for those who were assigned by the Ministry of Education. The reasons indicated by the instructors for their intentions to leave the universities are ranked and given in Table 4. Low salary and lack of other financial incentives and bureaucratic administrative systems were found to be the most important causes for the intention to leave the universities. It was also identified that 35 instructors expressed their demotivation to continue working at the universities but said that they did not have immediate intentions to leave the universities. The majority of them stressed that they would not leave their universities since it’s located in the midst of their birth places and will rather strive to work hard to contribute to the betterment of the life of the future generation in the area. One instructor said, “I will serve my country in the same university hoping changes will come in the future”. Similarly, 94 instructors expressed the intention to leave the universities even though they were motivated to work. Despite having the motivation to work, most of these instructors resented the state of working in a locality very far away from their relatives’ domicile.

As the main stakeholder, instructors gave a number of recommendations for change to attract and retain staff. The need to increase salaries was the foremost recommendation. Accordingly, they recommended minimum salaries under 2013/14 market conditions (see Table 6) which is 19,641.89, 16,165.40, 13,458.92, 10,517.47, 7,385.26 and 5,477.09 Birr for Professor, Associate Professor, Assistant Professor, Lecturer, Assistant lecturer, and Graduate Assistant, respectively. Instructors also recommended that the 35% taxation imposed on their salaries as well as honoraria for part time work have to be reduced. They also suggested that the minimum wage or salary on which tax must be imposed should be raised beyond the current one which is 150 Birr. Changing that level at least to the current new minimum 615 Birr may reduce some economic burden from employees. What is called maximum salary, which is Birr 5000, has also been changed. Hence, the salary level for 35% tax must be re-fixed.

Table 4. Reasons for instructors’ intention to leave their universities.

|  |  |  |  |
| --- | --- | --- | --- |
| Reason for the intention to leave | Number of instructors | %  who agree to the reason | Type of  problem |
| Lack of financial incentives outside salary?? | 353 | 90.3 | Income |
| Low salary | 355 | 87.9 | Income |
| Lack of  value/rewards/appreciation/recognition to my works or performance | 342 | 76.9 | Income, admin |
| Lack of opportunities for part time work | 348 | 72.1 | Income |
| Lack of timely responses to my requests | 337 | 68.3 | Admin |
| Congested office spaces, lack of office facilities | 349 | 68.2 | Admin |
| Lack of positive responses to my requests | 342 | 66.4 | Admin |
| Lack of organs to handle complaints | 330 | 65.7 | Admin |
| My expectations have not been met | 335 | 65.4 | Income, admin |
| Lack of participation in decision making | 340 | 60.9 | Admin |
| Absence of fringe benefits | 310 | 60.6 | Income |
| Lack of academic freedom | 348 | 56.0 | Admin |
| Because social status of teachers is quite low | 343 | 55.4 | Social, political |
| Lack of participation in university affairs | 342 | 55.3 | Admin |
| Unfairness in assignments | 336 | 54.3 | Admin |
| Unfair selection and recruitment procedures | 335 | 50.2 | Admin |
| Discrimination in selection for future studies | 334 | 47.6 | Admin |
| Fear of retribution when I comment on required changes | 327 | 45 | Admin |
| Unfairness in granting promotions | 322 | 41.9 | Admin |
| I am unable to publish research paper as required | 333 | 38.7 | Personal |
| Because of my family related problem | 331 | 36.0 | Personal |
| Unfavorable weather condition | 340 | 34.7 | Environment |
| Because I do not like the style/personality of my boss | 331 | 23.9 | Admin |
| Difficulty to work with pears (co-workers) | 329 | 23.7 | Environment |
| Lack of good school for the education of my children | 321 | 19.0 | Environment |
| Because of my health problem | 331 | 18.8 | Personal |
| Unable to follow organization timing, rules and regulation | 327 | 17.7 | Admin |
| Because some friends/relatives are changing jobs | 333 | 12.0 | Environment |
| Because of fun | 316 | 10.1 | Personal |
| Because teaching is a difficult job | 327 | 8.0 | Personal |

Before we finalized writing this report, the government announced a new salary scale for all government employees. The government action is appreciable as it answers one of the greatest questions of instructors working at universities. In the announcement, the

government said that it utilized its maximum financial capacity in fixing the new salary scale. The results indicated in Table 6 show; however, that the instructors’ expectation is significantly more than the salary increments made. This may be because of policy lags. The government promised to assist its employees through other incentive mechanisms. As researchers, we displayed the differences between the salary increment and the expectations by instructors according to this study. A study is also required to assess the current market situation and re-fix the salary that goes with the market at least for some five years.

Table 5. Association between the intention to leave and the way the instructor joins the university (chi- square=12.542, p=0.014).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| How did you join at the University? | | |  |  |
| Employ | Transferr | Assigne | Transferred/ Othe | Tot |
| ed by | ed from | d by | left from rs | al |
| the | other | ministr | other non- |  |
| Universi | Universit | y of | teaching |  |
| ty | y | educati  on | organization |  |

If you Ye

are not s

motivate

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| d, do you have the intention to leave the  Universit  y? | 145 (65.9%) | 30 (73.2%) | 170 (80.6%) | 6 (66.7%) | 6 (85.7%) | 357(73.2%) |
| No | 75 | 11 | 41 | 3 | 1 | 131 |
| Total | 220 | 41 | 211 | 9 | 7 | 488 |

The instructors also suggested the following to be fulfilled in order to curb attrition.

1. Providing a competitive housing allowance and making it free of tax;
2. Providing transport facilities for staff on their daily routines in nearby market and towns;
3. Providing staff with opportunities for part time work;
4. Providing houses on campuses;
5. Providing decent school for staff children;
6. Providing loans for staff to own/buy cars;
7. Providing staff with land and loans to build own houses;
8. Placing the right persons in university positions based on merit and competence only;
9. Providing staff with lap tops, scanners, and other amenities;
10. Rewarding good performances and holding people accountable for bad performances (Institute reward and punish systems);
11. Providing good infrastructure at work places;
12. Providing decent staff lounges and catering services for staff;
13. Provide staff with improved education and research grant opportunities;
14. Providing staff with health insurance;
15. Reduction in the amount of tax imposed on staff (for example 35%) to 2% for part time income after working for own and other organizations;
16. Establish strong links with overseas universities for collaborations in teaching, research, and community engagement;
17. Salaries of fresh Master/PhD graduate and those who have experiences should not be the same even if there is no change in the rank;

20. Recruiting many local staff rather than paying lots of money for expatriate staff; and

1. Avoiding forceful assignment of staff to work at universities that are not their choices against their interests.

Table 6. New minimum salary recommended by the instructors against the old and new government salary levels, by academic rank

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Recommendation by instructors | |  | Old salary (B) | New salary New salary increased by the government  (C) | iffeDrence (C-A) |
| Academic Rank | Number of respondents | Mean minimum  expected salary (A) | Std. Deviation |  |
| Technical Assistant | 274 | 3,842.35 (211.62%) | 1,724.104 | 1233 | 1663 (34.87%) | -2,179.35 |
| Graduate Assistant | 311 | 5,477.09 (143.43%) | 2,261.108 | 2250 | 3145 (39.78%) | -2,332.09 |
| Assistant Lecturer | 310 | 7,385.26 (93.33%) | 3,186.827 | 3820 | 5077 (32.91%) | -2,308.26 |
| Lecturer | 403 | 10,517.47 (128.39%) | 5,727.007 | 4605 | 7286 (58.22%) | -3,231.47 |
| Assistant Professor | 305 | 13,458.92 (147.25%) | 6,741.488 | 5443 | 8847 (62.54%) | -4,611.92 |
| Associate Professor | 296 | 16,165.40 (154.69%) | 9,009.388 | 6347 | 10790 (70%) | -5,375.40 |
| Professor | 296 | 19,641.89 (168%) | 11,082.969 | 7329 | 13468 (83.76%) | -6,173.89 |

Note: The differences are statistically significant at a—0.01.

The staff strongly urged promotion of good governance at the universities. They recommended the following in this respect. According to the participated staff, all university positions, including the president position, should be filled based on merit rather than by political affiliations or loyalty. They urged also the availability of people on managerial positions at offices for services instead of frequent meetings and travels; and top university management should treat all colleges, schools and departments in fair and similar manners. Capacity building training for both university management and the staff; avoiding religious, ethnicity, birth place and other biases/discrimination by the university management at different levels in assignments, education opportunities, promotion, research grant and other areas in the university system were also other important recommendation given by them. They continued recommending clear government and university strategies supported by research evidence; cultures of transparency and accountability where the staff can express own ideas without fear and retribution/revenge; ensuring rule of law; and the distribution of burdens and benefits among all in order to avoid exploitation. Flexible management that has the ability to understand and interpret laws, rules and regulations in the country and the university was also another important recommendation made by the instructors. The other recommendations include assigning competent anticorruption commissioners, who are free of religious and ethnic bias/discrimination, not corrupt themselves and who are independent of university management and different and fair rules and regulations for staff and students where the staff resides in the campus. It was also suggested that instructors should not be forced to serve double of the years they studied for masters/PhD as being practiced in some universities. Studying while serving the universities, studying abroad, studying in local universities, and studying in own university should have different waits in contractual agreements for future services required of the staff who gets study leave opportunities. Instructors suggested also that the service the staff gave before going for further study should also be counted in the agreement to be fair between the staff and the organization as some staff gets the opportunity after serving for longer time than required.

1. Conclusions and Recommendations

Based on the finding of the study, the following conclusions are made.

1. About 61% of university staff, on average, lives in a rented house but the housing allowance is insufficient under the prevailing market prices.
2. About 70% of academic staff, on average, has no means of earning income other than the basic monthly salary.
3. About 63% of academic staff in the studied universities, on average, is not motivated to work at their universities.
4. On average, 73% of the instructors in the universities have the intention to leave their universities in any time in the future.
5. Low salary, absence of other sources of income beyond salary, and lack of good governance at different management levels in the universities were among the major causes of staff turnover.
6. The instructors who work in the universities nearest to their birth places do not have the intentions to leave even if they are not motivated. They want to struggle to bring changes rather than escaping.
7. Instructors’ minimum salaries at 2013/14 market conditions to be 19641.89, 16165.40, 13458.92, 10517.47, 7385.26 and 5477.09 birr for full professor, associate professor, assistant professor, lecturer, assistant lecturer and graduate positions, respectively. The salary adjustment made by the government some weeks after our data collection but before our data analysis falls significantly below these recommend levels.
8. The culture of exit interviews is low in many places either because of lack of awareness of its benefits, lack of attention to the institutional development or for fear of inability to answer what the staff could raise in the process of the interview.
9. University physical environment is also one of the causes of instructors’ turnover in some universities.
10. Staff raise the tax rate and its fairness when working for own university and when working for other universities. They consider it best to work for other universities whenever there is part-time work as they are taxed 35% when working for own university but 2% for other universities.

Based on these major conclusions and other findings discussed in the text, we give the

following recommendations.

1. Improving salary levels based on the suggestions of the staff and adjusting it to the prevailing market conditions. There must be some sort of optimization between the instructors’ recommendations and the government made salary adjustments. As there are few full professors in the country, for example, it is possible to raise their salaries even more than what the staff recommended so that people work towards achieving such higher levels. The benefit gained by doing so is by far more than the cost incurred by paying such a salary. The salaries of other levels can be adjusted accordingly in such a way that instructors are motivated to work and other are also motivated in joining university teaching positions.
2. The tax levels should change with salary adjustments made and to be made by studying its impact on the motivation to work and country’s investment.
3. Instructors have to be given houses in the campus or paid the allowance that is sufficient for renting houses in the prevailing market conditions.
4. Government has to install system of good governance in its universities and monitor the implementation of the same. Assigning visionary leaders to universities can also help in this regard. Complete homogeneity of people from the same religion and/or from the same birth place or relatives in university management positions should be minimized to avoid discriminations.
5. The universities have to make their university physical environment comfortable for life. Offices, classrooms, cafeteria, residence houses, toilets, residence houses and laboratories are those which the universities can change themselves.
6. Creating opportunities of double employment and encouraging staff to work/ be transferred in the areas of their interests can also reduce staff turnover a lot.
7. Universities regulations concerning staff rights to further education, promotion, transfer, research, and other should be clear and consistent. Decisions should not be based on the personal judgments as judgments change when the persons change.
8. Instructors have to work themselves also to upgrade their statuses by participating in research, publication and consultancy works. The most competent the instructors will be the better the opportunity to bring changes in the universities.

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1. Investigating Community-based Conflict Dynamics in Selected Woredas in Eastern Hararghe Zone

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Abstract: Our research is an intensive inquiry into causes and dynamics of land-related conflicts and conflict governance problems in east Hararghe Zone. The research was conducted in two selected districts of the zone, namely Kombolcha and Haramaya districts. During the study, attempts were made to identify the social, cultural, attitudinal, economic and demographic factors that contribute to land-related conflicts in the area. In both districts, land and water are the scarcest natural resources. The trends show that lack of other sources of livelihood in the area and the community members’ socio-cultural attachment to land have contributed to intensity and complexity of violent conflicts over land. Population pressure combined with commercialization of agricultural products in the area increased both the demand for land and the intensity of conflict over it. The other source of land-related conflict in the area is an illegal and poorly documented practice of transferring land to neighbors or relatives. Above all, a gradual decline in the power and influence of the customary institutions of conflict prevention, management and resolution reduced the effectiveness of conflict management and justice protection in the area. The research revealed that the community members spend their economic assets over land ownership disputes and rival claims. They lose a significant portion of their time in courts to win bitter disputes. The disputes often become complex and prolonged since other elements that aggravate differences emerge in the process including the individuals who manipulate the created disputes to fulfill their selfish economic and social motives. Usually, the disputants were exposed to conditions that not only drain their economic assets, but also endanger their social capital. In the sample districts, families became disintegrated and neighborhood relations broken as a result of land-related conflicts. It became clear also that some individuals commit fatal crimes when they are frustrated by the injustice around decisions made on disputed resources that caused them to become unfair losers. In this area, there is strong linkage between natural resources, governance and conflicts in the area. Based on our study, we concluded that the attempt to overcome land-related conflicts and violence in the area should take into consideration the broader context within which the

problems occur. This includes transforming the cultural, social, and economic foundation of the problems.

1. Introduction

There is strong nexus between natural resources, governance, and conflict in countries like Ethiopia where rural livelihood is primarily based on natural resources. Eastern Ethiopia is known in the country as one of the areas where low-level, but incessant intra-group and inter-group conflicts over ownership of natural resources such as land and water points prevail. One good example of intra-group conflict is resource-based conflicts between neighbours and family members in highland and farming communities in various districts of Eastern Hararghe Zone, Oromiya. The conflicts in the area have complex and interacting linkages with population pressure, environmental degradation and stiff competition over scarce resources.

The project attempted to investigate community-based conflict dynamics in selected woredas of Eastern Hararghe Zone by focusing on land-induced conflicts. The study was an exploratory analysis of the nature of the conflicts and their socio-economic impacts. Attempts were made to provide integrated accounts of the conflicts, their causes, consequences, dynamics and trends. The study was conducted in two conflict prone districts of Haramaya and Kombolcha. The two districts were identified in consultation with concerned government units both at zonal and district levels.

The study was designed with the assumption that the interpersonal conflicts between neighbours and family members in the agricultural communities living in districts of the Eastern Hararghe Zone is strongly connected to population pressure, environmental degradation and the resultant stiff competition over the available resources. The other assumption was that the conflict dynamics could be exacerbated by the declining power and influence of community-based institutions of conflict prevention, management and resolution. Another assumption was that the major causes for gradual degradation of natural resources are population pressure, poor concern for natural resources such as water and soil, ineffective and uncoordinated policies on natural resources management and utilization, and the negative impacts of the broader environmental failure in the region.

* 1. Objectives of the Research
     1. General objectives

The overall objective of the research wasto investigate the community-based conflict dynamics in two conflict prone woredas in Eastern Hararghe Zone.

* + 1. Specific Objectives

The specific objectives of the research were:

* Identifying and analysing the major causes of the conflicts in the study area
* Analysing the consequences of the conflicts in the communities
* Examining the interconnectedness of the causes of conflicts
* Assessing the dynamics and trends of the conflicts;
* Assessing measures being taken to deal with the conflicts and evaluating the magnitude of interventions and their outcomes;
* Exploring the views and concerns of the local community members’ and the government representatives about the conflicts in the area and ;
* Examining the status of the customary as well as formal institutions in dealing with the conflicts
  1. Research questions

The research attempts to find answers to the following research questions.

1. What are the major causes of the conflicts in the study areas?
2. What are the consequences of the conflicts in the communities?
3. In what way are the major causes of conflict interconnected?
4. What are the conflicts and trends?
5. What measures have been taken so far to prevent, manage and resolve conflicts in the area? What contributions did the interventions, if any, make in helping overcome the conflict-related challenges?
6. What are the views and concerns of the community members and the government representatives regarding the conflicts and their impacts?
7. What roles are the formal and informal institutions playing in preventing, managing and resolving conflicts in the area? What are the factors, if any, that minimize the power and influence of the institutions?
8. Materials and Methods

The data required for this study was generated from field researches in rural areas of the districts identified to have long been conflict prone. The research was qualitative case analysis (Yin, 2003). The research blended elements of both descriptive and explanatory case studies. In other words, in addition to describing the nature of phenomena under study, it attempted to generate explanations for the occurrences of the phenomena. The data required for the research were in-depth descriptions of situations, events, people, interactions, observations, accounts of participants (e.g. attitudes, thoughts and feelings) and the direct words of those who undergone or were undergoing experience and usually appear in the form of texts, pictures, audio and video recordings (Hancock &Algozzine, 2006).

* 1. Description of the Study Area

The research was conducted in Haramaya and Kombolcha. The areas’ altitude is between 1850 and 2200 meters above sea level and can be generally categorized as

“WoinaDega” agro-ecological zone with an average annual rainfall of 870mm (560— 1260mm range) (Defersha et al 2011). Both of these districts are known for cultivating khat, vegetables, sorghum and maize. The districts are highly overpopulated and are known for high scarcity of natural resources per population. Agriculture is the mainstay of rural livelihood. The agricultural products such as khat and diverse vegetables are highly demanded in local as well as regional markets. This makes land an important resource. In both districts, land provides a sense of security and the principal source of income for farmers (Crewett&Korf, 2008). In addition, land is the main cultural commodity on the basis of which social practices such as marriage and inheritance are conducted. In this respect, land is not only an economic resource, but also a symbolic resource. It is the sustainer of social and cultural contract. Since land is scarce and is unable to fully support family, some family members mainly women in the districts are involved in petty trades. Women are important figures in selling agricultural resources in neighbouring towns. Because of this reality, the role of women in conflict dynamics was also addressed in the study.

* 1. Research Participants and Sampling Procedures

The principal participants in the research were community representatives, elders, religious personalities in the community, government representatives including development agents, justice officers, police officers, and youth and women representatives. The research participants were recruited purposively based on the nature of the issues and sub-issues investigated. In general, the research involved as multiple representatives as possible to generate as rich and diverse data as possible. The number of representatives kept on increasing till the researchers felt that the data required for the study were saturated enough. Therefore, theoretical sampling approach is used to recruit the representatives. The respondents were recruited from various administrative units shown below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Administrative localities Haramaya District | from | the | Number of respondents involved | | |  |
| Elders | Females | Youth | Total |
| GobbeChala |  |  | 13 | 5 | 7 | 25 |
| GobbeSalama |  |  | 14 | 2 | 4 | 20 |
| KerrensaDarabba |  |  | 18 | 12 | 10 | 40 |
| KurroJalala |  |  | 10 | - | 5 | 15 |
| Hamumma |  |  | 16 | 5 | 9 | 30 |
| Total |  |  | 71 | 24 | 35 | 130 |
| Administrative localities | from | the | Number of respondents involved | | | |
| Kombolcha District |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  | Elders | Females | Youth | Total |
| Samte |  |  | 9 | 2 | 4 | 15 |
| Burka Naga |  |  | 20 | 2 | 5 | 27 |
| Worra Mohammed |  |  | 11 | - | 7 | 18 |
| Tatessa |  |  | 9 | 3 | 8 | 20 |
| Total |  |  | 49 | 7 | 24 | 80 |

In addition to the target rural community members, administrative officers of various levels were involved in the study. They included zonal, district and kebele level officers who were considered in the research as stakeholders in the community-based conflicts and their consequences. In total, 25 various administrative officers were involved during the research. They were involved at various phases of the research. At the beginning, they were involved to obtain information about localities known to be generally conflict prone. They shared also how they sensed the problems, their dynamics, trends and consequences, and the actions taken as well as strategies developed to overcome the challenges. The administrative officers were involved as well in the characterization, categorization and interpretation of the identified problems.

|  |  |
| --- | --- |
| Administrative Offices involved | Number of persons involved |
| Eastern Hararghe Zone Security Administration Office | 3 |
| HaramayaWoreda Administration Office | 5 |
| HaramayaWoreda Security Administration Office | 5 |
| HaramayaWoreda Public Affairs Office | 3 |
| KombolchaWoreda Security Administration Office | 5 |
| Administrative officers of the respective kebeles | 30 |
| Total | 51 |

1. Instruments and Procedures of Data Collection

The research tried to generate rich and multiple data through diverse methods of data collection. The three principal instruments of data collection chosen to meet the objectives of the research were in-depth one-on-one interview, field observations and focus-group discussions.

In-depth one-on-one interview, this is method of accessing the lived experience of people and the meanings they attach to their experiences. Through this tool, the researchers collected detailed data regarding the essence and operational processes of conflict resolution through the institutions. Data regarding the social psychological factors that affect the conflict resolution process and ways of dealing with the dynamics was also be collected through this instrument. The researchersengageed research participants in a lively, engaging, and interactive process of revealing the issue under study. The other most important information that was obtained through this instrument was the views of victims of conflict and the justice professionals about the overall quality of the reconciliation processes in meeting human’s need for justice and in balancing peacemaking with justice restoration.

Field observations: during this study, selected observations of settlement conditions, farming systems, population growth, land use strategies and problems, water scarcity and development practices, impacts of farming and water development practices on land as well as water body structure, land scarcity and land redistribution efforts within family members, land management problems and impacts of natural factors such as seasonal

floods on land structure. The impacts of these emerging natural as well as manmade factors on causing conflicts were reinforced through interviews and focus group discussions.

Focus group discussion: this tool was selected to qualify or substantiate the data collected through the in-depth one-on-one interview. At this occasion, the researchers engaged the research participants in the focus group discussion to provide explanations, details and interpretations about the issues under study. The main role of the researchers was eliciting the focus group discussion by asking questions and getting the participants to engage in extensive and in-depth analytical and interactive responses to the problem under study. The method was expected to yield a broader range of perspectives within a relatively short period of time regarding all of the issues addressed in research questions.



Figure 1. One of the Focus Group Discussions held with Community Members

1. Methods and Procedures of Data Collection

Following standard principles of data collection, the researchers collected data procedurally and step by step. First, conflict prone localities were identified in consultation with the administrative offices as well as through informal contacts with key informants. Based on that, the causes of the conflicts were identified and analyzed. Information about the causes and consequences of conflicts was identified at the community level involving diverse groups in the community including victims and perpetrators. Then, the government as well informal community-based institutions were contacted to evaluate the measures so far taken to deal with the conflicts and to minimize their negative impacts. After this, the interaction between causes of conflicts and the actions taken to minimize their negative impacts were examined thoroughly to gain an overall picture of the situation. Finally, the collected data were analyzed following standard procedures of data analysis and insights were drawn out of it.

1. Methods and Procedures of Data Analysis

The data collected through interviews, observations and focus group discussions were organized around major thematic areas. This is a system of integrating related issues, concerns and dynamics around dominant thematic categories. In this procedure, related cases were connected systematically to create broader themes. This helped avoid not only data fragmentation and repetition, but also maintain the inter-linkage between events, experiences and concerns. The major themes and cases characterizing their occurrence were first discussed independently, but later connected to other themes to provide a holistic picture of the issues under investigation. The insights gained from interconnected data analyses were explained in light of appropriate theoretical as well empirical literature.

1. Results and Discussion

As stated in the previous chapter, the findings of the investigation are presented here under systematically developed themes. Again, the inter-connection between issues in each theme will be revealed as deemed necessary.

Resource Scarcity, livelihood demands and conflict

According to Dijk and Bruijn (2005), scarcity is relative and must be understood in a local context and from a local perspective. Scarcity is the result of environmental degradation and most observers regard degradation as the result of land-use systems becoming maladapted because of population growth, technical inadequacies, and high levels of exploitation of soil nutrients. Scarcity is, therefore, induced by human action. When resources are scarce, people have no choice but to engage in a Darwinian struggle for survival and challenge others who compete with them for the use of the resources they need for their own survival. This type of struggle is inevitable among the rural community where land is scarce and agriculture is a base of livelihood.

As indicated in Chapter One of the report, the livelihood of the rural population of the two districts is largely based on agriculture. The common agricultural products in the area are Khat, sorghum, maize and vegetables of different kinds. Both districts have huge population. In both districts, agriculture is supported by scarce land and water resources. In both districts, khat seems to be gradually replacing other agricultural crops. This is followed by vegetables especially in the pockets of the two districts where ground water is available. The reasons why khat in particular is dominating the agricultural activities of the areas are the following. One is increasing economic benefits that go with cultivation of khat. The khat’s dominance in the area goes back to the last 25 years, but its increasing impact in the area is highly connected to the regional and international demands on local khat produces over the last 20 years. The data obtained from the respondents indicated that, in the Dergue regime, the peasants were forced to uproot their khat shrub and produced other types of crops such as maize, sorghum and vegetables. The Dergue in addition organized peasants under peasant associations to control both the production and business activities. With the downfall of the Dergue and the breakdown of central government in Somalia, illegal khat trading across the borders increased. This became a new incentive for the local peasants to make a drastic shift of their attention towards cultivation of khat. This was further exacerbated by the social, political and economic opportunities that characterized the transition period. Another policy-driven factor that promoted the value of khat is promotion of agricultural practices based on maximum use of the available land and water resources to enhance productivity. This shows the role of national policy on local livelihood practices mainly by creating what can be called a competitive and exploitive mentality at local levels. In general, the national as well as local resource use policies increased new demands and aggravated the old ones, but there was no system in place to control the drive to utilize the available resources.

In these districts, livelihood challenges are complicated by human and environmental factors that interact in mutually reinforcing dynamics. In the research sites, respondents claimed that the carrying capacity of the available resource, especially land and water, has generally declined from time to time again due various pressures. The reasons are the following:

1. Increasing population: in this area there has been uninterrupted population growth due to cultural and social reasons. Children in these areas usually get married early even without having adequate resource to support themselves and their upcoming children. Culturally, a male child has the right to claim over the land of his family and that is processed through the institution called miraga. This is the institution that manages claims over parents’ resources. The problem and pressure on this institution is that it deals with conflicts over parental resources in the context where those resources are already dwindling both in size and quality. In some conditions, the miraza institution attempts to operate in a context where land does exist to be apportioned. Even in that context, the parents are obliged to allocate resources for their demanding children from what they have saved in the form of money or other physical asset. As would be made clearer below, this problem is further exacerbated by continuing negative impacts of shortage of other livelihood strategies and environment.
2. . Over-exploitation of existing resource: Land has many, multifaceted values to people. The values provided to people by land and its relative scarcity has resulted in minor and major competitions for its possession, use, and management (Bergstrom, 2005). As indicated above, land is extremely scarce in the study areas. The same land is used to maintain life. The local market demand on khat and vegetables intensified land use in the area because the products have high market values that in turn intensify pressure on land. To produce as much product as they can, the peasants over-exploit the land as well as water required to grow the crops. The available scarce land is cultivated and re­cultivated throughout the year. There is no tradition of allowing land rest to re-generate its fertility.

Participants of the study had a view that depletion in the fertility of the land resulted in insufficient cultivation of products. This in turn caused failure in self-feeding capacity of households. This problem in turn evoked intra-communal and intra-family conflicts over access to and ownership of the available resources. As Bergstrom (2005) stated, the struggle for survival leads to competition for land as an input for producing the basic necessities of life such as food, shelter and clothing. In this context, conflict serves as a survival strategy and duplicates itself as system. Shortage of land resulted in unhealthy competition for access, which in turn developed hatred and intolerance among siblings.

In the land transference system of society, female children are totally illegitimate. The illegibility of females is based on the view that they are married away. Females are entitled to lands of their parents only under some circumstances. One is in a situation where the parents do not have male children. The other is by goodwill of their brothers. However, females sometimes claim over inheritance based on the constitutional and legal provisions of the country. This by itself igniting conflict between children especially if the female children married away are entitled to the lands through legal ownership enforcement mechanisms. The male children become intolerant when the husbands of their sisters come and work on the plots of their parents. There were cases where conflicts ignited by situation resulted in deaths of the brother in-laws. This intra-family problem leads to inter-familial or inter-communal conflicts. Another dimension of conflict is a situation where brothers compete over the plots left behind when a sister is married away.

Conflicts over resource occur also when one of their brothers owning plots dies. This happens usually when the man dies while his children are not young enough to inherit and take care of their deceased father’s property. The other brother enters the competition arena in several ways. One possible way is to claim responsibility to take care of the children of a deceased brother. After they have grown these children usually know that their father died a long time ago and his land was taken by their uncles. On the basis of information they start to reclaim the land of their father. However, the transference is not smooth since life has already deeply established on this same land. There were cases in Samtekebele of the Kombolcha District where such children fought violently to drive away their uncle who had married their mother upon the death of his brother. Tension within family and siblings get more complex and continue in a self- perpetuating manner mainly because the children of the long deceased father would enter a new cycle of violence with their half siblings.

There is also a case where men’s double marriage causes violent conflict between family members. A case in point is at Samte locality where a woman left her home with her two young male children simply because her husband had one more wife up her. After the children grew up she narrated to them how she together with them was displaced from her resources and forced to live a destitute life. From the story they told, the children learned that their father evicted them unfairly and unjustly and decided to claim justice on the basis of the cultural and social provisions. They directly went to the place where their mother claims to have had resources including land. They identified themselves as children of the village and approached their father to claim their mira%a. These happened years after the claimed land had already been inherited to other children by the second wife. The resource being claimed had already got strained due to massive economic and social pressure on it.

Though the children are entitled to get their share on the basis of the cultural institution, the condition did not allow mainly because the children of the second wife felt that strangers were trying to take away their resource. Both the children and the second wife refused to recognize the claimants as rightful children of the man. While in this tension, one of the claimants reacted violently to resolve the tension through violent and desperate mechanism. This violence resulted in severe physical disability on two children of the same father. The family and neighbors were exposed to unexpected social and economic crisis. As Azar (1990) states, denial of human needs is a source of conflict because basic human needs are experienced as defining of the self and the group, and perceived to be non-negotiable, and the resulting conflict is likely to be forceful, brutal, and, irrational.. Thus,the cost family who failed to negotiate and accommodate differences became easily vulnerable to huge financial and social costs as a result of the ensued violence. Before the physical violence occurred, the two claimants reacted against refusal of their rights by destroying a plot of land covered with khat plants there were ready for market to bring economic and moral damage on the family. It is that finally led to physical assaults which in turn brought about more complex economic as well as social pressures on the family.

To maintain their life, the rural community has to over-exploit the land till it totally stops to produce anything planted on it. However, to keep the land lively and active, the local community members employ various natural as well as artificial inputs. Water is also highly exploited to grow khatand vegetables. In both districts the farmers dig wells in or adjacent to their plots and draw the developed water through pumping machine. During the study, the researchers observed some critical problems resulting from the over-exploitation of water. One problem is pressure on the existing surface water that results in gradual depletion of surface water. The point in case is HaroJitu where the local farmers started to compete among themselves in developing private water wells. Before this happened, HaroJitu was a small lake. This lake disappeared due to agricultural pressure on it that exposed the lake to gradual disappearance. The cycle of disappearance is continuing as the peasants, instead of reviving the lake, are digging further deep to follow the disappeared water for further exploitation. In search of water, the private water point developers dig as far as 20 meters. As can be seen in Figure 2, the activities have already changed the structure of the water body. In this area, the farmers were exposing the available surface water to further wastage mainly because the water is being exposed to evaporation. In addition, wastage occurs due to poor water management that occurs when irrigating fields. Two conflicts conditions were created in this process. One is competition over freed land (lands previously occupied by water) and the second is over the depth of the wells. Farmers that develop water side by side sometimes dispute over each other’s activities. For example, they may disagree over the size and depth of the wells they develop.

In the area, the farmers were not guided by expert support when they develop water. There were situations where they did as far as 60 meters and come out without having the water they were searching for. In this effort, they lose huge amount of money and energy spent during the search. Conflict arises mainly when those who search for water do not agree to pay their other community members used as labour. The importance of

water for agriculture reinforces further demand and stimulates the desire to search elsewhere where land is available. In this process, the farmers were not only damaging their own lands, but also crossing into borders of other farmers. This creates conflict between farmers who have plots side by side. This problem is common particularly in some of the visited localities in Haramaya and Kombolcha District.



Figure 2. Unwisely search for underground water.

1. . Limitation in alternative livelihood options and Demand on scarce resource: As indicated earlier, one of the key forces behind intra-communal and inter-familial conflict in the two districts is population pressure. The informants indicated that the size and quality of land is dwindling from time to time. At the same time limited alternative livelihood options have been aggravating pressure on land which is the key source of economic and social survival in the area. Parents inherited small land sizes from their own parents and are now obliged to slice out from the same small plots to their grown up children. There were cases at KuroJalala of Haramaya district where a father was obliged to slice out small plots for his 4-5 children from his own farmland that was as small as 500 ca.

The community members are aware that the pressure on land is causing conflict between family members and among neighbors. Some of them made effort to send their children to schools and private colleges with the hope and expectation that the children would use their education to get job that can move them away from the village where resources are extremely scarce and conflicts are inevitable. Some parents indicated that they invested hugely to educate their children by covering all the costs required. However, only few were successful in meeting their goals. The main challenge is that no matter how hard they try, their children generally fail to pass important academic exams and come back home with reports indicating their failure. The children who come home after certain years in urban areas come with several problems including addictions that intensify their demand for resources. Elders indicated that their children are expected to learn and find jobs in urban areas, but unfortunately due to various factors they come back and lay claim to small and diminishing resources. This created a situation where siblings gather up around a scarce resource and compete among themselves for possession. Without having something of their own, their children generally tend to bring wife home and complicate the dynamics of competition. 'I have a wife and my own life now. I need land to cultivate and construct house on.' This is an example of multiple cases in which social practices such as self-fulfilling prophesies contribute to and exacerbate resource-based conflicts. In a context where resources are intensely scarce and the land’s supporting or carrying capacity is extremely reduced, disputes emerge among close family members over who should and should not share from the available resources.

Others indicated that even some of their children with jobs in urban areas also come back and claim land according the tradition called Miraga. There are two reasons behind this. One reason is cultural tendency to attach oneself to parental resources based on the institutional provision. The second and more important reason is the economic benefit that is generated from working on land especially if the acquired plot is used to plan khat which is significant market value and as a result become a strong source of financial self­support. Some informants indicated that those children with job in urban areas are aware that the annual income they generate from selling khaton their plot is far better than what they obtain in the same year from the formal job they secured in urban areas. The competition among the children become more complicated and intolerance over entitlement/ownership of plots increases when all of the male children are married and have several children of their own.

In some conditions conflict over land and other available resources leads to family breakdown and tension between parents and their children as well as among the children themselves. This is true mainly in a situation where some children based in neighboring urban areas simultaneously own and use the plots they had secured through the miraga institution. The children in rural areas who at the same time take care of their elderly parents complain about their brothers who without providing similar day-to-day care to the parents are entitled to equal share of the plots based on the institution. In some conditions, they take away the plots in the name of the urban-based children without their permission. This triggers violent conflict between brothers. Here, the role of cultural institution in structuring causes of conflict is evident.

D). Climate change, demand on resource and conflict: Like in other places in the region, the research area has long been under climatic pressure. The economic and social activities on natural resources themselves intensified the unfriendliness of the environment. In this area, over the last two-three decades, the economic and livelihood impacts on natural resources such as land and water resources was increasingly high. Farmers in the area try to exploit the resources to sustain their life and produce income generating agricultural products such as khat and vegetables. In this effort, they are forced to exploit as much resource as available, but this is usually at the expense of environmental and resource continuity. Evidences regarding the impact of intense agricultural activities on natural resources include the growing number of water wells in rural areas and changes in the landscape of the environment due to over-cultivation. The population pressure has also resulted in thousands of congested homesteads in rural areas where the inhabitants construct houses without adequate spacing between each house.

Asked about the environmental factors that affect their life and contribute to conflicts, elders indicated that water is the main source of existence whose shortage is affecting both their agricultural economy and human relationship in the system. They underlined that the amount of rain has been declining from time to time and this in turn has increased economic or livelihood demand on the surface as well as underground water. Shortage of water increased stiff competition in the area. In both districts, farmers dispute even when they try to divert flood waters to their own wells. Another serious problem is that there is lack of cooperation as well as mechanism for environmental and resource management. In other words, it seems that the community members do not have a sustainable or long-term plan and initiatives for maintaining, protecting and improving the resource on which they heavily depend for day today survival.

E). Decline in social capital, weakened customary institutions and inter-communal conflict: In principle, shortage of resources, environmental factors and differences in identity and interests cannot become direct and irreversible causes of conflict on their own. These factors contribute to conflicts and become causes of violence when other conditions that contribute to peace and social co-existence are weakened. As Dijk and Bruijn (2005) argue, however, the idea that increasing resource scarcity leads to more (violent) conflict has gained currency and analytical credibility. Rapid population growth, ecological decline and an increasing number of violent conflicts seem to confirm the causal relationship between these phenomena. Most conflict theories agree on the view that provided that social capital and institutions that control, monitor, manage and resolve conflicts are intact, the probably for resource-based violence to occur and create societal disruption is minimal.

In contrast, participants of this study indicated that one of the serious problems in the area is decline in social capital and weakened institutions of conflict governance. The main manifestations of decline in social capital and weakness in institutions of conflict management contributed immensely towards general failure in managing inter- communal and inter-familial conflict. Instead of resolving land-induced conflicts in their own villages and with the help of the elders, disputants prefer to go to modern justice institutions. This may be an option to seek justice, but has its own drawback according to the informants. It is multiple impacts. These are:

1. . Erosion of social capital: the decision to go to court and litigate a family member or a neighbor would increase unnecessary contestation and hostility between community members. It also develops the moral psychology to compete instead of negotiate. There cases where some family members had totally broken up due to this phenomenon.
2. . Economic cost, in their attempt to gain justice in courts and other modern institutions, some community members make themselves vulnerable to unexpected expenses in the process. The informants indicated that some community members lost their huge assets in the process instead of resolving the original and minor disputes. The asset they secured over a long period of time is wasted through informal expenditures. Failure during the effort to win justice causes frustration which induces violence as an option. This unfortunately creates human relationship defined by violence.
3. . Time and energy cost, some of the cases of disputes take longer time than originally expected and require the disputants to move from district to zone and from zone to region and even from region to the federal courts. This requires the community members to incur huge part of their time for agricultural activities.
4. . Reduced productivity and farm management, as some cases of the disputation take much time and energy before they are resolved, the disputants generally tend to be away from their agricultural activities. Especially in a situation where there is no alternative source of labours on the farm, the disputants are obliged to hire new paid labour. In most cases the farmers are financially unable to hire labour on their farm. Therefore, their departure increases the vulnerability the family whose plot of land remains unattended to. There are situations where the crops planned on such a land are destroyed or stolen by other community members who are aware that the land and its crops are unprotected. Such farmers having know that they are unable to work on their farm due to their frequent travel to court usually informally and trustfully pass their land to one of the community members for temporary holding. This could also cause new dispute mainly if that land is reclaimed before the informal contract or agreement time has ended. The person who has received the land and spent money and energy on it may require compensation or totally disagree with the proposal to uproot him from the land. All of this complication occurs as a result of the weakened role of the customary institutions, their values and acceptance. There are cases were members of the community encountered violent and destructive conflicts over such dynamics of claims and counter-clams.
5. Conclusions

In this project attempts were made to analyse the dynamics and patterns of resource induced conflicts within and among rural communities in two selected districts of Eastern Hararghe Zone. The study involved community members in nine administrative units of the two districts. In addition, administrative officers of diverse levels were involved to increase the data base of the research. The methods of data collection included interviews, focus group discussions and filed observations of the livelihood and environmental conditions which are part of the conflict system.

The study indicated that rural resource-based conflicts are complex and their intricate relationships can be understood only when connected to broader social, environmental, administrative and cultural factors that exert direct as well as indirect impacts on day-to­day life of the rural communities. In general, in the selected districts are intra-communal conflicts are most commonly observed than inter-communal ones. It was also observed that, water and land are the main sources of violent conflicts that occur among family members. The intensity of the conflicts is increasing and changing it dynamics from time to time due to the huge gap between the needs for resources and dwindling of the resources. Increasing population, over-exploitation of the scarce resources, limitation of alternative livelihood strategies, climate change, and declining social capital are exacerbating the situation. The conflicts are causing serious moral, social, economical, and environmental crises and seriously weakening the social bond that should exist among the community.

In general, the research revealed that the intra-familial conflicts are affecting the social cosmos in general and the social-psychological relationships of the community members in particular. The costs of the conflicts range from huge amount of money up to irreplaceable human life. The research conducted as well the interventions made both to reveal the reality on the ground and curb the impacts of the conflicts on the life of the local community are insignificant. Due to time and budget constraints, this particular research was also concerned with limited issues in few localities. Therefore, large scale and multifaceted research endeavors should be conducted on the areas of peace, conflict, and their dynamics so as to bring out root causes of the conflicts and their intricate relationships. Parallely, there should also be continuous awareness raising trainings and community mobilizations to maintain the culture of peace and restore social and cultural norms and values.

Based on the study, we recommend that the rural communities be supported in their effort to manage resource-based disputes through mechanisms that reduce the magnitude of violence, societal disruption and institutional inefficiency. The most important thing in this process is rural capacity building for peacemaking at grassroots level. Reconstructing the functioning of the customary institutions of conflict governance may reduce the frequency, intensity and complexity of resource-based conflicts. The other important thing is establishing strong collaboration between the formal and informal constitutions to minimize causes of conflicts and to make meaningful intervention in processes of conflicts that lead to undesirable consequences that jeopardize the fabrics of peaceful co-existence.

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1. Primary Schooling Vis-a-vis Food Insecurity in Pastoralist Communities of Mieso District: The Double Jeopardy

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Abstract: The purpose of this study was to describe the interdependence between primary schooling and food insecurity among pastoralist communities of Mieso District, West Hararghe Zone, East Ethiopia. The study employed descriptive qualitative research design which used focus group discussion, key informant interview, observation, and document review. Parents, students, Parent-Teacher Association (PTA), school principals, supervisors, aradda heads, education, health, and pastoralist office personnel, development agents (DA) and health extension workers were participants of the research. Data from these sources were triangulated, organized, tabulated and analyzed through theme and explanation building. Thus, the finding of the study shows enrollment, completion rate, and gender disparity remains heightened. There also seems high dropout and frequent absenteeism. Primary school children are either absent or dropout for varying reasons among which child labour, as a coping strategy for food insecurity was at forefront. Prevalent food insecurity and serious water scarcity appear to be devil primary schooling.

In order to achieve UPE by 2015, improving the school attendance of the pastoral children in Mieso context is an imperative, which in turn calls for improving the food security situation and access to safe drinking water. Unless these issues are ameliorated, embracing pastoral communities of Mieso district in universal primary education by 2015 seems going off track.

Keywords: pastoralists; primary schooling; food insecurity; Mieso; Oromia; Ethiopia

1. Introduction
   1. Background

Located approximately between 3° 14’ N latitude and 33° 48’E longitude in the Horn of Africa, Ethiopia is the second most populous country next to Nigeria. Growing rapidly at an average annual rate of 2.58%, the current size of population is projected to have escalated to well over 80 million. World Bank (2005) reported sizable population to have been urbanized in Ethiopia; however, the country claimed to have remained the least in terms of urbanization in Africa. According to the 2007 Ethiopian Population Census report, about 84% of the total population was rural dweller whereas urban population constitutes the remaining about 16% only. The country’s economy mainly depends on rain- fed agriculture that makes the country vulnerable to climate related shocks, which in turn threatens food security. Even though there have been substantial progresses, the country is still among the poorest nations in the world with such low human development Index (HDI) of 0.396, below the average calculated for Sub-Saharan Africa 0.475, ranking 173 out of 187 countries of comparable data for the year 2012 (UNDP, 2013).

Ethiopia is one of the most disaster prone countries, incessantly affected by a multitude of catastrophes with increasing frequency (UNDAF, 2011). Devastating and recurrent droughts, coupled with rapid population growth and land degradation have put the country under serious food insecurity (UNICEF, 2012). This specifically believed to erect a severe setback in lowlands and pastoralist areas where annual rainfall is below 700mm. As a result, low standard of living, poor health condition, and high illiteracy rate are the thorniest tribulations affecting the life of the people in general; and strikingly impinge on pastoralists’ life in particular; which in turn believed to have jeopardized the education system. Despite the fact that education is taken on by government as a key strategy for poverty alleviation, the provision of education for all citizens still seems long way off. According to UNESCO (2012) education for all report, for instance, Ethiopia is among the low Education for all Development Index 0.622, ranked 116th out of 120 countries for the year 2010.

Though the country is currently making inroads towards achieving universal primary education (UPE) by 2015, it appears to be much more demanding. Enrollment, dropout and completion rate are also turn out to be another predicament undermining the endeavor to universalize primary education. World Bank (2012) reports that the net enrollment rate (NER) to primary schooling is increased from 79% to 85% at an annual growth rate of 1.9% that is less than the population growth rate; and grade 8 completions remain low at 49.4%. Most importantly, the current education system that follows eight years of primary education is explicitly vexing, as it demands more than offering five years of primary schooling. This dilemma could be more exigent for agro-pastoralists and pastoralists as their educational participation lags far behind others (Pact Ethiopia, 2008; Ziyn, 2012). There were about three million out-of-school children needing special attention (ESDP VI, 2010), of which most are bound to be female, rural, poor and vulnerable (UNICEF, 2012). Though strong emphasis placed on reaching such marginalized sections of the society to boost up their participation in Education Sector Development Plan (ESDP) IV, years have elapsed to put it fully into practice.

* 1. Statement of the Problem

Enshrined in the 1948 Universal Declaration of Human Right by United Nations, in article 26:1as: ‘Everyone has the right to education. Education shall be free, at least in the elementary and fundamental stages. Elementary education shall be compulsory’. Access to quality primary schooling has long been accepted as a basic human right. Thus, it was underscored that denying the child the right to primary education would tantamount to handicapping him/her for life; as life exclusive of such skills as numeracy and literacy would turn out to be anomalous at best (UNESCO, 2006). More on this point, UNESCO (2010) emphasize that such repudiation violates basic human right and would undercut economic growth and poverty reduction as it wastes a precious national resource and potential driving forces. Irrespective of such acclaim; however, problem of universalizing primary education is strongly persevered that some regions are going off track. Estimation by UNESCO (2010) shows 56 million children could remain out of school by year 2015, with 28 million children dropping out each year. Similarly, according to UNESCO (2012), trend analysis suggests that the rate of advance towards universal primary education goals has shown declining trend in recent years, which could escalate the number. The number of out-of­schoolchildren, in sub-Saharan Africa has increased by 1.6 million between 2008 and 2010, for instance.

Children around the world are obligated to remain out of school for diverging reasons, among which poor health and nutrition are barriers between children in poor communities and their educational potential (Jukes, et. al, 2008). In UNESCO (2010, 2011), the issue of malnutrition and child health is also clearly accentuated as one of most glaring problem to achieve Education for All as children who suffer malnutrition tend to start school at later age and drop out early prior to completion of primary schooling. Further, Siegler, et al. (2006: 308) caution, “chronic inadequate diet early in life can disrupt brain development, and missing meals on a given day can impair intellectual functioning on that day”. Jukes et al. (2008) also underscored that hungry or poorly nourished children have impaired cognitive abilities and are less attentive in class. Put it differently, food security, and hence proper nutrition is a prerequisite for the right to education to be realized (Raimbault, 1979). Similarly, a study by Tefera et. al., (2012) shows adolescent and household food insecurity is positively associated with school absenteeism and a lower educational attainment.

Hunger and malnutrition are direct outcomes of food insecurity (UNDP, 2012), which in turn results from such complicated factors as drought, land degradation, population growth among others. According to APRM (2011), drought is the prime cause of food insecurity in Ethiopia. Ethiopia is known to be the most food insecure, and famine-trademarked for over years. According to Tenna (2012), Ethiopia reportedly experienced about 54 natural disasters between 1974 and 2003, the 1983-5 famine episode being the worst ever the country had experienced. The country is one of the most disaster prone areas in East Africa, with frequent drought affecting millions of People. Accordingly, most parts of the country, specifically the lowland areas are drought prone areas, with all parts of Afar and Somali regions, are classified as high drought-risk areas whereas parts of East and West Hararghe are categorized as medium drought-risk areas (UNICEF, 2012).

Predicated on this, food insecurity and malnutrition could be heightened for pastoralists where depletion of resources and water scarcity seem so immense. Malnutrition among child remains an acute and widespread challenge in Ethiopia (Save the Children, 2012), more so in arid and semiarid or pastoralist areas (Rajkumar, 2012).In Ethiopia, pastoral areas are one of the most drought prone regions facing chronic food deficiencies where erratic and poor rainfall impinges on pastoralists through shortfall of fodder and water (Mekonnen, 2011). In similar vein, FAO/WFP (2012) reports the number of people in need of relief assistance in 2011 had heaved to 4.6 million due to poor rainfall, which affected mostly the agro-pastoral, and pastoralareas. Consequently, about 329,500 children were admitted to therapeutic feeding; that could have a bearing on primary schooling. According to FAO (2005), the persistence of hunger and malnutrition are one of the prime reasons attributed for impeding the inroad to universal primary education.

In pastoral areas, social services like: infrastructure, safe drinking water, and education are disappointingly developed (Pastoralist Forum Ethiopia, 2002). Pastoralists are the most marginalized social group in terms of economy, politics, and educational provision among other things (See, Ayalew, 2001; Hogg, 1997), explicitly in the acquisition of education (Ziyn, 2004 & 2012). Following this, Pact Ethiopia (2008) asserts enrollment in education is the lowest among pastoralists in Ethiopia. Disappointingly, from those who enrolled, only few complete the first eight years of schooling and high dropout rate (MoE, 2011), as a result of which they have lagged far behind others (ESDP IV, 2010).

Of many such pastoral groups, the East — Central pastoral communities comprise Oromo, Somali, and Afar are groups of pastoralists inhabited West Hararghe Zone. Of many West Hararghe districts, the current study focuses on Mieso, most part of which is known for its minimum annual rainfall and inveterate drought, hence chronic food insecurity that suffered the 2011 drought. OCHA (2011) report reveals at least 58,000 school dropouts and more than 280 school closures in Somali and Oromia regions during same year. Correspondingly, the problem continued to exist in 2012 as the rain failed for two consecutive seasons in West Harerghe Zone that resulted in failed crop, reduced livestock, scarcity of pasture and water (FEWSNET, 2013).

* 1. Objective of the research

The general objective of this research was to assess the impact of drought induced food insecurity in universalizing primary schooling in pastoral communities of Mieso district. In specific, the research addresses the following objectives.

* Examine how the progress towards universal primary education is affected by drought induced food insecurity in pastoral communities of Mieso District.
* Figure out how drought induced food insecurity impacts school attendance in pastoral communities of Mieso context.
* Identify what the interplay between primary school attendance and food insecurity looks like in pastoral communities of Mieso District.

1. Literature Review: Theoretical Consideration
   1. Universal Primary Education

Ethiopia is signatory to Education for All (EFA) and Millennium Development Goal 2 (MDG 2). MDG 2 states ‘Ensuring that by 2015 all children, particularly girls, children in difficult circumstances and those belonging to ethnic minorities, have access to and complete free and compulsory primary education of good quality’; where quality universal primary education is conceptualized as entering school at an appropriate age, and progressing through the system and completing a full cycle (UNESCO, 2010). The definition of primary education also varies from country to country (UNESCO, 2007), mainly based on the years required for basic literacy and numeracy attainment though it comprises the first four or five years of schooling.

Catering for 7 to 14 age groups, in the 1994 Education Policy of Ethiopia, however, primary education comprises the first eight years of schooling in two cycles: first cycle (grades 1-4) and second cycle (grades 5-8) (MoE, 2012). Stated in the Education and Training Policy; ‘Primary education will be of eight years duration, offering basic and general primary education to prepare students for further general education and training’(TGE, 1994:14). Primary education is, thus, the most decisive turning point where foundation for further education can be laid.

Concordant with the above global commitment, Ethiopia has developed successive Education Sector Development Plans (ESDPs), and currently implementing ESDP IV, a five year Program Action Plan (2010/2011 — 2014/2015). Prioritized in ESDP IV is, ‘to improve access to quality primary education in order to make sure that all children, youngsters, and adults acquire the competencies, skills, values and attitudes enabling them to participate fully in social, economic and political development of Ethiopia’. Irrespective of such ambitious objective, nonetheless, ensuring access to quality primary education for all children seems easier said than done. Though there has been improvement in access, many children still do not complete the first cycle of primary school, and repetition and dropout rates remain high throughout the whole cycle (ESDP IV, 2010). The most challenging aspect of UPE is thus from all primary school age cohorts, some remain out of school; of those who do come, most of them leave prior to completing the mandatory level of schooling for required literacy and numeracy level. Even if the issue was well accentuated in ESDP IV, little has been improved during the last three years of implementation.

Of course, there have been improvements in enrollment in Ethiopian primary schools as shown in Educational Abstract 2012**.** However, from those who enrolled, only 74.1% survive to grade 5; whereas completion rate to grade 8 is 52.1%, which is well below the rate computed for sub-Saharan Africa; that is 62%. Counted alongside the Sub-Saharan African countries, whether Ethiopia is to meet the MDG of UPE or not is subjected to critical scrutiny though some argue the country is well on truck (UNDAF, 2011). Despite substantial progresses, gender gap has also remained a serious challenge, where girls were more likely to have never attended school, and about 43% of poor rural females aged 7 to 16 have never been to school in 2011(UNESCO, 2012).

Even though vast gap between the enrolment rates in first cycle and second cycle was a primary focus of ESDP IV, the gap still persists. GER was 122.6 for first cycle and 65.6 for second cycle, which indicates low primary school completion rate regardless of expected 100% cohort completion ratefor a country to achieve UPE (UNESCO, 2012). Another important point is the gap between GER and NER, which shows 122.6%, for 1st cycle including Alternative Basic Education (ABE), and 65.6% for second cycle, whereas NER for primary cycle shows 92.2%, and for second cycle 48.1%. Strongly associated with low enrollment to the second cycle, this has important ramification for UPE, as when children come late or over-aged, there is high possibility for them to drop early (UNESCO, 2012). As indicated in MoE (2012), the average annual growth rate of enrolment increased nationally by 4.5% for primary school during the academic year 2011/2012. NER is 85.4 with sharp regional disparities: as high as 100.3 and 108.1 for

Benishangul-Gumuz and Gambella, respectively and as low as 35.5% for some regions like Afar.

Most importantly, with only five more years to go, there were about three million primary school-age children left out of school in Ethiopian context as of 2010 (ESDP IV, 2010). In this view, mostchildren from pastoral communities could remain out of school by 2015 unless utmost effort is exerted during the coming two years. To this effect, Ethiopian government committed to develop special support programs for the emerging regions so as to tone down a steep and swift pupil dropout rates (ESDP, 2010). Though it has been well accentuated in 1994 education policy to offer special financial assistance to those who have been deprived of educational opportunities, and to take steps to raise the educational participation of deprived regions (TGE: 1994), pastoralist groups remained underserved, and lag far behind others (ESDP IV, 2010; Pact Ethiopia, 2008; Ziyn, 2012).

While concluding the existing Sub-Saharan Africa circumstances of pastoralists, UNESCO 2010 underscores that pastoralist children are extremely disadvantaged in terms of educational provision. If Universal Primary Education is to be achieved by 2015, thus, including pastoralist children is a matter of overarching significance. Providing all pastoral children with eight years primary education is, however, the most challenging and demanding assignment facing the government of Ethiopia, which may oftentimes, gets exacerbated by food insecurity as pastoral areas are inundated by drought induced food insecurity and widespread destitution.

* 1. Food Security Situation in Pastoral Areas

Last decade has entertained increased frequency in droughts occurrences (Venton et al., 2012), though the 2011 East African drought that affected about 13 million populations was the worst ever crises in 60 years (Save the Children, 2012). As such, this drought episode affected most parts of Ethiopia because of which rainfall was either delayed or failed completely with agro-pastoralists and pastoralists in the south and south-east being the worst affected (FAO/WFP, 2012). Inundated by environmental degradation and shrinkage of the traditional pastoral territory, coupled with climatic change, put the area under chronic food insecurity, which made most pastoralists dependent of relief support (Mekonnen, 2011). They are among chronically food insecure households in Ethiopian context (Workineh, 2008). Similarly, FAO/WFP (2012) asserted that pastoral areas generally are deficit in crop production where rising food prices has amplified food insecurity and vulnerability, with the main hunger season lasting from December to February/March. Pastoralists are, for instance, the hardest hit segments of population during the 2011 drought that affected about 13 million people across East Africa (Save the Children, 2011).

Comprising many pastoralist groups, Oromia is one of the most affected regions in terms of food insecurity, specifically in West and East Hararghe zones (OCHA, 2011). Similarly, FAO (2012) indicated that East and West Harerghe zones are among worst affected agro-pastoral and pastoral lowlands due to the late onset, early withdrawal, and poor performance of the 2011-hagayya rains. The situation in East and West Hararghe

Zones still seems hard-hitting as there was below normal rain during 2012 rainy season too. According to FEWSNET (2013), in East and West Hararghe and surrounding areas, the performance of June to September rains was especially erratic and poorly distributed that crop has failed and would put poor households in these areas under crisis during January to at least June 2013.

A note must be made at this point that the prevailing food insecurity situation had seriously jeopardized the schooling of children in the drought stricken areas. Regarding this, OCHA (2011) referring to Education Cluster, indicated that 1.8 million children of an estimated 2.3 million children aged 5 — 17 years were not attending school. Similarly, over 300 schools, Alternative Basic Education facilities closures, and over 87,000 dropouts in Somali, Oromia and Afar Regions, was reported during 2011 drought. Thus, the bearing that food insecurity could have on education, explicitly primary school children appears to be pervasive. More theoretical clarification on this point; specifically the interplay between education and food insecurity, is in order.

1. The Interplay between Education and Food Insecurity

Apparently, poor food insecure households can never prioritize education as existence precedes education. It is equally unwise to expect the hungry or famished family to send their children to school, nor expect starving children to make a benefit out of schooling. Food insecurity results in hunger and malnutrition, which in turn brings about health problem and impair proper cognitive functioning (Del Rosso, 1999). Obviously, the importance of good nutrition and health is unquestionable for overall development of child (Rodriguez-Salina et al., 2008). Even to the extent that missing one time meal may inflict adverse impact to cognitive development that would acutely bedevil school learning (Del Rosso, 1999; Siegler, et al., 2006). The issue appears more worrisome for primary school children in an attempt to universalize primary education. Commenting on the adverse impact of food insecurity, UNDP (2012) asserts food insecurity debilitates society by increasing mortality, disease and disability that would result in absenteeism and poor education which could last generations.

Malnutrition and hunger increases the risk of disease and early death (UNDP, 2013), reduce learning achievement of children (Birdsall et al., 2005), and impair children’s performance (FAO, 2005). With enduring effect, it creates vicious circle in that malnourished poor mother would give birth to low-birth weight babies whose chance of getting school on time, and taking advantage of schooling would be much constricted. This in turn perpetuates poverty circle, as less educated ones possibly remain poor and food insecure that the cycle starts all over again (Sanchez, et.al.2005). Put it differently, food insecurity and, hence, malnutrition implies a less productive people, and less capable to create opportunities to gradually break the cycles of both poverty and hunger in a sustainable way (UNDP, 2012).

If a household skips a meal for days or reduces food intake for prolonged time, then comes malnutrition. Hunger and malnutrition believed to pose adverse impact on schooling of children. From this, it follows that in chronically food insecure parts of Ethiopia, school learning could be constrained. Manifested through such indicators as stunting (low height-for-age), wasting (low weight-for-height) anemia and iodine deficiency, malnutrition impair cognitive ability and reduce children’s capacity to learn (FAO 2005, Rajkumar et al. 2012). Poor nutritional status of children and women has been a serious problem in Ethiopia for many years (CSA, 2012). As a result, stunting and wasting of children under five are common public health problems. According to the latest Demographic and Health Survey (DHS) data, 29% of Ethiopian children are underweight and 9% are severely underweight, about 45% are stunted and 10% are wasted; and 3 percent are severely wasted. Similarly, 44 percent of children under age five are stunted, and 21 percent of children are severely stunted (CSA, 2012).

1. Research Design and Method

In this study, descriptive case study research design was employed. According to Hancock and Algozzine, (2006) it is a design where an attempt is made to present a complete description of a phenomenon within its context. Data for case study comes from myriad of sources; including document review, observation, interview, and focus group discussion. In this light, Yin (2002) has figured out six such sources of data: “documentation, archival records, interviews, direct observation, participant observation, and physical artifacts” (pp. 83). Of these, interview, focus group discussion, observation and document review were used as major data collection instruments.

In so doing, observations of school environment and classroom situation were effectuated in some selected schools. Focus group discussions with parents, Parent- Teacher Association (PTA), supervisors, school directors and teachers, Development Agents (DA), aradda managers (abba Ganda) were executed. In the meantime, documents were reviewed from schools, Mieso District Education Office, Mieso District Pastoral Office, Mieso District Water Mineral, and Energy office and Mieso District Health Office. In the same way, few anthropometric data were accessed from some Health post. Besides, interviews with school principals, DA, health extension workers, students, supervisors, and head teachers were conducted. In so doing, field note taking, photographing, and recordings were effectuated. Data from these instruments were classified, organized and tabulated. Analysis was made qualitatively through explanation and theme building.

Site selection was criterion-based following information obtained from the district officials. Subsumed under Mieso District are 46 Aradda/kebeles, of which 23 are totally pastoralists while the remaining 22 are either semi pastoralists or agro-pastoralists. As the research focuses on pastoralists, pastoralist PAs and primary schools within six Cluster Resource Centers (CRC): Mieso, Asebot, Dhaga Daku, Annanno, Bordodde, Gohlcha and Waltane were sampled purposively based on such criteria as serious food insecurity, water scarcity, pastoralist preponderated, little or no farming at all. Furthermore, as these PAs are easily accessible, and are where children from different ethnic groups conflate, they were taken up as research site.

1. Results and Discussions
   1. Primary Schooling in Mieso Context

According to UNESCO (2007), two indicators are most important to determine the school attendance: enrolment of the children who have registered with a school and net attendance: the number of children who are actually going to school. Accordingly, to shade light on what primary schooling in Mieso context looks like, such indicators as enrolment rate, absenteeism, dropout, and completion rates will be presented hereinafter.

* + 1. Primary school enrollment

Enrolment shows the number of children registered for schooling in a given academic year. Overall primary school enrolment rate shows high achievement at national as well as regional level as indicated somewhere. According to the zonal education office, same works true for West Hararghe, that is, 82.36% for grade 1 — 8 for 2012/2013, though there is a slump from what it was during 2011/2012 academic year that was 90.4%. Correspondingly, official data from Mieso District Education bureau showed an improvement in Gross enrolment rate (GER) during the last two years, 66% and 70.8% for 2010/11, and 2011/12, respectively, but falloff to 65% during 2012/13 academic year. However, net enrolment rate (NER) remained unsatisfactory at the rate of 53% in 2010/11, 57.27% during 2011/12, and 55% for 2012/13.

Comparison between cycles showed noticeable discrepancy in terms of NER that is 73%, 85.6%, and 93% for 1st cycle, and 24.2%, 22%, and 19% for 2nd cycle during school year 2010/11, 2011/12, and 2012/13, respectively. Evidenced here is improvement for the 1st cycle, but a declining trend in NER for second cycle for the last three successive academic years, which would tell us the low primary completion rate. Similarly, one possible conjecture that can be made from the difference between GER and NER is that over aged children are coming to school, which case is congruent with data from other sources. Besides, noteworthy is gender gap noted from the latest 2012/13 data from Mieso District with GER 74% and 56%, and NER 57% and 14%, respectively for boys and girls.

The aforementioned official data showed the number of children registered through campaigning, which might have been exaggerated. Procedurally, enrollment or registration starts late in August each year through house-to-house campaign where all unschooled primary school age (7 years old) and beyond who have never been to school, and dropouts would be registered. For most parents, however, getting registered their children at home, and sending them actually to school mean different things that would result in inconsistency between official student statistics and actual school attendance. From this, it follows that not all those who registered would be sent to school as parents were not properly convinced about children education, or need them around for their labour. As registration is hardly ever based on the willingness of the parents but the government, it is not a fostered; but forced one. Even though there has been serious punishment put in place for parents; either for not sending or pulling out them from school, there were out-of-schoolchildren at every household. Even, from those whom

parents want them attend the school, many seem apathetic that they come one or two months later after the school has commenced. This would play a devastating role in education quality coupled with coming late to class, class-forfeit, absenteeism, and early dropout.

* + 1. School absenteeism

In Mieso context, there is relaxed school rule and regulation to entice, and to encourage the students stay in the school. Consequently, there were cases where students who had never shown up for two or so months, yet could be seated for the final exam. As a result, many are completing primary education without acquiring the required literacy and numeracy skill. According to some teachers[[1]](#footnote-2), it is quite common to find primary school complete unable to write his/her name properly. Even though children are absent from school for such diverging reasons as tending animals, helping parents during harvest time, collecting fuel wood or charcoaling, khat(Catha edulis)processing, gravel production, and fetch water; they also engage themselves in petty trade and menial jobs during market day.For instance, at Gumbi Primary School, only 33 out of 204 schoolchildren were attending class, whereas about 361 truants were reported at Gololcha Primary school.[[2]](#footnote-3) The number is so much alarming during market days as noted at schools like Bordodde.

Table 1. Market day Absenteeism in the Afternoon Shift.

|  |  |  |  |
| --- | --- | --- | --- |
| Grade | Number of students | No of Presents | No of Absentees |
| 5th | 76 | 14 | 62 |
| 6th | 64 | 17 | 47 |
| 7th | 55 | 8 | 47 |
| 8th | 33 | 15 | 18 |

Source: Bordodde school personal observation.

In Mieso context, the most glaring cause of school absenteeism seems attending market, as presented in Table 1 above. Well, over 75% schoolchildren were absent during this particular day. Market day is referred to as Ida Miskiinaa literally Poor’s Eid, to mean poor’s festivity. Put it differently, during market day many students never attend school, in most schools in Mieso district as household food consumption is always depends on market, which in turn determines the amount of money they would earn. Their food expense for the days to follow, and school expenditure is totally depends on the earning they would make during the market day doing menial jobs which case jeopardizes their school attendance, even beyond market days. To participate in petty trades or menial works themselves (from town), or let their parents to attend (from suburb and rural) by minding sibling, either tending cattle or look after young, children in Mieso habitually absent from school. And when they are absent for long school days, they eventually dropped out, often never to come back.

1. School dropout

Taken as an indicator of school attendance, dropout shows the number of students who leave out the school before completing certain cycle or achieving the required skill, or knowledge commensurate with that level. It also showed “the percentage of those students who discontinue their learning from a given grade compared to the previous year’s total enrolment in the same grade” (MoE & UNICEF, 2012: 33). Dropout rate is high in Ethiopian school system that challenges universalizing primary schooling. MoE (2012) report reveals that about 25.0% of pupils enrolled in grade 1, in 2010/11 have left school before reaching grade two in 2011/12. The fact is that children continue to drop out as they advance to the next grade. Dropout, thus, seems the prime factor standing against universalizing primary schooling in rural areas in general, and in pastoralist areas in specific. In Mieso context, for instance, primary school student population shows that the number of students decrease as the grade level increases and is higher than the average computed at national level. The following table presents the existing student statistics at two sample schools.

Table 2. Students enrolled in 2012/13 to Ananno and Dhaga Daku Primary School.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Grade |  | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |
| No of Students | Ananno | 80 | 74 | 68 | 44 | 36 | 17 | 14 | 12 |
|  | Dhaga Daku | 63 | 55 | 34 | 22 | 32 | 29 | 24 | 24 |

Source: Ananno Primary School, and Dhaga Daku Primary School, 2012.

What is clear from the above table (Table 2) is that as students move on to the next class, there is a cutback in the number of students. In fact, even if this is the actual official figure provided from the school, the reality on the ground appears different. For instance, during classroom observation at Ananno[[3]](#footnote-4), as few as four 8th grade, and seven 4th and 5th grade students combined in one class were observed. From this, one can estimated the number of students who complete grade 4 and would persist to the second cycle. In this connection, a note has to be taken that only 345 students were at school out of 577 estimated primary school age populations, which translates into 222 (38%) out-of-school children in **Ananno** context. To better have a fuller picture of primary school dropout rate and survival rate in Mieso Pastoralist children context, it seems of paramount significance to present **Dhaga Daku** Primary School student statistics as follows.

Table 3. Dhaga Daku Primary School 2012/2013 Student Statistics.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| School Year | Gender | Grade Levels | |  |  |  |  |  |  |
|  |  | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |
| 2004/05 | Boys | 81 |  |  |  |  |  |  |  |
|  | Girls | 100 |  |  |  |  |  |  |  |
|  | Total | 181 |  |  |  |  |  |  |  |
| 2005/06 | Boys | 56 | 56 |  |  |  |  |  |  |
|  | Girls | 40 | 34 |  |  |  |  |  |  |
|  | Total | 96 | 90 |  |  |  |  |  |  |
| 2006/07 | Boys | 35 | 47 | 45 |  |  |  |  |  |
|  | Girls | 24 | 26 | 23 |  |  |  |  |  |
|  | Total | 59 | 73 | 58 |  |  |  |  |  |
| 2007/08 | Boys | 23 | 30 | 42 | 37 |  |  |  |  |
|  | Girls | 22 | 20 | 26 | 20 |  |  |  |  |
|  | Total | 45 | 50 | 68 | 57 |  |  |  |  |
| 2008/09 | Boys | 31 | 25 | 28 | 34 | 30 |  |  |  |
|  | Girls | 11 | 20 | 20 | 19 | 15 |  |  |  |
|  | Total | 42 | 45 | 48 | 53 | 45 |  |  |  |
| 2009/10 | Boys | 25 | 25 | 21 | 36 | 26 | 32 |  |  |
|  | Girls | 21 | 15 | 14 | 21 | 21 | 11 |  |  |
|  | Total | 46 | 40 | 35 | 57 | 47 | 43 |  |  |
| 2010/11 | Boys | 42 | 19 | 16 | 18 | 35 | 27 | 23 |  |
|  | Girls | 29 | 16 | 17 | 14 | 17 | 10 | 9 |  |
|  | Total | 71 | 35 | 33 | 32 | 52 | 37 | 32 |  |
| 2011/12 | Boys | 37 | 25 | 14 | 15 | 26 | 22 | 18 | 17 |
|  | Girls | 34 | 15 | 11 | 12 | 10 | 9 | 10 | 9 |
|  | Total | 71 | 40 | 25 | 27 | 36 | 31 | 28 | 26 |
| 2012/13 | Boys | 30 | 35 | 20 | 9 | 19 | 22 | 18 | 17 |
|  | Girls | 33 | 20 | 14 | 13 | 13 | 7 | 6 | 7 |
|  | Total | 63 | 55 | 34 | 22 | 32 | 29 | 24 | 24 |

Source: Dhaga Daku Primary School, 2012/2013.

to acquiring the required skills. No single children, for instance, from Goda Chalk, Dhaddacha Gurracha, and Buri Arba first cycle schools could be able to proceed to the second cycle current academic year[[4]](#footnote-5). The situation is even more horrendous in schools like Balo. Much disappointing as it may, the school opened second cycle at Balo some years back where one more additional next class has to commence each academic year. Accordingly, 7th grade was launched the previous academic year, and 8th grade should have opened as of September 2012. Sadly, let alone opening 8th grade, even 7th grade that already had been inaugurated in September 2011 itself was shut down a year later due to the thinning number of students[[5]](#footnote-6). In short, completion rate seems a disturbing problem in pastoral communities of Mieso district. As the age increases, it is obvious that children are much needed by their parents to cope up with the food insecurity issues through such mechanism as petty trade, work on farm or mind siblings while parents are out for khat retailing, firewood and charcoaling, sand or gravel production among others.

1. Food Insecurity Situation

Several areas are facing severe food insecurity in Ethiopia including East and West Hararghe Zones with the estimated 3.7 million total number of food insecure people in need of humanitarian assistance (FAO, 2013). Situated in West Hararghe Zone, Mieso District is one of drought prone district characterized by erratic minimum annual rainfall. Following this, it is identified as one of food insecure districts of West Hararghe Zone. The food security situation is worse this harvest season, as per information from focus group discussion with Development Agents (DA) and Arada heads[[6]](#footnote-7), as the ganna (2012) rain come in late August, and stopped early September that resulted in crop failure. Expounding the issue in more details, FEWSNET (2013) indicates that short- cycle crops wilted and long-cycle were not sown timely as a result of delay in the onset of the 2012 afrasa rain, which was followed by unusually early withdrawal resulted in reduced yields.

Similarly, data from informants and discussants showed that there was extreme worry in having something to eat during months to come[[7]](#footnote-8). Skipping meal and consuming low cost food was common among most households. As per data from some health posts and discussion with PTA, most families did not have enough food or income to properly feed their children. According to some health extension workers, malnutrition and poor health were widespread among Mieso district community. At Kurfa Sawa

Health Post, for instance, there were about 72 underweight, out of which 22 were moderate and four of them severely malnourished[[8]](#footnote-9). Though appears under reported, Mieso District under-5 age Screening of Acute Malnutrition for November 2012 shows only 129 children with moderate, while 43 with severe acute malnutrition. Similarly, according to West Hararghe Zone Health Office, nutritional screening conducted as of August 2012, shows 21, 262 children with medium acute malnutrition, and 4, 102 serious acute malnutrition. Further, the April 2013 screening reveals 23, 530 with medium acute malnutrition, and 1,665 children with serious acute malnutrition. In food insecure areas, thus, where nutritional and health status of children is low, it can bear negative impact on educational achievement and contributing to the dropout rate (UN report, 2012).

If there is food insecurity, and, hence malnutrition and poor health, school learning would be constrained. UNESCO (2012) underscores malnutrition constrains progress towards the Education for All goals by hindering cognitive development and the capacity to learn. Further, while commenting on the effect of malnutrition and poor health on school learning, Del Roso (1999: 5) explicates, “Weak health and poor nutrition among school-age children diminish their cognitive development either through physiological changes or by reducing their ability to participate in learning experiences - or both”. From this, it follows that food insecurity in Mieso district is plugging pastoral children to make a benefit out school learning.

These two-year drought periods appear to have devastated the life of many Mieso pastoralists. For instance, in semi-pastoralist PAs like Hametti, Huse Mandhera, Kurfa Sawa, and Asebot where some sort of small-scale cultivation is possible, crop has entirely failed, fodder was depleted, and water points were utterly dried up[[9]](#footnote-10). According to the discussants, they have much worry in that they have not enough to eat or to feed their children. Asked if they can afford nutritious meals for their children, one mother replied:

We wish we could. With our current capacity, it is unthinkable to feed our children nutritious food; though we have been trained on how to feed balanced diet, and urged to do so. Let alone feeding balanced diet, affording twice a day has become most challengingfor us. We feed them suummoo (boiled cereals), shuuroo (porridge), and sorghum bread. This by itself is not found in abundance. So, we feed them twice and sometimes thrice a day. You see, young children cannot tolerate hunger, they demand meal repeatedly. Nevertheless, when you fail to provide them you feel desperate.[[10]](#footnote-11)

It is contended that for children to have all rounded development, the issue of food

security and hence nutrition and health are matters of profound importance.

Nonetheless, many children around the world are experiencing hunger. Owing to poverty, low food production, mothers’ lack of education, poor water, sanitation and health facilities, and climatic shocks, developing countries experience high level of underweight preschool children as they cannot afford food of sufficient quantity or quality to meet their nutritional requirements (Sanchez,et.al.2005). In this view, in Mieso district many parents made clear that there are times when children go to school without breakfast. Sending children to school without breakfast has so many damaging aspects. Similarly, during focus group discussion with PTA, teachers, and students[[11]](#footnote-12), it has been indicated that children oftentimes come to school without breakfast, and skipping meal is common.

Apparently, the food intake of pastoralists is highly dependent on milk and milk products. Nonetheless, it is not obtainable to the required quantity during long dry season. During time of drought, however, milk obtained in small amount is never be used for home consumption, rather exchanged for low cost food item, most parents struggle to sustain their children’s life. According to the discussants[[12]](#footnote-13), most parents are supposed to milk early in the morning, go to shopping, and exchange it for low cost flour to get the breakfast ready for their children. Schoolchildren sometimes, have to wait long for breakfast, missing the first two or three classes for the day. In case the mother is unable to come back promptly and meal could not get ready on time; it is most likely for the children to go to school without meal; or to totally absent from the school. This in turn challenged the benefit a child has to get from schooling. To curb such schooling ills and evils, there are school-feeding program in few schools in the district, but not as much as necessary.

4.2.1 School feeding

School feeding is a program meant to support schoolchildren in food insecure areas like pastoralists. It is believed to have a positive contribution in enticing more children to school, explicitly girls. Beyond boosting up enrolment and retention, school feeding is also believed to enhance school learning by ameliorating hunger and malnutrition. In light of this, there was a plan to assist 1,185 schools across six regions: Afar, Amhara, Oromia, SNNPR, Somali and Tigray, targeting primary school children during academic year 2012. Accordingly, 688,500 beneficiaries were planned for 2012 through on-site feeding and take-home rations (FAO, 2012), out of which 649,000 schoolchildren in food-scarce areas were provided with a daily hot meal during same year (WFP in Ethiopia, 2012).

Though school feeding is implemented in pastoral areas to boost up the enrolment and retention, very few actions were taken by the government or NGOs in arranging school-feeding programs to tackle this prevailing problem in most schools. In context of

Mieso District, for instance, out of 59 primary schools in only 8 that school-feeding program is currently functional. School attendance, motivation and performance of learners are said to be relatively good at the schools where the program is operational. Nevertheless, some school directors say, it could not be produced the aspired-for result in terms of magnetizing pastoralist children. Out of the eight, only one school had water supply during the study period. In other schools, children were asked to bring cooking water. As water is so in short supply in the area and bringing it is a must-do activity, students opt to abandon school whenever they fail to get water. Thus, it is contributing massively its own share to increasing absenteeism and dropout, though meant to lure more children to school. To have a closer look at how school feeding is boosting enrolment and mitigated school dropout, juxtaposing Huse Mnadhera Primary School, where school feeding is operational, and Bordodde Primary school; where school feeding is relinquished five years before; seems of paramount importance to have a better view of the issue.

Table 4. 2011/12 EC School Dropouts at Huse Mandhera and Bordodde Primary Schools.

<u Huse Mandhera Bordodde

d Enrollment Dropout % Enrollment Dropout %

^ Boys Girls Total Boys Girls Total Boys Girls Total Boys Girls Total

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1st | 104 | 58 | 262 | 22 | 11 | 33 | 12.59 | 91 | 76 | 167 | 11 | 16 | 27 | 16.17 |
| 2nd | 66 | 41 | 107 | 5 | - | 5 | 4.67 | 52 | 37 | 89 | 3 | 2 | 7 | 7.86 |
| 3rd | 27 | 19 | 46 | 3 | - | 3 | 6.52 | 46 | 59 | 106 | 11 | 8 | 19 | 17.92 |
| 4th | 17 | 19 | 36 | 2 | 1 | 3 | 8.33 | 27 | 18 | 45 | 7 | 2 | 9 | 20.0 |
| 5th | 43 | 11 | 54 | 5 | 1 | 6 | 11.11 | 56 | 36 | 92 | 15 | 7 | 22 | 23.91 |
| 6th | 40 | 10 | 50 | 4 | 2 | 6 | 12.0 | 49 | 26 | 75 | 12 | 6 | 18 | 24.0 |
| 7th | 37 | 3 | 40 | 2 | - | 2 | 5.0 | 45 | 22 | 67 | 13 | 3 | 16 | 23.88 |
| 8th | 26 | 1 | 27 | 8 | - | 8 | 29.62 | 43 | 18 | 61 | 2 | 2 | 4 | 6.55 |

Source: Huse Mandhera and Bordodeprimary School, 2012.

As can be observed from Table-4 above, there seems better school attendance at Huse Mandhera, where school feeding is operational. In comparison with Bordodde Primary School, it showed that dropout is less and there seems high likelihood for more children to complete at least the first cycle. Nonetheless, there is no strong evidence to conclude that school feeding had fruitfully encouraged retention to the first eight years of primary schooling. Similarly, information from Balo Primary School reveals that relinquishment of school feeding has dropped off school attendance; the number of children at school seven years before and to date is incomparable, though supposed to improve. Their number deteriorated to 355 now, from 460 in 2006/2007 when there was school meal. It is commonplace for children to depart to the neighboring schools in search of school meal, even across regions from Bordodde to Hardim, and from Qiqilfitu to Mullu, for instance.

In similar vein, WFP in Ethiopia (2012) reported that in chronically food-insecure districts Ethiopia, school feeding promoted increased enrollment and attendance of children. That is why everywhere, parents, teachers, and students, beseech and put forth in one voice that school feeding could have a positive influence in enticing pastoral

children to school, and help take advantage of education. Jointly managed by the Ministry of Education, WFP and other partners, it is a program meant to boost up children’s school attendance. Accordingly, remarkable results have been produced in the year 2012 whereby attendance at participating schools reached 95% in 2012 and dropout rates fell to 7% for girls and 9% for boys (WFP in Ethiopia, 2012). However, improvements are irrefutable, in some schools observed in Mieso district; the aspired-for result is not as remarkable as this one.

1. Acute water scarcity

In The Dakar Framework for Action (2000), one of the strategies to achieve Education for All goals was creating safe, healthy, inclusive and equitably resourced educational environments among which access to adequate water and sanitation facilities was one. Yet, in Ethiopian schools, water supply and sanitation facilities are posing a great influence on the quality of education (ESDP IV, 2010). Thus, about 50% of schools were more than 1 km of travel time access to water sources is an overarching concern in Ethiopia(ibid), and only 36.9% primary schools have water supply in 2011/12 (MoE, 2012). Access to water is, thus, so much limited regardless of attempts so far made. The limited access to safe drinking water is so striking in pastoralists’ context, which grew from roughly 28% in 2001/02 to an estimated 54% in 2007/08 (UNICEF,2012). Regardless of government plan to improve rural potable water supply within 1.5 KM radius from 65.8 to 98% at the end 2014/15(GTP, 2010); so far less has been delivered. In Mieso district, for instance, water coverage was only 35.76% as of 2012, but there seems a push to 40.23 with two new water sources and maintenance of the existing borehole at Balo PAat the beginning of 2013[[13]](#footnote-14) [[14]](#footnote-15).

Water problem is much more considerable in time of drought, specifically in pastoralist areas. Even though access to safe water during a period of drought is the commonest hazard in Ethiopia, it is the most neglected aspect of food security by only focusing on analyzing access to food (Tenna, 2012). As one of pastoralist district, Mieso experiences serious water shortage. Water scarcity and water related problem is a serious predicament of schooling in many Ethiopian schools(ESDP IV, 2010). No exception is for schooling in Mieso district. For instance, Ananno is among PA with agonizing water problem where mothers and children have to travel more than 16 KMs to get drinking water. At Gololcha CRC, getting water for drinking and for home consumption is demanding with Gumbi PA gravely affected. It was mandatory for pastoralists to journey as distant as Awash to water their animals. Similar situation also exists at Hametti, Waltane, and Qiqiliftu14where mothers supposed to move to the water point early in the morning and come back home late in the afternoon. Whenever adults depart either to fetch water or water animals, it is given that children would absent from school to mind the homestead or young siblings, which case affects their school attendance or achievement.

Water scarcity, thus, could constrain children’s schooling directly or indirectly. On one hand, without water, human survival is unthinkable; neither does schooling. Without water, survival is seldom possible, explicitly plays a critical part for the brain to function well (Marcus, 2007). On the other hand, some children come late to school or absent from school, either to fetch water or to water animals. Furthermore, water scarcity can result in health related problems that would restrain school learning. According to Degnet et al. (2011), though there seems a gradual improvement nationally in coverage of safe drinking water supply, the rate is still very low and remains a major cause of health problems in rural areas of Ethiopia. Water scarcity increases sanitation and health problems and exacerbate risk of diseases and malnutrition (APRM, 2011). While emphasizing the educational implication of water related problem, MoH (2012) reported that women and children spend several hours every day fetching water that often stands in the way of their education, combined with the lack of sanitary facilities in schools that disadvantage girls.

In most of the cases, albeit water is available, waiting for long queue is mandatory to get a single drop of water where schoolchildren are supposed to stay for the whole morning or afternoon that gravely affects their school attendance and even achievement, for instance[[15]](#footnote-16). According to Degnet et al. (2011), physical distance to the water source is one of the starkest problems of drinking water supply in Ethiopia, with an estimate of well over 50 percent of the population traveled half an hour or more every day to the nearest water source whereby women and children are victims. Costing them 1.00 to 4.00 Birr per 20 liters jerry cane, fetching water was taking them 11 hours every other day that takes 3 hours to reach the nearest water source, 4 hours waiting for long queue, and additional 4 hours to return with heavy jerry cans (CARE, 2012). This erects a hurdle for most girls’ attendance and success in school as it consumes significant amount of their time (Degnet, et al. 2011).

1. Finding and Implication

Irrespective of substantial progresses in enrolment, in Mieso context, some children whose age is appropriate for school are not coming to school owing to diverging reasons; and of those who are coming, many dropout early. In many schools, it is commonplace to find over-aged schoolchildren, specifically in suburb and rural schools. This appears to emanate from parents’ perception of appropriate school age, where children are kept at home until they grow strong enough to withstand the long distance to school; and become capable enough to resist hunger and dehydration at school. Nonetheless, when students enrolled late to school, it is contended that they dropout early prior to acquiring the required literacy and numeracy skills.

Thus, enrolment, dropout, primary completion rate, and gender disparity seems daunting primary schooling challenges in Mieso district which seem to have interlinked with food insecurity. For instance, children are not sent to school in favour of more productive works to cope with food insecurity; and those who are at school frequently absent, or are supposed to assist their parents back home after school that consumes much of their study time. On one hand, children are much needed at home to tend or water animals, work on farm, collecting firewood and fetching water, minding homestead and siblings when parents are engaged in food insecurity coping mechanisms like khat transaction, running petty trades, gravel and sand production among others. Eventually, eschewing the business of schooling altogether, they finally dropout. On the other hand, it seems less likely for children from poor food insecure household, to come to school and even when they do, they benefit less out of schooling. This has strong implication for Education for All and Universal Primary Education as, food insecurity, hence, malnutrition hinders cognitive development and the capacity to learn, limits progress towards the Education for All goals (UNESCO, 2012).

In Mieso context, regardless of the hitherto steps forward, many pastoralist households appear to be food insecure and hence malnourished. It thus seems logical to argue that food insecure households can never prioritize schooling as existence precedes education. Put differently, for the poor food insecure households, it seems less likely to send their children to school. Thus, it equally appears unlikely for children from poor food insecure family to take advantage of school learning. Thus, most pastoralist children in Mieso suffer the double jeopardy of food insecurity and left out-of-schooling as Jukes, et al. (2008) states, being more likely to be affected by poor health and nutrition, and being more likely to have cognitive delays or educational problems as a result, the poor suffer the Double Jeopardy.

Thus, to improve school attendance, children learning capacities and performance, accentuates FAO (2005), ameliorating hunger and malnutrition, especially among rural people who constitute the vast majority of the unschooled and hungry is massively vital. In the light of this, in Mieso context, more resilience program such as school feeding, productive safety net program, food aid, and public work need to be strengthened. For instance, school feeding seems more imperative for schools at Golokha, Ananno and Bordodde CRCs than anywhere it is operational now. Equally calling for attention is access to safe drinking water in most parts of the district, as water scarcity is the single most agonizing issue affecting schools in Mieso. Further, community sensitization on the importance of children education and significance of education for breaking the food insecurity trap also appears enormously crucial. As it stands now, universalizing primary education for pastoral communities of Mieso district by 2015 seems going off track, unless these issues are acted on.

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1. The Potentials of Developing Community Based Ecotourism (CBET) to Diversify Livelihood and Assure Environmental Conservation in Haramaya and Girawa Districts

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Abstract: The main objective of this study was to reveal the potentials of Haramaya and Girawa districts for developing community based ecotourism to diversify livelihood and assure environmental conservation.

The data were gathered through questionnaires, interviews, focus group discussions, site visit/observation/ and document analysis. The collected data were analyzed using both qualitative and quantitative data analysis procedures. Different econometric models, spike model to estimate parametric mean of willingness to pay (WTP) for community based ecotourism development (CBED) and bivariate probit model to determine factors affecting WTP for CBED, and SPSS were used in the study. The study identified three different caves, two lakes, century old mosque and church and royal prison with their distinctive relics and architectural designs, various wedding procedures and its ceremonies, a range of cultural foods and handicrafts. Most of these resources were unidentified and not researched so far. Some of the major problems investigated are lack of awareness on the part of the local communities about all these tourism resources and absence of integrated works between tourism stakeholders. Using these potential resources and the local community’s willingness to pay (86%) for CBED, the article argues that, community based ecotourism should be developed in the study site to diversify livelihood and assure environmental conservation. In addition, significant community works have to be done to increase their awareness and the government should create promising environment where different stakeholders of tourism can work together.

Keywords: Community Based Ecotourism; Livelihood;, Environmental Conservation

1. Introduction

Ethiopia’s development efforts have been hindered by irregular rainfall (droughts), volatility in export earnings and costly wars (Fekadu Assefa, 2011). The population increment in the rural and suburb areas has drastically diminished the rate of farmland holdings. There is no private land-ownership in Ethiopia. The state owns all land and with a growing population and the majority of Ethiopians engaged in subsistence farming, subsequent generations of farmers are inheriting increasingly small plots. Average land holdings fell from 0.5 hectares per person in 1960s to 0.11 hectares in 1999 (UNICEF, 2014). The fragmented and small farmland holdings backed by shortage of rainfalls and soil degradations have resulted in food insecurity (Samuel Syraji, 2013). Besides, in agricultural employment, earnings are typically lowest and poverty rates are highest (Chen et al., 2005; Epstein et al, 2008; Pollinet a/., 2008).

Tourism is a labor-intensive industry that provides a wide range of employment opportunities (UNDP, 2011). It is the most promising industry to bring socio-cultural, environmental and economic changes by participating huge amount of the population in the communities. It is the major source of foreign exchange earnings for many developed and developing countries. Thus, many countries stimulate tourism development in order to enhance their national economies (Amelung et al, 1999). Ecotourism, unlike other forms of tourism, now days, is recognized as a significant tool to alleviate the cultural, economic and environmental problems of many developing and developed countries. The inauguration and development of community based ecotourism (CBET) has a positive consequence in enhancing the livelihood and improving the economy in various aspects. Ecotourism is a sound choice to empower local communities to rush against poverty and secure sustainable development (TIES, 2015).

It is the growing niche market in the womb of the larger travel industry as a tool for sustainable development (Wood, 2002). Similarly, Himberg (2006) stated that unlike other segments of tourism, ecotourism is well expressed by its sustainable development results, i.e. conserving natural areas, educating visitors and benefiting the local communities.

As globalization makes local economic control increasingly difficult, ecotourism seeks to reverse this trend by stressing on and improving the local communities (Wood, 2002). Community- based natural resource management is appreciated from time to time as a means to handle the environmental problems and realize community empowerment in developing countries (Himberg, 2006).

Almost all countries of Africa are striving well to create favorable conditions for and to gain the necessary benefits from tourism. They are doing all their best to be among the popular worldwide tourist destination areas. Ethiopia devotes much to work against poverty and furnish the necessary infrastructures for tourism to enhance its role in its development endeavors (Samuel Syraji, 2013). This is true for it has many precious natural, cultural and historical touristic resources that can attract different potential tourists from different corners of the world (Little, n. d). Carrying the objective to make the country one of the top five tourist destination areas in the continent by the year 2020, the incumbent Ethiopian government has given a due attention to tourism as one of the tools in poverty reduction and a means to change the image of the country (Markos, 2012). To realize this goal, the FDRE government has set up Tourism Transformation Council presided by the Prime Minster, the chief executive of the country, in the year 2014.

Ecotourism in Ethiopia highlights opportunities for tourists and other visitors to experience the country’s ecology and natural endowments as well as unique features of its archaeology, history and culture (Henze, 2007). Oromia State is a region blessed with so many priceless natural, archaeological and cultural/historical tourism resources. Though the region is endowed with these resources, the development of tourism and its contribution for economic development is not yet viable and sound.

1. Literature Review

Tourism is the activities of persons traveling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from within the place visited (WTO, n.d & Tourism Information and Research Center Kingdom of Saudi Arabia, 2009). It is a business that includes services like attraction, transportation, accommodation or catering to the needs or wants of persons traveling to, or staying in, places outside their home community. By scrutinizing the positive impacts tourism has on the economy, environment and social life of the community, many countries stimulate tourism development in order to enhance their national economies (Amelung et al, 1999). The different types of tourism activities are Coastal tourism and other water related recreations, Mountain tourism, City-tourism, Rainforest-tourism, Geo-tourism, Culture tourism, Food tourism, Nature tourism, Ecotourism, Agro-tourism, etc.

Different scholars and researchers have defined the term ecotourism at different time and circumstances. One among them is Cristina (2004), who defined ecotourism as a form of tourism that deals with visiting natural areas carrying the mission to learn /study or participate in activities that do not bring negative effects to the environment and empowers the local community socially and economically. It is also defined as an environmentally friendly means of bringing development and protecting natural areas and their wild inhabitants in remote locations (Weaver, 2001). On the other hand, ecotourism has an onus to unite the community, conservation and sustainable travel (TIES homepage).

The development of ecotourism assists the local people in terms of economy, preservation of the environment, cultural values and social wellbeing and also provides visitors with an elaborative explanation of the natural and cultural heritages (ecotravelperu.com). Ecotourism is a sustainable utilization of local resources and hence it promotes biodiversity conservation through preservation. CBET is defined as a “visitor-host interaction that has meaningful participation by both, and generates economic and conservation benefits for local communities and environment” (Mountain Institute, 2000. P.8). Besides, Medlik (2003) explains CBET as an approach to tourism where interests of local communities are considered in the planning and development processes.

According to Beeton (2006), CBET is a form of tourism controlled and administrated by the community. This implies that CBET has the potential to make the communities aware of their resources and initiates them to participate in sustainable conservational activities. In a nut shell, for any ecotourism activity to be considered as community based, it should encompass and participate the local communities. These communities have to be empowered and given significant opportunities in the planning, management and administration activities to sustain tourism activities of their area. This is because their participation would have paramount importance for the conservation of both natural and cultural resources. A livelihood in its simplest sense is a means of gaining a living (Robert Chambers & Gordon R. Conway (1991).

The development of CBET has multifaceted merits for the economic, social and environmental changes to happen in the lives of the local communities. CBET with its focus on small-scale, locally designed products and active involvement of the communities can be part of sustainable development strategies (Mountain Institute, 2000). The virtues of developing CBET in the economic, social and environmental issues of the local communities are discussed hereunder.

Natural and cultural resources are becoming sources of viable economic benefits in many underdeveloped countries by attracting both domestic and international tourists who love the authentic natural and cultural experiences (Mountain Institute, 2000). Tourism is a labor-intensive industry that provides a wide range of employment opportunities. It contributes to poverty reduction by creating job opportunities even for the low-skilled workers in remote areas to become tourism exporters (UNDP, 2011). The inauguration and development of CBET has a positive repercussion in enhancing the livelihood and improving the economy in various aspects. By hastening capacity building and employment opportunities, ecotourism is a sound choice to empower local communities to rush against poverty and secure sustainable development (TIES, 2015).

CBET deals with the cultural conservation, community and gender empowerment, poverty alleviation and income generation for the societies (Mountain Institute, 2000). This is because the development of CBET relies on the use of local labor, local goods and services, the development of appropriate and sustainable infrastructures, supportive policies and environmental strategies which result in the increment of benefits to the local communities. It can also bring positive livelihood impacts, which include the prevalence of economic and employment opportunities for individuals, households, and the collective community by reducing vulnerability, developing skills, improving access to information, enhancing infrastructure, market and food security and strengthening community organizations (Simpson, 2007).

CBET creates favorable conditions for local communities’ empowerment, participation in the conservation of both natural and cultural heritages and obtaining economic benefits. In addition to this, Vellas (n.d.) has mentioned different social benefits of ecotourism like creation of employment and new activities related to ecotourism, enhancing community wellbeing and social services (electricity, access to healthcare and education, etc.). Community wellbeing, which refers to the quality of life and level of sustainability, is shaped by a number of psychological, cultural, economic and environmental factors that outline how people are thinking and acting in their daily lives (Simpson, 2007).

Ecotourism is considered as a type of tourism that enhances conservation and socio­economic development in the rural communities’ emergent economies. Comparatively, ecotourism is one of the fastest growing sub-segments of the tourism industry that have stamped its authority in today’s world economy. This being the case, tourism, especially ecotourism, has emerged as a striking chord section of tourism that seems to be the remedy for the prevailing socio-cultural and environmental challenges bedeviling the universe (Mawere and Mubaya, 2012).

TIES explained the role of ecotourism in conserving and preserving natural endowments in the following manner. “With an emphasis on enriching personal experiences and environmental awareness through interpretation, ecotourism promotes greater understanding and appreciation for nature, local society, and culture. Offering market-linked long-term solutions, ecotourism provide effective economic incentives for conserving and enhancing bio-cultural diversity and help protect the natural and cultural heritage of our beautiful planet” (TIES, 2015).

It is clear that conservation of both natural and cultural resources has to be given a due attention for it attracts tourists to the destination. Tourists should also behave in an environmentally friendly way. Eco-tour operators need to be provided with necessary advice on how travelers can minimize their impact and participate in the conservation of fragile ecosystems. The idea here is to make eco travelers well aware of the environmental issues and continue to behave in an environmentally conscious way (Eco­Tour, 2007). Development through conservation fosters collective actions and strengthens the institutional capacity needed for sustainable development (Tai, 2007).

In general, CBET underscored the need to conserve cultural and natural resources like biodiversity, water, forests, cultural landscapes, mountains etc. This in turn, can be realized through the increased intensities of acquiring benefits, participations and decision making powers and onuses vested in the hands of the local communities.

CBET development empowers communities’ role and participation in the conservation of natural and cultural heritages. The involvement of local communities is very crucial for the long lasting existence of both natural and cultural resources. Brandon (1996) argues that if the conservation efforts miss the active participation of these people, it is more likely that the resources on which tourism lies will be destroyed and the investment will be lost (cited from the Mountain Institute, 2000). Thus, the initiations of sustainable conservation projects need to place more communication efforts in building intra-community trust and consensus.

Empowerment of the local communities can be increased if their involvement in the planning, decision making and management of ecotourism enterprises is so great. This is achieved through capacity building efforts mainly by education and training activities.

These capacity building activities could be based on organizational and technical capacity to deliver specific services, infrastructural and community capacities (Beeton, 2006). The government and other tourism experts are supposed to provide the communities with the opportunities to make decisions and encouragements through skill development- trainings.

Farrelly (2011) argues that, decision making process introduced by external development, no matter how effective it is, cannot be the best alternative to the traditional decision making systems. Because management by local people is more preferable for it is more accountable and sustainable in the long term. There is worldwide accreditation of community based conservation (CBC) as a vital element of conservation policy. This is because CBC underlines the positive roles of local communities’ participation to conserve biodiversity, natural ecosystems and cultural values so as to achieve their socio-economic developments.

Beeton (2006) further elaborates the importance of community empowerment/ ‘self­determination’ saying that various ‘empowered’ tourism and community development initiatives have failed due to the failure of communities to maintain them. He also explained as ecotourism includes issues like sustainability, which refers to the community and the natural environment, generation of financial support for the protection and management of natural areas, benefits for residents and resident support for conservation.

1. Methods
   1. Description of the Study Sites

Haramaya and Girawa districts are two of the 18 districts found in East Hararghe zone, Oromia Regional State, Ethiopia. Haramaya district is situated in the Northern part of the zone, bordered on the south by Kurfa Chele and Fedis, on the west by Kersa, on the north by Dire Dawa administrative council, on the east by Kombolcha, and on the southeast by Harar regional state. On the other hand, Girawa is surrounded by Gola Odana on the south, Bedeno on the west, Kurfa Chele on the north and Fedis on the east. The study areas, Haramaya and Girawa districts, are endowed with midlands and lowland agro-climatic zones. The average annual rainfall and temperature of the districts range between 118mm and 866mm and 9.40c and 240c, respectively. The altitude of Girawa woredarages from 500 to 3230masl, Geyle and Mount Gara-Muleta are the highest peaks in the area (Agriculture and Rural Development Offices of Haramaya and Girawa Districts).

* 1. Study Area Map

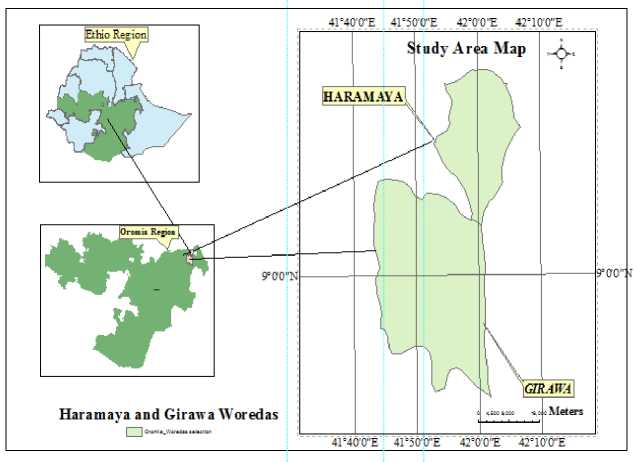


Figure 1. Map of Haramaya and Girawa Woredas.

1. Data Collection Instruments Questionnaire survey:

This was prepared in two languages, English and Afan-Oromo, to analyze opinions of local communities of the study site on the available potential resources. It was pre-tested and amended before the actual questionnaire survey was made. The survey involved randomly selected 300 local respondents.

Key Informant Interviews: structured interviews were held with community elders and religious fathers to gather basic information related to the available resources. On the other hand, semi-structured interviews were made with woreda and zone culture and tourism office workers about Haramaya and Girawa districts tourism potential resources in general and ecotourism in particular.

Observation (Site Visit): was used to enumerate and make inventory of tourism resources and products of the study area. It was during this site visit that most of the resources were photographed.

Secondary Data: Several written materials like books, journal articles, reports, magazines, newsletters, leaflets and recorded audio and videos were intensively utilized to analyze tourism resources of the area and the role of ecotourism for community development and environmental conservations

1. Methods of Data Analysis and Interpretation

The gathered data was analyzed through both qualitative and quantitative data analysis procedures. The qualitative data is analyzed through narration and using pictures. On the other hand, the quantitative data is analyzed through descriptive statistics like frequency and percent and using different econometric models like spike model which was used to estimate parametric mean of willingness to pay (WTP) for community based ecotourism development (CBED) and bivariate probit model applied to determine factors affecting WTP for CBED.

In contingent valuation method (CVM) survey to distinguish between genuine and protest zero responses we should adopt an appropriate framework of analysis (Strazzera et al, 2003). In this study we adopted the Spike model. The Spike model was proposed by Kristrom (1997) and it explicitly allows for the possibility that some portion of the respondents are indifferent to the good being valued, i.e. this model assigns a non-zero probability to zero willingness to pay (WTP) responses. Following Kristrom (1997), the simple spike model was used in the study to allow a better handling of the zero responses that are common when using the dichotomous choice referendum format. A respondent was asked whether or not he or she is willing to contribute to a trust fund that was used for community based ecotourism development (CBED). The WTP for development from Zc —\* Z1) can be expressed as:

■' = r (1)

Where V(y, z) is an individual’s indirect utility function and y is income. If there is a continuum of individuals who associate different values to the development of community based ecotourism, the probability that an individual’s WTP does not exceed an amount A is given by:

Pi(WTP < A) = Fwrtp(A) (2)

Whereivtp 00 is a right continuous non-decreasing function. As a result, the expected WTP can then be expressed as:

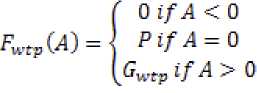
*EiWTP)* = *f0* 1 - *Fwtp (A)dA*-O-*(A)dA*

(3)

To be able to estimate **/WOO** when binary valuation questions are used, three

amounts of A(30, 70, 100 birr) was presented to each sub-sample. The spike-model assumes that the distribution function of WTP has the following form:

(4)



Where p belongs to (0, 1) and Gwtp (A) is a continuous and increasing function such that Gwtp (0) = p and lim A^-w Gwtp (A) =1. This creates a jump-discontinuity or a spike at zero.

In this study after the contingent valuation scenario was presented to the respondents’ two valuation questions was offered for the spike model. These valuation questions include:

1. Whether the respondent is willing to contribute to the trust fund for CBED, and

2. Whether the respondent is willing to contribute Birr per year for CBED.

For each respondent, i, an indicator S’, was defined to determine whether die respondent

is “in-the-market” or not.

[1 *if WTP >* 0 [0 *if WTP* < 0

(5)

The respondent was “in-the-market” if the additional amount that he/she was asked to contribute to the trust fund is lower than his/her willingness to pay. To identify the effect of respondent’s socio-economic characteristics on their WTP for CBED non linear model was used. The model is specified as:

***Si*** = *Y* 0 **+ *n*** *Vij* **+ *YzVzj + ■*** ■ ***■* + *V*** It ***vk.j* + (**6**)**

Where V2, ,VK) is also a vector of explanatory variables not necessarily

distinct of Xr( below; y= unknown parameters of the model. Analogously, one can assume that behind die decision to participate in die hypodietical markethT; = the latent variable?’\* was used to indicate die respondent’s WTP the suggested prices A,

or

**0 *otherwise***

*T \_* ri *if WTP > A and* ! t 0 *otherwise*

(7)

This latent variable T is specified as:

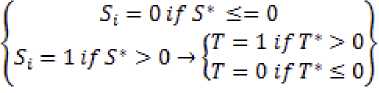
***Tt*** = ***a + pA i*** + *YiXlri* + *y2XZii* + ***-*** + *YuXm* ***+ sTi-*** (8)

Wliere XTi = X2, ■■■, XH ] is a vector of explanatory variables, A is the initial bids,

offered to die respondent in order to enjoy die development from Zc —\* Z1,in the case of this study, CBED. And ct, andy are unknown parameters of die model. The disturbance terms are assumed to have a bivariate normal distribution with a correlation parameter, p. That is, Therefore, widi die introduction of

these decision rules, the spike model becomes a bivariate specification with sample selection:

(9)



The log likelihood for the sample is then given by:

**i = *nSi=Qp(.s\** < o)*Us^i[nTi=iPis\* >* o,***t\** ***>* j)n*Ti=Qp(s\**** *>o,t\*<* **>i]**

(10)

which implicitly contains the joint probability of S\* and T\* and die marginal probability of 5\*.

1. Result and Discussion

The study involved 300 stakeholders selected randomly; of which 52.2% and 47.8% of them were males and females, respectively. In terms of age composition, about 44.2% of the respondents’ age was between 31-35 years. Whereas about 29.9% of therespondents’ age lies in the middle of 26-30 years, the age range of 7.6% of the respondents was greater than 40 years old.

Identifying marital status and educational level of the respondents are very vital to determine respondents’ understanding of the economic, social, cultural, historical and environmental aspects of the area under the study. Thus, 62.1% of the respondents were married and the remaining 37.2% & 0.7% of them were single and divorced respectively. Academically, while about 37.2% & 26.6% of the respondents attended only primary and high schools respectively, about 24.3% and 11.6% of them were not educated and had attended college education, respectively.

Ecotourism potential resources of Haramaya and Girawa Districts Gara Muleta Royal Prison:

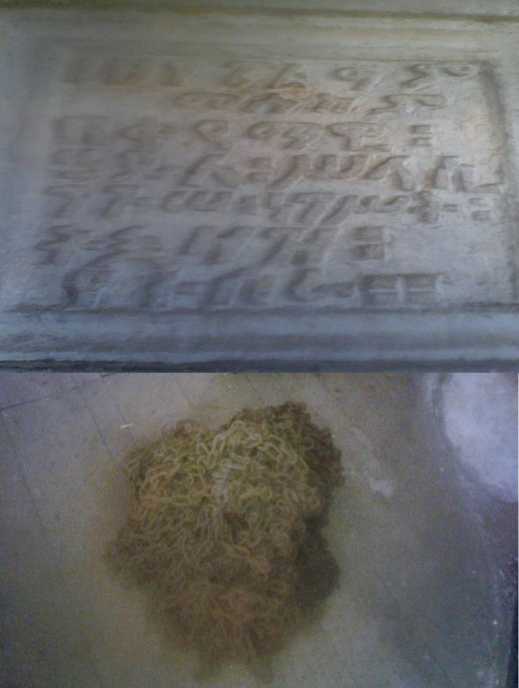
The tradition of putting power successors into custody was a practice started during the medieval period in Ethiopian history (1270-1855). Photius Coutsoukis has explained when and why royal prison was started as follows:

In 1285 Yekuno Amlak was succeeded by his son, Yagba Siyon (reigned 1285­94). His reign and the period immediately following were marked by constant struggles among the sons and grandsons of Yekuno Amlak. This destructive conflict was resolved sometime around 1300, when it became the rule for all males tracing descent from Yekuno Amlak (except the reigning emperor and his sons) to be held in a mountaintop prison that was approachable only on one side and that was guarded by soldiers under a commandant loyal to the reigning monarch. When that monarch died, all his sons except his heir were also permanently imprisoned.

This practice was followed with some exceptions until the royal prison was destroyed in the early sixteenth century. The royal prison was one solution to a problem that would plague the Solomonic line throughout its history: the conflict over succession among those who had any claim to royal lineage (2004).

The prison house constructed in Girawa is also called Lij-Eyassu Prison house for it was meant to jail him. The prison house is found in Girawa town which is 76km away from Harar town and 600km far from the country’s capital city, Addis Ababa. Li-Eyassu ruled Ethiopia from 1913-1916, when Ras Teferi (the latter Emperor Haile Sellasie I) became a heir in the dual power of 1916-1930 with Zewditu by a full-fledged support of the Shoan nobility, Lij-Eyassu was dethroned and put in prison first in north Shoa, Selale and later at Girawa East Hararghe, where his life was cut short.

This wonderful edifice was constructed by an Armenian female engineer named Emalia by the order of his imperial majesty emperor Haile Sillasie I in 1931. The building has got three parts and several classes built for different purposes like prison, reception class, kitchen class, rest rooms, and offices. The prison house owes a good trace of Ethiopian history and an interesting destination for tourists, historians and lovers of history. Currently, however, this historic heritage is in the verge of collapse for it is not well kept and maintained.



Picture 1. Gara-Muleta Royal Prison, the date when it was constructed and the chain used to chain Lij Eyassu, (Photos by Authors).

Ancient religious buildings:

St. George Church:

St. George church is found next to the Royal prison and is in existence for the last 100 years. It once served as a place where people used to gather for different social and religious issues. It houses quite ancient religious relics.



Picture 2. St. George Church of Girawa (Photo by Authors).

Mesgida Biyo Guda (Biyo Guda Mosque):

Biyo Guda Mosque is an old mosque with around 800 years age (as to the local elders) found in Grawa woreda Mudana Qurquroo village. Every part of its body is made up of well carved stone blocks except the water outlet (in Amharic ashenda) which is totally made up of a curved half-tube like wood. There is another building next to the mosque with four rooms. According to our informants, while one room was used as a toilet and the rest three rooms were reserved for zawiyas (rooms to undergo Islamic education). The mosque is located at an elevation of 1500 meter above sea level. Today there is no any house or any resident leaving around the mosque. However, it is protected and managed by a person called Sheik Abdulhamid Sheik Umar who is believed to be the right descendant.



Picture 3. Biyo Guda Mosque (Photo by Authors).

Rakober Zala Cave:

This is a cave where one can see the flow of water but couldn’t understand where it comes from and it goes to. The locals use the flowing water for three purposes based on its access, i.e. the first part is the place where one can find it when entering into the cave and the water found here is preserved for animal drink, the second is part of the water body found next to this and is used by the local inhabitants for washing their cloths and bodies and the last one is part of the water body found much deeper than the former two and is used for human drink. Our informant told us the story kept in the minds and hearts of the people regarding how the aboriginals have started to use this underground water. Once the water was fond, he said, the local elders have gathered and make discussions on how to use it. The result of their discussion was first to test it by giving to aged animals like dog and donkey, and then to aged cows and oxen and finally to elder human beings. Knowing those who have consumed the water faced no problem, the elders publicly declared that the water is pure and good for human drink.



Picture 4. Rakober Zala Cave (Photos by Authors).

Mountains of Gara Muleta

The mountain is the highest peak of all mountains found in East Hararghe zone of Oromia Regional State with heights over 3500m above sea level. The mountain is shared by four woredas, i.e. Girawa, Kurfachelle, Kersa and Bedeno. In the local language/A/an Oromo/ Gara-Muleta means “a mountain that can be seen from different directions”. It has interesting remnant forests largely the dense Afro-Alpine vegetation cover, several birds and wild animals of different kinds. The possible tourism activities that can be developed in this area are canyon, mountain climbing, adventuring and controlled hunting. In addition, its scenic value is also quite impressive.



Picture 5. Mountains of Gara Muleta (Photos by Authors).

Natural Lakes

The site is endowed with three different natural lakes namely Haramaya, Tiniqe and Adalie. Eventhough Haramaya Lake disappeared, strong effort has been made to recover it since last year. The significant resources found in and around these lakes are various aquatic bird species like Lesser Flamingo, Cattle Egret, Hamerkop, Sacred ibis, White pelicans, Wattled ibis, to name a few. In addition, the dominant aquatic plant species in the study area are Typhabeds and Papyrus. Fish species are also found in the district.



Picture 6. Natural Resources of Haramaya District (photos by Authors).

Gole Gaya Cave

The cave is found in Girawa district specifically in a place called Gofra Burqa which is 75km away from Harar town. There are various pictures of home animals being depicted on the walls of the cave. Though everyone who paid a visit to this cave wonders about who painted them and the date when these pictures were painted, again it has to be left for historians and archaeologists to deal with, the rock painting techniques used and the inks selected for painting carried a lot of secretes to tell. It is a wonderful attraction site of the woreda.



Picture 7. Gole Gaya Cave (Photos by Authors).

Abdullahi Ibro Cave

Abdullahi Ibro Cave is located in East Hararghe zone Grawa Woreda Mojo-sade Kebele. According to the local elders, the cave is created naturally and has been used by the local community for several activities. First, it has served as an ideal place to celebrate the major Islamic religious holiday (Eid). Because the immediate six days after Eid Al-Fitr are the days of fasting (Shewal soum), the locals prepare different things in common here for one day consumption. Next, it also has served as a fortress for the local community to hide their family and belongings during war times. More specifically, during the clash between the locals and Central Ethiopian Government (1890s), Italo- Ethiopian war (1935/36) and Ethio-Somalian war (1970s). Finally, the cave, even today, is serving as a shelter for the local cowboys or shepherds to escape rainfalls. Though the gate to the cave is small (narrow), its internal body is quite large and has got several sections/rooms. Due to ease of access, usually the locals conduct their ceremonies only at the first session of the cave. It is also advised for anyone who wishes to discover this cave to have a light with him/her.



Picture 8. Abdullahi Ibro Cave (Photos by Authors).

Wedding styles and its ceremonies

Inhabitants of the site have proud history, culture and value systems passed down from generation to generation. Some cultural elements of the people are the culture of tolerance, marriage ceremonies, producing and using cultural tools, foods, folklores and music etc. More importantly, it is quite impressive to give a due attention to the cultural processes of marriage arrangements among these people. The minimum appropriate age limit to get married is 18 years for male and 15 for female. There are around five possible ways of arranging marriage, i.e.

1. **Qap**i**mechu**/ through fiancee/:- this type of marriage arrangement requires the male families to send elders to the female families to ask their willingness. Here, the two families, the male and female, need to reach into consensus concerning the date of marriage and for how long the male families should wait before marriage.
2. **Wel**li**n De’amu:** Here marriage is arranged based on the interests of the partners. The couple would sit down and communicate the date of their marriage.
3. Buti/abduction/: this is of two kinds. The first is conducted without the consent of the lady and may result in stiff conflict between the two families. However, the second one is conducted with full interest of the lady and abduction may be arranged by the couple to get the good will of parents.
4. **Chebsa/**Accidental/: in this process the male families together with elders go to the female house without informing them/ accidentally/. Though they may stay there one or two days, they won’t come back without getting okay responses from the female families.
5. **Asse’ena:** in this kind of marriage arrangement the female, who fall in love, will go to the house of her beloved ones and enter into his house. At this juncture, the male parents have only two options; either to accept her request for marriage or see her

off with a gift, i.e. cow. Culturally, the later is considered so as to maintain the female’s psychological demise.

Cultural Foods: merqa/porridge/, ambaberoo/best bread/, chechebsa, tuftufa, derara shum, etc.



Picture 9, Cultural food items (compiled by the Authors)

Handcrafts:

The community has the capability of producing wonderful handcrafts out of several materials for quite different purposes. Some of them are used to carry food, milk and water.

Dressing styles of hararghe people



nm mry com - FEFW&J

Picture 10. Cultural Handcrafts (compiled by the Authors).

The local communities of Hararghe zone of Oromia regional state have their own peculiar dressing styles. This dressing style distinguishes them from other people in the region. Mostly they put on such a wonderful and eye-catching clothes during several gatherings like, Irrecha (Oromo thanks giving ceremony), wedding ceremonies, religious holidays, national festivals, and in times of other special events.



Picture 11, Cultural Dressing styles of Hararghe People (compiled by the Authors)

The Community’s level of awareness about tourism resources of the districts

Community involvement and participation in leisure and tourism planning has become increasingly popular, not only to ensure that the right planning takes place, but also on a local scale to ensure a sense of community and civic pride in the new developments. The ability to increase civic pride, community spirit and collective self-image through the

hosting of events has become a way of including the local community in all levels of decisions for the outset. Local communities made sound participation whenever they came to acquaint with what they have around them. Local communities of Haramaya and Girawa districts had inadequate understanding about the resources found in their areas/Table 1/. Even those who know something about their resources knew through personal observation and word of mouth/ table 2/.

Table 1. What is Your Level of Understanding about the Tourism Resources of Your District?

|  |  |  |
| --- | --- | --- |
|  | Frequency | Percent (%) |
| Adequate | 19 | 6.3 |
| Moderate | 100 | 33.6 |
| Inadequate | 180 | 59.8 |
| Not available | 1 | .3 |
| Total | 300 | 100.0 |

Source: survey data, 2015.

Table 2. Which Source of Information Acquaints you with Tourism Resources of Your District?

|  |  |  |
| --- | --- | --- |
|  | Frequency | Percent (%) |
| Data base inventory | 33 | 11.3 |
| Folders, brochures and | 10 | 3.3 |
| leaflets |  |  |
| Broadcast media/ TV, | 53 | 17.6 |
| Radio, Internet/ |  |  |
| Word of mouth | 102 | 33.9 |
| Personal observation | 102 | 33.9 |
| Total | 300 | 100.0 |
| Source: survey data, 2015. | | |

Households WTP for CBED

The result showed that while 86% of the respondents were willing, the remaining 14% of them were not willing to pay for CBED. The descriptive statistics of households’ responses from the single bounded dichotomous choice format showed that 60.3% of the respondents’ were willing to accept the initial bids, whereas the remaining number of respondents’ rejected the initial bids (Table 3). The average initial bids assigned to the respondents were computed at 66.67 ETB per year.

Table 3. Households’ response on initial bids.

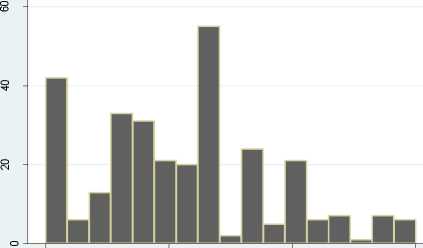
|  |  |  |
| --- | --- | --- |
| Response to initial bids | Frequency | Percent (%) |
| No | 119 | 39.7 |
| Yes | 181 | 60.3 |
| Total | 300 | 100.0 |
| Source: survey data, 2015 |  |  |

Using the spike model, the mean annual WTP for CBED of the sample respondents was computed at 95.67 ETB per year per household for ten years horizon (Table 4).

Table 4. Parameter estimates of spike model for CBED.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Coef. | Std.err | z | V  CSJ |
| Eq1 |  |  |  |  |
| B  S  \_cons | 0.020 | 0.002 | 10 | 0.000 |
| 1.80 | 0.16 | 11.25 | 0.000 |
| A: 1/(1+exp(\_b[s:\_cons])) |  |  |  |  |
| wtp: 1/(\_b[eq1:b])\*log(1 + | exp(\_b[s: | \_cons])) |  |  |
|  | Coef. | Std.err | z | P>|z| |
| A | 0.14 | 0.02 | 7 | 0.000 |
| Wtp | 95.67 | 6.88 | 13.91 | 0.000 |
| Log likelihood= -268.10 |  |  |  |  |
| Number of Respondents= | 300 |  |  |  |
| Wald chi2(1)= 102.4 |  |  |  |  |
| Prob>chi2= 0.000 |  |  |  |  |

The mean WTP of the respondents from open ended questions was computed at 56.17 ETBper households per year. The total WTP of the sample respondents was also estimated at 16851.00 ETB per year with minimum 0 and maximum 150 ETB. The maximum WTP of the sample households’ is presents in Figure 1 below.



0 50 100 150

Maximum WTP of sample respondents(ETB)

Figure 1. Sample Households Maximum WTP(survey data, 2015).

To determine what motivates households’ willingness to pay for CBED, different reasons were identified. The respondents provided different reason for their maximum WTP. That is, about 52% of the respondents reported that they could not afford more than what they stated because of inadequate income. (Table 5).

Table 5. Reason for maximum willing to pay.

|  |  |  |
| --- | --- | --- |
| Reason | Frequency | Percent (%) |
| No response (zero WTP) | 42 | 14.0 |
| I think it is adequate | 78 | 26.0 |
| Others should pay | 24 | 8.0 |
| I could not afford more | 156 | 52 |
| Total  Source: survey data, 2015 | 300 | 100.0 |

However, about 14% of the sample respondents were not willing to pay for CBED and provided zero response. About 3.3% of the sample households were responded protest zero[[16]](#footnote-17). The respondents provided different reason for not willing to pay for CBED (Table 6).

Table 6. Reason for not Willing to Pay for CBED.

|  |  |  |
| --- | --- | --- |
| Respondents reasons for zero bid | Frequency | Percent (%) |
| None (for the willing households’) We do not believe that the money | 258 | 86.0 |
| we pay will actually be used for CBED | 8 | 2.7 |
| We believe that CBED is unnecessary | 10 | 3.3 |
| Lack of money | 24 | 8.0 |
| Total | 300 | 100 |

Source: survey result, 2015.

Determinant of households WTP for CBED

The bivariate probit model was used to analyse the determinants of households’ willingness to pay for CBED (Table 7). The result showed that annual income of the respondent had positive and significant relationship with the households’ WTP. This positive effect indicates that respondents with higher annual income were more likely willing to pay than households with lower income. Education level of the respondents was also positively and significantly related to WTP for CBED. Besides, sex of the respondent was also measured as a dummy variable taking the value of 1 for male respondents and 0 for female respondents. The result showed that coefficient of sex has positive sign and significant at 5% level of significance. The positive sign of the coefficient indicated that male respondents were willing to contribute for CBED than female respondents. This might be due to high involvement of women in home activities and they might be face money shortage that restricted them from contributing for CBED.

Households who had familiarity with potential tourism resources were expected to have high WTP. The result found similar result. The coefficient of this variable was significant at 1% level of significance. Married respondents were more likely willing to pay for CBED than single respondents. The coefficient of this variable was positive and significant at 5%.

Furthermore, the result of the bivariate probit model showed that respondents with large family size were less likely willing to pay for CBED than respondents with small family size. The coefficient of starting bids has negative sign and significant at 1% level of significance. The negative sign and the significance of this coefficient indicated that as the starting bid price increases, the probability of household’s WTP decrease. This may indicate that there is income scarcity or cash poverty.

Table 7. Bivariate probit regression result.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Coef. | Std. Err. | V  CSJ |
| s(participation in CBED) | | | |
| b(initial bids) | -0.018 | 0.005 | 0.001\*\*\* |
| familiarity | 1.296 | 0.372 | 0.000\*\*\* |
| Sex | 1.903 | 0.417 | 0.000\*\*\* |
| Age | -0.041 | 0.022 | 0.058\* |
| Marital status(base: single) |  |  |  |
| 2(married) | 1.028 | 0.464 | 0.027\*\* |
| 3(divorced) | -0.134 | 2.010 | 0.947 |
| 4(widowed) | -0.583 | 24.29 | 0.981 |
| Total familysize | -0.263 | 0.094 | 0.005\*\*\* |
| Education(base: illiterate) |  |  |  |
| 1(primary school) | 0.671 | 0.331 | 0.043\*\* |
| 2(high school) | 0.625 | 0.576 | 0.278 |
| 3(college) | 5.356 | 242350.6 | 1 |
| Credit | -0.118 | 0.287 | 0.681 |
| square rootofincome (sqrti) | 0.018 | 0.006 | 0.004\*\*\* |
| \_cons | 0.156 | 0.886 | 0.86 |
| t(response to initial bids) |  |  |  |
| b(initialbids) | -0.022 | 0.004 | 0.000\*\*\* |
| Familiarity | 0.606 | 0.315 | 0.055\* |
| Sex | 1.004 | 0.246 | 0.000\*\*\* |
| Age | -0.014 | 0.016 | 0.38 |
| Maritalstatus |  |  |  |
| 2(married) | 0.604 | 0.403 | 0.134 |
| 3(divorced) | -0.597 | 0.785 | 0.446 |
| 4(widowed) | 0.415 | 0.908 | 0.647 |
| Totalfamilsize | -0.145 | 0.068 | 0.034 |
| education (base: illiterate) |  |  |  |
| 1(primary school) | 0.738 | 0.258 | 0.004\*\*\* |
| 2(high school) | 0.593 | 0.323 | 0.066\* |
| 3(college) | 7.349 | 48595.89 | 1 |
| Credit | 0.093 | 0.228 | 0.684 |
| squarerootofincome(sqrti) | 0.013 | 0.005 | 0.003\*\*\* |
| \_cons | -1.001 | 0.723 | 0.166 |
| /athrho | 3.404 | 65.92 | 0.959 |
| rho | 0.998 | 0.291 | -1 |
| Number of obs = 300 |  |  |  |
| Wald chi2(26) = 102.66 |  |  |  |
| Log likelihood = -166.4602 |  |  |  |
| Prob > chi2 = 0.0000 |  |  |  |

Aggregate WTP for CBED

An important issue related to the measurement of welfare using WTP is aggregation of benefit. Mean WTP was used as a measure of aggregate value of CBEDsince the good dealt with is not a pure public good. The aggregate WTP was calculated by multiplying the mean WTP by the total number of households in the population. Therefore, the aggregate benefit for CBEDof the total population of the study area were computed at 5,409,181.8 and 3,175,851.8 ETB[[17]](#footnote-18)per year from spike model and open ended question respectively.

Tourism Stakeholders’ Role for CBET Development

[

Table 8. The Government Works with the Local Communities to Develop Tourism in the Area.

|  |  |  |
| --- | --- | --- |
|  | Frequency | Percent (%) |
| Disagree | 197 | 65.4 |
| Neutral | 47 | 15.6 |
| Agree | 57 | 18.9 |
| Total | 301 | 100.0 |

Source: survey data, 2015.

Successful development of tourism destination highly relies on strong coordination of the various and vital stakeholders of tourism. One of the central organs of tourism stakeholders is government; its function has a decisive role either for promotion or demotion of any tourism activities of any country. Specifically in the study area of this research, the government is not actively working with the locals and other tourism stakeholders to develop tourism in the area /table 8/.

Table 9. The Local Community is Encouraging to Conserve Natural and Cultural Resources

|  |  |  |
| --- | --- | --- |
|  | Frequency | Percent (%) |
| Disagree | 90 | 29.9 |
| Neutral | 71 | 23.6 |
| Agree | 140 | 46.5 |
| Total | 301 | 100.0 |

Source: survey data, 2015.

Indigenous, First Nations, traditional, and local people, isolated from markets and politically marginalized, depend for their survival and cultural identities on the sustainable use of natural resources. That makes them our best partners and constituents for conservation. It’s strongly believed that wildlife and natural resources are most likely to be conserved when they are managed by the people whose wellbeing and sense of self are founded on them. Any conservation effort made by outsider, no matter how excellent it is, will remain in vain if it doesn’t include the local communities [(http://www.wcs.org/ our-](http://www.wcs.org/our-work/solutions/communities) [work/solutions/communities)](http://www.wcs.org/our-work/solutions/communities). The local communities in the study area are not encouraged and getting the necessary motivations to conserve both cultural and natural resources of their districts /table 9/.

1. Conclusion and Recommendation

The major opportunities to develop CBET in Haramaya and Girawa districts are; first, various mesmerizing tourism attractions, i.e. historical, cultural and archaeological; different aquatic and non aquatic bird species, lakes, mountains covered by Afro-Alpine vegetations; and several wild animals. Second, accessibility: the area is accessible by different means of transportations like automobile, bus and minibus, pack animals, and pedestrian. Third, the site has geographical advantages: it is located near to Harar, UNESCO registered World Heritage Site, Dire Dawa, where there is an International Airport, Qulubi Gebriel Church, a famous church in the country celebrated twice in a year, and Haramaya University with more than 14,000 communities. Fourth, the existence of good national policy and strategy for tourism is additional opportunity to develop tourism activities. Finally, the local communities’ willingness to pay for CBED (86%) is also an important issue that can be considered as another prospect.

The CVM was used to elicit households’ WTP for CBED in Girawa and Haramaya Districts. About 86% of the respondents were willing to pay for CBED. The annual WTP value of households from the single bounded dichotomous choice format was greater than the annual total WTP from the open-ended format. We conclude that the single bounded dichotomous choice is affected by the anchoring/fixing effect. Thus, when designing a new development policy, decision makers and researchers should give more attention to solving the problem of the anchoring/fixing effect from the single bounded dichotomous choice format. The value can be used in future cost-benefit analyses for policy formulation, and can be considered as the societal benefits of CBED. Our findings can also be used to compare the cost of the CBED plan, for example to the aggregate WTP of the households which is ETB 5,409,181.8 and 3,175,851.8 per year from spike model and open ended question respectively. If the aggregate WTP is lower than the proposed cost of the development plan, effort is required from the development agency or government to solve the social acceptability problem. Furthermore, the WTP was affected by the socio-economic characteristics of the different households. This result leads us to conclude that an understanding of the socio-economic characteristics that significantly affect households’ WTP is a necessary and first step to achieving CBED.

In a nutshell, based on the finding of the study, community based ecotourism should be developed to diversify livelihood and encourage the locals to give due attention for their resources as sources of income and thereby to ensure environmental conservation. Specifically, this research is believed to encourage the government to launch CBET project in the study site so as to create job opportunities for the locals and maintain authenticity of heritages, Environmentalists/Conservationists to subsidize such a project with an intention to preserve the pristine nature and protect future loss of valuable resources, private stakeholders to engage in this business for it is a niche market in the area, academicians to make further explorations, Haramaya University to make necessary professional support and the local communities to strengthen their custodianship.

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**I**



Theme V

**Institutions, Innovation Systems, and Economic Development**



**Theme V**

1. The Dynamics of Food Price Convergence in Ethiopia Degye Goshu

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Abstract: This paper examines the dynamics of relative price convergence of nine agricultural commodities among regions in Ethiopia using a panel dataset of 18-year monthly prices collected by CSA in two periods (1996­2004 and 2005-2013). Panel unit root tests, fixe-effects, and half-life method were employed to estimate the rate and speed of relative price convergence of commodities. The findings markedly indicate low rate and speed of relative price convergence and considerably persistent relative price shocks unadjusted among regions, suggesting the need to design proactive market policy intervention in improvingconvergence of commodity prices in Ethiopia.

Keywords: Food price; commodity; price convergence; fixed-effects; Ethiopia.

JEL codes: Q11; Q13.

1. Introduction

The burgeoning literature on commodity price adjustment suggest the importance of spatial, temporal, vertical and intercommunity price integration for the presence of market efficiency. A priori economic theory suggests that spatially efficient markets increase supply and decrease price of goods and flow of goods and services in between food deficit and surplus areas, generating positive net welfare effects. Spatial food insecurity can be even be prevented before triggering famine if spatial arbitrage is efficient in distributing produces from surplus areas to deficit areas (Webb et al, 1992; Tschirley, 1995).

Since grain trade liberalization in 1990, a number of short- and long-run policy measures including establishment of commodity exchange, banning of export of food stables like cereals following food price inflation, direct price setting (price ceilings) on some basic food items (oil, wheat flour, sugar), and privatization of many parastatals were implemented to improve domestic commodity market performance in Ethiopia.The most important question in this regard is whether or not these market reform measures and policies have resulted in domestic market performance in Ethiopia. One of the common indicators of the success of domestic market performance is price convergence. Price convergence shows the degree to which prices for goods in spatially differentiated markets, regions or countries have moved together, or converged towards unity (Susanto et al. 2008; Bukenya and Labys, 2005; Cecchetti, et al. 2002; Parsely and Wei, 1996). Price divergence, as opposed to this, shows the degree to which prices have moved apart as an indicator of poor internal market performance mainly attributable to inadequacy of market information, institutions and infrastructure. It is expected that increases in marketing infrastructure and globalization are broadly suggestive of relative commodity prices in spatially differentiated markets adjusting towards unity over time.

The primary focus of most previous studies in Ethiopia was; however,to measure the spatial, vertical or intercommunity price transmission among markets (se Webb et al., 1992; Dercon, 1995; Asfaw and Jayne, 1997, 1998; Gebremeskelet a/., 1998; Eleni, 2001; Kindieet al, 2006; Kindie, 2007; Degye et al, 2009). They also have various limitations in terms of market coverage, methodology, and many empirical irregularities. The assumption of spatial price adjustment that commodities are homogenous is not testable and would frequently be unsatisfied. Commodity markets are different in terms of seasonality, geographical location, and other factors, which are difficult to be accounted for by such price adjustment models. Because of these problems, there is still a wider gap of adequate and relevant empirical evidence on the Ethiopian commodity marketing system.

Multivariate price series models frequently employed for the purpose of spatial, vertical and inter-communityprice adjustment in Ethiopia have some common limitations and difficulties. The first limitations is that researchers are forced to focus on limited number of markets and commodities due to the fact that these methods are data- intensive, leading to model misspecification emanating from unavoidable omission of many important markets and commodities.Second, the existence of unobserved market- specific effects is ignored, and the assumption that markets are static is admitted. But the market-specific unobserved heterogeneities can contribute more towards the dynamics of price adjustment. The other most important limitation is that they are point estimates, unable to capture the dynamic pattern of price adjustment.

This paper employs rigorous dynamic panel data models which can account for non­time dependence, transportation costs, and unobserved quality differences of commodities. The presence of market or region fixed effects in the estimation also suggests the relative version of the law of one price (LOP), with an advantages over the absolute LOP, which assumes that transaction costs vary proportionately over time. The attempt to use wholesale and retail prices at supply and destination markers in multivariate forecasting models cannot capture these unobserved cross-section- dependent heterogeneities.Accordingly, this study was conducted to generate new and reliable empirical evidence on the dynamics of price convergence of major commodities traded and consumed in Ethiopia. Using an 18-year monthly price series of 9 commodities in 7 regions (including the benchmark region), the dynamic process of food price convergences was investigated over three periods (1996-2004, 2005-2013, and 1994-2013). The remaining part of the paper covers theoretical and empirical framework in Part 2, dataset and analytical methods in Part 3, and presentation and discussion of empirical findings in Part 4. Finally some concluding remarks are presented in Part 5.

1. Theoretical and Empirical Framework
   1. Theoretical Framework

Theoretical and empirical literature proposes many alterative models of univariate and multivariate time series forecasting. If two or more non-stationary time series follow a common longrun path, a test for cointegration would lead to a stationary linear combination of the timeseries (Engle and Granger, 1987; Johansen, 1988). Co­integration analysis is useful because estimated coefficients from cointegrated regressions will converge at a faster rate than normal, they are super consistent. The two widely employed models of multivariate timeseries are the vector autoregressive (VAR) and vector error correction (VEC) (Johansen, 1995). The VEC specification restricts the longrun behavior of endogenous price variables to converge to their longrun equilibrium relationships and allow the shortrun dynamics. Johansen proposes two different likelihood ratio tests of the significance of canonical correlations, the trace test and maximum eigenvalue test (Johansen and Juselius, 1990: Johansen, 1995). The trace test tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of k cointegratingvectors. The maximum eigenvalue test, on the other hand, tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of r+1cointegrating vectors. Since the critical values used for the maximum eigenvalue and trace test statistics are based on a pure unit-root assumption, they will no longer be correct when the variables in the system are near-unit-root processes. Thus, the real question is how sensitive Johansen’s procedures are to deviations from the pure-unit root assumption.

The very limitation of VAR and VEC model is that they both assume linear price adjustment, which might not be always true. Unlike models with linear price adjustments, the threshold vector error correction (TVEC) and Markov-switching vector error correction (MSVEC) models are appropriate candidates for estimation of short run and long run adjustment parameters under the presence of nonlinear price adjustments (e.g. Meyer, 2008; Tadesse et al. 2008; Reziti et al. 2008; Saghaian, 2008). A threshold introduces nonlinearities into the functional relationship and “specifies the operation modes of the system”. The threshold principle is the local approximation over the states, or the introduction of regimes via thresholds. Such regime-dependent parameter stability of some time series is usually referred to as threshold behavior (Tong, 1990). The TVEC model and the MSVEC models are the two regime-dependent econometric models for price transmission analysis. The assumptions regarding the nature of their regime­switching mechanisms are fundamentally different so that each model is suitable for a certain type of nonlinear price transmission (Ihle and Cramon-Taubadel, 2008).

However, all the above multivariate price series models have at least three common limitations and difficulties. First, they are data intensive which force researchers to focus on limited number of markets and commodities rather than including all important markets and commodities in their analyses. Second, they ignore the existence of unobserved market-specific effects. The market-specific unobserved heterogeneities can contribute more towards the dynamics of price adjustment. Finally, they are point estimators, unable to capture the dynamics of price adjustment process.

As evidenced by many scholars including Banerjee (1999), Maddala and Wu (1999), Hadri (2000), Levin et al. (2002), Im, et al. (2003), Pindyck (2004), and Bai and Ng (2010), panel estimators have methodological power to capture temporal and spatial dynamics of price convergence which cannot be accounted for by simple time series or simple cross sections. Panel estimators are powerful to any other estimators for the fact that they allow to control for individual or market-specific heterogeneity, better to study any dynamics of price adjustments, give time ordering of marketing events, and enable to solve omitted variable problems which are the major sources of divergent implications from previous studies in Ethiopia. The panel unit root test procedures are more relevant than are other methods if the panel is of moderate size (between 10 to 250 markets or regions ) and large observation (25 to 250 per market or region) (Levin et al., 2002; Goldberg and Verboven, 2005).

One of the first unit root tests developed for dynamic panel model is that of Levin, Lin, and Chu (LLC) (Levin et al, 2002). Their test is based on analysis of a simple autoregressive equation:

*^*yi,t = *a*i *+ S*it + A *+ p*iyi,t-1 + *?*i,t, qn,

i *=* 1,..., N, t *=* 1,.,T ( '

This model allows for two-way fixed effects (**a**and H) and market—specific time trends. The market—specific fixed effects (FE) are important sources of heterogeneity, since the coefficient of the lagged dependent variable is restricted to be homogeneous across all markets of the panel. The test involves the null hypothesis H0 : p = 0 for

all against the alternative Ha : p < 0 for all i with auxiliary assumptions under the

null also being required about the coefficients relating to the deterministic components. The LLC test assumes that the individual units (or regions in this case) are cross­sectional independent[[18]](#footnote-19).

The panel unit root tests by Im, Pesaran, and Shin (IPS) (Imet al., 2003) extends the

LLC framework to allow for heterogeneity in the value of p under the alternative

hypothesis. Given the same equation, the null and alternative hypotheses are defined as:

Ho : Pi = 4 Ha : pi < 4 (2)

i = *1*,...,N1; i = N1 +*1,* N1 + 2,...,N*.* ( 2

Under the null hypothesis, all series in the panel are nonstationary processes; under the alternative, a fraction of the series in the panel is assumed to be stationary. This is in contrast to the LLC test, which presumes that all series are stationary under the alternative hypothesis. The errors, git, are assumed to be serially autocorrelated, with

different serial correlation properties and differing variances across units. IPS test proposes the use of a group—mean Lagrange multiplier (LM) statistic to test the null

hypothesis. The ADF regressions can be computed for each unit, and a standardized statistic[[19]](#footnote-20) computed as the average of the LM tests for each equation.

1. Empirical Evidence in Ethiopia

There have been different studies on commodity market performance in Ethiopia since the commodity market liberalization in 1990. Webb et al. (1992) have studied the spatial integration of cereal markets in Ethiopia to detect the spatial efficiency of local markets and their contributions in alleviating food shortage that has occurred because of drought in different geographical locations. Relatively better methods of analyzing market integration were used after Dercon (1995) who used cointegration technique to analyze market integration in Ethiopia and verified that most market prices were cointegrated with Addis Ababa price. After grain trade liberalization in Ethiopia, the major breakthrough in grain market efficiency studies was theone conducted by Grain Market Research Project (GMRP). With this project, Asfaw and Jayne (1997, 1998), Gebremeskel et al. (1998), and Eleni (2001) analyzed the response of Ethiopian grain markets to market liberalization policy and market structure, conduct, and performance of many grain markets. They estimated descriptive measures of market integration and identified many constraints in the grain marketing system.

Kindie et al. (2006) have analyzed the dynamics of six white wheat markets (Nazreth, Shashemenie, Jimma, Addis Ababa, Dire Dawa, and Mekelle) using vector autoregressive (VAR) model assuming the first three to be surplus and the last three to be deficit markets of wheat. They used the VAR model asa better alternative to address the simultaneous interaction of markets by identifying markets with common factors for policy intervention. They selected these markets as they were major supply and consumer markets. The monthly wholesale price levels were tested for causality using VEC mechanism (VECM) in which case Nazreth and Shashemenie were found to be price leaders while there was no exclusive price leadership of wheat markets in the country. This study was relatively more empirical than previous studies conducted in Ethiopia and the weak parameter estimates signify the considerations to be taken in sampling of relevant wheat markets to avoid risk of misspecification of price interdependence. Kindie (2007) analyzed the spatial integration of wheat markets between Ambo and Addis Ababa using autoregressive distributive lag (ARDL) approach to estimate the dynamics of price transmission and recommended that it was cost- effective to initiate price intervention measures in Addis Ababa rather than in local markets.

Degye et al. (2009) used a bivariate instrumental variables method to estimate shortrun and longrun dynamic adjustment coefficients between 10 markets of wheat (Addis Ababa, Nazreth, Adaba, Diksis, Ambo, Debre Birhan, Woliso, Shambu, Dessie, and Mekelle). They found that Nazreth was the dominant wheat market dictating price formation in the country which was in line with the results of Kindie et al (2006). Kindie (2009) analyzed the price formation process for three cereal commodities (teff, wheat, and maize) in three markets (Addis Ababa, Nazreth, and Shashemene) using an ECM to identify a commodity which leads price formation in these three markets for cost- effective price stabilization measures. The results show that maize price plays a leadership role in the dynamics of teff and wheat prices at all market pairs except that of Addis Ababa teff market. For these three commodities, Rashid (2011) also analyzed the price leadership role by adding other three markets (Dire Dawa, Jimma, and Mekelle) but employed VAR and VEC models. He found the same result in that maize was the most significant in exacerbating price variability with respect to the persistence of shocks to itself and the two other cereals.

Degye (2011) analyzed the consumer price risk involved in Addis Ababa market for seven commodities (wheat, horse beans, beef, cow milk, egg, banana, and onions) selected from different commodity groups. After classical decomposition of the overall price risk involved into seasonality, predicable trends, and other unpredictable sources of price risk, he found that seasonality was the major source of consumer price risk.

1. Dataset and Empirical Models
   1. The Dataset

This paper utilized monthly price series of commodities widely traded and consumed in the four major regions (Amhara, Tigray, Oromia and SNNP) and three urban centers (Addis Ababa, Dire Dawa and Harari) in Ethiopia for the period 1996 to 2013. It considered nine commodities in six regions (panels) surveyed for 211 rounds (monthly observations) per commodity. Construction of panel data of these regions and commodities allows estimation of relative price convergence of each commodity by a pooled sample of 1266 per commodity.

Proceedings of the 33rd Annual Research Review Workshop, April 21-23, 2016 Table 8. Major food groups and their weights from consumption expenditure.

|  |  |
| --- | --- |
| Major group | Weights (2006 base year) |
| Food | 0.570 |
| Cereal, un-milled | 0.112 |
| Milk, cheese and egg | 0.095 |
| Food taken away from home | 0.054 |
| Pasta, bread etc. | 0.040 |
| Coffee and tea leaves | 0.040 |
| Oils and fats | 0.036 |
| Meat | 0.032 |
| Pulses | 0.030 |
| Vegetables and fruits | 0.020 |
| All other food items | 0.111 |
| Non-Food | 0.430 |
| House rent, construction materials, water and fuel and power | 0.187 |
| Clothing and footwear | 0.120 |
| Furniture, furnishing, household equipment and operation | 0.070 |
| All other non-food items | 0.053 |
| Total | 1.000 |

Source: Adapted from CSA (2013).

Major commodities used in the analysis were selected by their weights in the consumption bundle used by Central Statistical Agency (CSA) to compute the consumer price index (CPI) at national and regional level. The weight of each group of commodities is indicated in Table 1. According to the 2013 estimation of the CPI by the CSA, food covers about 57% of the consumption bundle in Ethiopia (CSA, 2013).

To investigate the dynamics of relative price convergence of commodities among regions, the 18-year monthly price data were divided into two periods, nine years each (1996-2004 and 2005-2013). The first period is characterized by depressed commodity prices and the second by skyrocketing food prices which has been exhibited since 2004/05 in Ethiopia. The point estimates from each period were compared between each other as well as to the pooled data (1996-2013). The changes in the speed and rate of price convergence were used to report on the rate and speed of relative price convergence of the commodities among regions in Ethiopia.

* 1. Benchmark Price

Relative prices of all regions were computed as a ratio of the benchmark price in Addis Ababa. Selection of a benchmark region and price requires adequate information on the supply chain channels, origin and destination markets, and commodities traded and consumed in each region. The benchmark region is assumed to have the supply of and the demand for all commodities under consideration. Addis Ababa is the best candidate benchmark market in Ethiopia since it has trade relationships with all regions either by supplying to or receiving from the regions. This is partly verified by the relative prices

computed by selecting Addis Ababa price as a benchmark (Table 2). Moreover, Addis Ababa is the best candidate because it is geographically separated from all regions except Oromia. There is no any other region satisfying the assumption of geographical separation in spatial price convergence and integration.

Table 9. Mean values of monthly relative prices of commodities by regions (1996-2013).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Region | Teff | Wheat | Maize | Beef | Sheep | Banana | Orange | Onions | Potato |
| Tigray | 0.94 | 1.06 | 1.07 | 0.89 | 0.80 | 1.24 | 1.11 | 1.38 | 1.75 |
| Amhara | 0.78 | 0.93 | 0.92 | 0.81 | 0.67 | 1.03 | 0.82 | 1.22 | 1.06 |
| Oromia | 0.83 | 0.89 | 0.82 | 0.89 | 0.66 | 0.81 | 0.77 | 1.26 | 1.03 |
| SNNP | 0.82 | 0.88 | 0.75 | 0.85 | 0.54 | 0.50 | 0.49 | 1.39 | 0.94 |
| Harari | 1.03 | 1.18 | 1.11 | 1.12 | 0.99 | 1.17 | 1.06 | 1.23 | 1.28 |
| Dire  Dawa | 1.06 | 1.15 | 1.11 | 1.18 | 0.99 | 1.07 | 0.91 | 1.14 | 1.21 |
| Mean  value  Standard  deviation | 0.93 | 1.04 | 0.92 | 0.92 | 0.69 | 0.96 | 0.85 | 1.36 | 1.34 |
| Between | 0.12 | 0.13 | 0.16 | 0.15 | 0.16 | 0.27 | 0.22 | 0.10 | 0.29 |
| Within | 0.07 | 0.12 | 0.14 | 0.11 | 0.14 | 0.20 | 0.18 | 0.27 | 0.28 |
| Overall | 0.13 | 0.17 | 0.20 | 0.18 | 0.20 | 0.32 | 0.27 | 0.29 | 0.39 |

Source: Author’s computation.

Regions with relative prices of commodities less than unity are expected to be suppliers of those commodities while those with relative prices greater than unity are destination markets of commodities supplied from Addis Ababa[[20]](#footnote-21). It indicates the trade relationships of all regions with Addis Ababa for all commodities under study. The computed relative prices were as expected in the real trade relationships among regions in Ethiopia.

Teff is supplied to Addis Ababa from all regions with the exception of Harari and Dire Dawa (destination regions). Addis Ababa supplies wheat received from other regions to Tigray, Harari and Dire Dawa. Maize is supplied by Addis Ababa to deficit regions (Tigray, Harari and Dire Dawa). The relative price of beef in Harari and Dire Dawa was greater than unity, which was not supported by reversed trade relationships with Addis Ababa since there was no evidence of such trade reversal. This was so because beef in these regions was supplied by other regions not included in this analysis, like Somali region. The case for beef also holds true for live animal trade like sheep. Relative prices of sheep were less than unity for all regions possibly because there were interregional trade relationships which influence price levels directly and indirectly.

* 1. Empirical Model of Price Convergence

Using point estimates of price adjustment, results from previous studies suggest the existence of market integration across markets in Ethiopia (Kindie et al, 2009; Degye et al., 2009; Rashid and Negassa, 2011). However, there is no empirical evidence generated so far on both absolute and relative price convergence of commodities among markets and regions in the country. Moreover, many markets and regions and commodities are not yet analyzed due to methodological and data problems discussed earlier. This study differs from previous studies in that it employed the panel unit root tests, fixed-effects, and half-life methods to examine the rate and speed of relative price convergence of major commodities traded and consumed among the major regions and cities in the country. These procedures were considered more powerful than the conventional unit root tests and models of simple time series and simple cross-sections. At the minimum, the methodologies improve the power of unit root tests because they provide a larger number of data points and use the variation across regions to improve estimation efficiency (Susantoet al, 2008). The empirical knowledge on the speed and rate of relative price convergence of commodities among regions has a paramount importance in designing and implementing market intervention policies.

To apply the methods of panel unit root tests on monthly prices, Addis Ababa was selected to compute the relative prices of all other regions following the method used by Parsley and Wei, (1996),Susantoet a/.(2008), Cecchettiet a/.(2002), and Goldberg and Verboven (2005).

The general dynamic panel model employed is specified as (Levin et al, 2002)

h=k

(3)

ARPi,t =a-i + A + PiRPi,t-1 + '^7hARPi,t -h + si,t

h=l

the price level of benchmark[[21]](#footnote-22) market j at time t: rp = ]n

Where RPt t is the log of relative prices (the log of the price level of region i relative to

P

V*P jt*

. In equation (3), at

is a region-specific constant to control for non-time-dependent heterogeneity across regions, A is the first difference operator, ^ is a common time effect in market i, yh is the historical effect of the relative price, k is the lag length, and Sit is the white noise

error term. The lag structure h can be routinely determined on a variety of information criteria as in a univariate Dickey- Fuller (DF) or Augmented Dickey-Fuller (ADF) test to account for possible serial correlation (Dickey and Pantula, 1987; Dickey and Fuller, 1979).

The interest in equation (3) is the coefficient on the lagged relative price, Pt, which represents the rate of convergence[[22]](#footnote-23). Under the null of no price convergence, pt isequal to zero (H0 : ft = 0 for all i), suggesting that a shock to RPt t is permanent. That is, the LLC test specifies the null hypothesis of Ho against the alternative hypothesis of Ha : ft = P < 0, where P is the normalized adjustment

coefficient. The major limitation of the LLC test is that ft is the same for all observations. To relax this assumption, Imet al. (2003) proposed an extension of the LLC procedure by allowing ft to differ across groups. They tested the null hypothesis

H0 : ft = 0 against the alternative that Ha : ft < 0 for at least one market.

To conduct the LLC test, several steps were performed. The first task is to remove the influences of time effects by subtracting the cross-sectional averages from the data:

*i* i=N

(4)

RPi,t = RP,,t - — Z RPi,t

’ N i=1 ’

Second, for each market, the first difference of relative prices (ARPit) was regressed on its lagged values (ARPit-h), a constant (af), and a trend (ft) and save the residuals

from equation (1) as 6i,t. Third, the lag of relative prices (RPit\_:) is regressed on the same variables in the second step to obtain the residuals I vt,t-i I. Fourth, the residuals

A

A

ei,t is regressed on I Vi,t-i I without a constant. If we denote the residuals from the

A

final regression as S i,t, the regression standard error obtained from this regression can be defined as

A

*&S-*

*Si*

*\t - k -*1)-

1

T A2

Z *Si,t*

*t=hi* +2

(5)

This estimate of the standard error will be used to normalize the residuals from the

A A

contemporaneous and lagged auxiliary regressions, eij and Vi,t-1, for controlling heterogeneity across individual regions. The normalized values of the residuals from the two auxiliary regressions are:

A

***eu =***

ei ,t ~

"A and Vi,t-1

A

*Vi,t-1*

<J*s*

A

*CTsi*

(6)

Finally, the panel OLS of the normalized residuals will be run to obtain the adjustment estimates (Levin et al., 2002; Susanto, et al, 2008)[[23]](#footnote-24):

*et,t =Pvt,t*—1 *+st,t*. (7)

The IPS model is a unit root test for heterogeneous dynamic panels based on the mean- group approach. This approach is similar to the LLC model, in that it allows for heterogeneity across sectional units. Instead of pooling the data, the IPS model uses separate unit root tests for the N cross-section units (regions). The t statistic (denoted as,

t, t-bar) is the average of t statistics for all N regions. Let t. T testing unit roots, and let E(tiT ) = j and V(tiT ) = u 2, then

denote the t statistics for

(8)

|  |  |  |
| --- | --- | --- |
| VN | tN ,T — j | ~N(0.1) where tNT = — |
|  | u  V j | N |

*i=N*

*'Zti,T*

*i=1*

2

The problem of the above equation is computing the mean, j , and the variance, u . Assuming that the cross sections (regions in this case) are independent, the standardization of the t-bar statistics, using the means and variances of t evaluated

under ft = 0, denoted as w-t (Obar

statistic is given by (Imet al, 2003):

VNI ***t*** *N,T* ***— E\ t*** *N,T*

>K

=-

(9)

varl tN t

where t n,t is the average t statistic for each region or individual unit, and E

tN,t I and

(*\_* \

***ar***

*tN ,T*

V J

, respectively, are its mean and variance, respectively.

1. Empirical Results
   1. Patterns of Price Convergence

The purpose of this study was to analyze the rate and speed of relative food price convergence of commodities in Ethiopia. It considered 18-year monthly data of consumer prices of nine commodities widely consumed and traded among the seven regions and markets in Ethiopia (including the benchmark market). In order to investigate the rate and speed of relative price convergence of these commodities, the study period was classified into three as period 1 (1996-2004), period 2 (2005-2013), and the full period (1996-2013). As a preliminary investigation of the pattern of price convergence to unity, the mean values of relative prices of commodities during the two periods were tested for the presence of significant difference. As reported in Table 3, the tests for five commodities (cereals, banana, and potato) suggested the presence of mean relative price difference between the two periods. The null hypothesis that there is no mean difference between the two periods was rejected at one percent level. But there was not significant relative mean price difference for the other commodities. This preliminary test leads to further investigation of the expectations with more rigorous methods.

Table 10. Two-sample mean-comparison test of relative prices between the two periods.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| B | Mean value |  |  | t-value |
|  | 1996-2004 | 2005-2013 | 1996-2013 |  |
| Teff white | 0.88 | 0.94 | 0.91 | -8 23\*\*\* |
| Wheat white | 1.05 | 0.98 | 1.01 | 7.86\*\*\* |
| Maize | 1.02 | 0.90 | 0.96 | 11.52\*\*\* |
| Beef | 0.95 | 0.96 | 0.96 | -0.83 |
| Sheep 10-15 kg | 0.72 | 0.71 | 0.72 | 0.66 |
| Banana | 0.86 | 1.08 | 0.97 | -13.47\*\*\* |
| Orange | 0.85 | 0.87 | 0.86 | -1.10 |
| Onion | 1.27 | 1.27 | 1.27 | -0.40 |
| Potato | 1.23 | 1.19 | 1.21 | 1.87\*\* |
| Number of  observations | 642 | 624 | 1266 |  |

method, which could only be employed in a strongly balanced data. The lag structure in the ADF regression was routinely identified by Akaike’s Information Criteria (AIC).

The results from the two methods of panel unit root tests were consistent. As shown in Table 4, all point estimates were negative, as expected, and strongly significant at one percent level. Therefore, the null that panels contain unit roots was rejected and the alternative that panels are stationary was accepted in the LLC tests. Similarly, the IPS test rejects the null hypothesis of unit roots regardless of the sample periods. Both tests confirm that the panel dataset of the relative prices were stationary at their first differences suggesting that linear panel estimators could be employed to estimate rate of price convergence of commodities among the regions.

Table 11: LLC and IPS tests of panel unit roots for monthly relative price changes in Ethiopia.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Percentage change in  relative prices | LLC test (adjusted Panels contain unit Panels are stationary | | t\*): Ho:  roots: Ha: | IPS test (W-t-bar): Ho contain unit roots; panels are stationary | | : All panels Ha: Some |
|  | 1996- | 2005- | 1996- | 1996- | 2005- | 1996- |
|  | 2004 | 2013 | 2013 | 2004 | 2013 | 2013 |
| Teff | -29 3\*\*\* | -11 6\*\*\* | -7 4\*\*\* | -28.8\*\*\* | -19.7\*\*\* | -2.0\*\*\* |
| Wheat | -21 8\*\*\* | -22.4\*\*\* | -12.6\*\*\* | -23.5\*\*\* | -25 4\*\*\* | -25.3\*\*\* |
| Maize | -26.0\*\*\* | -8.6\*\*\* | -13.4\*\*\* | -27.6\*\*\* | -18.9\*\*\* | -26.4\*\*\* |
| Beef | -2.8\*\*\* | -10.1\*\*\* | -4.7\*\*\* | -17.5\*\*\* | -18.5\*\*\* | -23.9\*\*\* |
| Sheep | -12.8\*\*\* | -13 1\*\*\* | -3.6\*\*\* | -21.6\*\*\* | -21.3\*\*\* | -25.6\*\*\* |
| Banana | -23.5\*\*\* | -28.3\*\*\* | -1.5\*\*\* | -27.2\*\*\* | -27.2\*\* | -25.1\*\*\* |
| Orange | -16.4\*\*\* | -25.3\*\*\* | -17.6\*\*\* | -22.3\*\*\* | -25.6\*\*\* | -27 4\*\*\* |
| Onion | -11.4\*\*\* | -3.8\*\*\* | -14.2\*\*\* | -19.5\*\*\* | -16.0\*\*\* | -26.6\*\*\* |
| Potato | -11 3\*\*\* | -12.9\*\*\* | -2.7\*\*\* | -20.5 | -21.7\*\*\* | -25 4\*\*\* |

Proceedings of the 33rd Annual Research Review Workshop, April 21-23, 2016 Table 12. Fixed-effects estimation of rate of price convergence (%) among regions.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Change in annual relative prices (%) | 1996-2004 |  | 2005-2013 |  | 1996-2013 |  |
| Convergence  rate | Stand  ard  error | Converge nce rate | Standard  error | Convergenc e rate | Standar d error |
| Teff | -0 27\*\*\* | 0.03 | -0 19\*\*\* | 0.03 | -0 13\*\*\* | 0.02 |
| Wheat | -0.37\*\*\* | 0.04 | -0.32\*\*\* | 0.04 | -0.21\*\*\* | 0.02 |
| Maize | -0.35\*\*\* | 0.03 | -0.57\*\*\* | 0.05 | -0.26\*\*\* | 0.03 |
| Beef | -0.24\*\*\* | 0.04 | -0.26\*\*\* | 0.04 | -0.17\*\*\* | 0.02 |
| Sheep | -0.43\*\*\* | 0.05 | -0.29\*\*\* | 0.04 | -0.34\*\*\* | 0.03 |
| Banana | -0.21\*\*\* | 0.03 | -0.32\*\*\* | 0.04 | -0.07\*\*\* | 0.01 |
| Orange | -0.43\*\*\* | 0.04 | -0.45\*\*\* | 0.03 | -0.32\*\*\* | 0.03 |
| Onion | -0.04 | 0.04 | 0.02 | 0.02 | -0.04 | 0.03 |
| Potato | -0.50\*\*\* | 0.05 | -0 44\*\*\* | 0.04 | -0.36\*\*\* | 0.03 |

Notes: The optimum lag lengths routinely identified by AICfor each commodity and period are rounded off to their positive integers in order to be used in the estimation of convergence rate in the FE model.

\*\*\* and \*\* indicate significance level at 1% and 5%, respectively.

Source: Author’s commutation.

As shown, all the coefficients, with the exception of onion, were negatively and strongly significant and the signs of all parameter estimates were as expected. The rate of relative price convergence among regions in the 18-year period was generally low for all commodities. The maximum and the minimum convergence rate estimated for the whole period was 36 percent for potato and 7 percent for banana, relatively more perishable. A unit percentage shock of relative prices of potato in previous-year had only 0.5 percent change in the current-year relative price convergence with the benchmark market (Addis Ababa). It is generally evidenced that the rate of convergence was very low (7%-36% for the whole period) because greater proportion of the price shocks were unadjusted among regions. Low or nearer-to-zero rates of convergence are indications of permanent shocks which could not be adjusted among regions. Food items covering about 57 percent of the consumption expenditure in Ethiopia have exhibited very low rates of relative price convergence which would deplete the welfare effects expected from spatial and temporal arbitrage (CSA, 2013).

Under the null of no price convergence, the adjustment coefficient for onion was equal to zero, suggesting that the price shock to the relative price was permanent. Due to its perishable nature, there was no significant convergence in the relative prices of onion over the 18-year period and across regions. This evidence is supported by previous studies which verify that marketing agents involved in the production and marketing of onion, particularly onion producers, have used to face exceptionally high price risk in Ethiopia (Degye, 2011).

Some food commodities have undergone increased rate of monthly relative price convergence in the 18-year period. The maximum change in the rate of convergence from the first to the second period was for maize (22%) followed by banana (11%) and potato (5%). This is a good indication of improved domestic market performance

favoring the prices of these commodities. However, there were some commodities with significant price divergence as an indication of poor market performance. The relative prices of teff, wheat and sheep were rather diverging at a rate of 8 percent, 5 percent and 14 percent, respectively. The findings pointed out that the market intervention measures implemented in the country had both negative and positive repercussions. This down turn of price performance of some commodities is possibly explained by the supply of and the demand for the commodities among regions, and the price stabilization measures related to direct price setting (price ceilings) by the government.

1. Speed of Price Convergence

The average speed at which commodity prices move toward parity price is commonly measured by half-life method. Speed of relative price convergence of commodities among regions in this study is measured by half-life of relative price shocks. Half-life of a shock may be defined as a period in which the marginal change in the stationary component of the response becomes half of the initial response. The closer the rate of convergence to zero, the longer is the estimated half-life of a shock. It is computed as - in (2)/, , where rho is the correlation of errors (within and between) panels. The estimated half-life of commodities is reported in Table 6.

Speeds of relative price convergence of five commodities under consideration were fairly long in the first period and short in the second period, indicating increased responsiveness of markets in the regions. In the first period, regions tended to slowly and partially respond to relative price shocks of these commodities. In the second period, they required a few days to adjust to half of the relative price shocks with the benchmark market.For instance, the time required to adjust to half of the shocks was reduced by about 38 percent (11.5 days) for potato, 31 percent (9.4 days) for wheat, 30 percent (9.2 days) for teff, and 25 percent (7.6 days) for orange. The findings markedly showed that some commodities experienced considerable improvement in the speed of their price convergence. The computed half-life[[24]](#footnote-25) of relative price shocks was adjusted among regions and over time as rapidly as possible. On the other hand, banana and maize were characterized by price divergence at a rate of 41% percent and one percent, respectively.

Table 13. Estimated half-life of shocks as a measure of speed of relative price convergence

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Commodity | 1996-2004 |  | 2005-2013 |  | 1996-2013 |  |
|  | Half-life | Days | Half-life | Days | Half-life | Days |
| Teff | 0.69 | 20.8 | 0.39 | 11.6 | 0.30 | 9.0 |
| Wheat | 0.73 | 21.9 | 0.42 | 12.5 | 0.32 | 9.7 |
| Maize | 0.62 | 18.5 | 0.63 | 18.8 | 0.34 | 10.3 |
| Beef | 0.42 | 12.7 | 0.40 | 12.1 | 0.29 | 8.7 |
| Sheep | 0.49 | 14.7 | 0.44 | 13.3 | 0.43 | 13.0 |
| Banana | 0.76 | 22.8 | 1.17 | 35.0 | 0.25 | 7.4 |
| Orange | 0.90 | 27.1 | 0.65 | 19.5 | 0.50 | 15.0 |
| Potato | 0.72 | 21.6 | 0.34 | 10.1 | 0.37 | 11.1 |

Notes: The speed of relative price convergence can be converted to days by changing the (unit rate or percentage) half-life into 30 days rate (i.e, half-life multiplied by 30 and the product divided by the rate, 1 or 100).

Source: Author’s commutation.

The attempt to categorize the 18-year period into two using relatively observable market and policy events generally resulted in some meaningful implications on the patterns of rate and speed of food convergence among regions and cities in Ethiopia. Market policy measures initiated in Ethiopia before and after 2004 have some positive and negative implications on the performance of commodity markets and prices across regions and cities in Ethiopia.

1. Concluding Remarks

This paper investigated the dynamics of monthly relative price convergence of major commodities consumed and traded in seven regions and cities of Ethiopia. It utilized monthly consumer prices of nine commodities in these regions and cities. A pane dataset comprising the regions (panels) over 211 months with 1266 data points was constructed for each commodity. Relative price levels and changes were computed based on the benchmark price in Addis Ababa.

Panel unit root tests were conducted by employing two widely used techniques, the LLC and IPS unit root tests. Rate and speed of relative price convergence of commodities among regions were measured by dynamic adjustment parameter estimates and half-life of relative price shocks, respectively. The empirical results indicated that the panel datasets of the log-normalized relative prices were stationary at their first differences. The estimated rates of relative price convergence of commodities among regions were generally low. The speed of relative price convergence of commodities measured by the half-life method was; however, mixed. There was significant improvement in the rate and speed of relative price convergence of some food commodities among regions during the 18-year period.

The findings generally suggested the need to initiate and implement marketing policies designed to optimize the net welfare effects emanating from domestic market

performance and interventions. Improving marketing infrastructure, information and institutional arrangement and marketing policies will improve market performance by improving the responsiveness of actors to price shocks. Interventions related to value­adding activities, particularly for perishable commodities, will improve convergence to unitary price among region of Ethiopia. It is also a policy imperative to promote sustained supply-side intervention in order to increase production and productivity of agricultural commodities characterized by low or declining relative price convergence.

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1. Technical Efficiency of Selected Hospitals in Eastern Ethiopia

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Abstract: This study was conducted to examine the relative technical efficiency of selected hospitals in Eastern Ethiopia. Using panel data for the period 2007/08 to 2012/13, the technical efficiency, total factor productivity and determinants of technical inefficiency of hospitals were examined. Data envelopment analysis (DEA) and DEA based Malmquist productivity index were used to estimate relative technical efficiency, scale efficiency and total factor productivity index of hospitals. Tobit model was also used to examine the determinants of technical inefficiency of hospitals. The DEA Variable Returns to Scale (VRS) model indicated that 6 (50%),5 (41.7%),3(25%),3(25%),4(33.3%),and 3(25%) of the hospitals were technically inefficient between 2007/08 and 2012/13 respectively while 9(75%),9(75%),7(58.33%),7(58.33%),7(58.33%) and 8 ( 66.67%) of hospitals were scale inefficient during the same period. On average, Malmquist Total Factor Productivity (MTFP) decreased by 3.6 % over the panel period. From the second stage analysis, it was indicated that being teaching hospital, doctors to staff ratio and inpatient treated per medical doctor negatively and significantly related with technical inefficiency of hospitals. Hence, policy interventions that increase doctor to other staff ratio and also the number of inpatients treated per doctor would contribute to improve the technical efficiency of hospitals.

Keywords: Technical inefficiency; DEA; Scale Efficiency; hospitals; Malmquist total factor productivity

1. Introduction

The health care system of many countries in sub Saharan Africa including Ethiopia faces resource constraints to provide quality health services to the people. The shortage of health care resources may relate to poor economic performance, rapid population growth and decline in public spending. Moreover, in Sub-Saharan Africa, communicable, maternal, nutritional and new born diseases still continue to dominate and putting stress on the already scarce health care resources of these countries (World Bank, 2013).

Hospitals consume larger proportion of the total public health budget. Even though the percentage vary from country to country, hospitals in Sub-Saharan African countries consume a larger proportion of public health care resources. The situation in Ethiopia is not different from other Sub-Saharan countries. Hence, the efficiency of hospitals need to be given due attention as the budget they consume is enormous.

It is widely recognized that improved efficiency is one of the main goals of health systems (WHO, 2000). Health policy makers in Africa have also stressed the need to utilize the scarce health sector resources efficiently (Lambo and Sambo, 2003). A growing number of countries in Africa have undertaken health facility efficiency study to guide the development of interventions to reduce wastage of scarce health system resources.

Data Envelopment Analysis (DEA) has been used to analyze technical efficiency of hospitals in a number of Sub-Saharan African countries. Different studies have used different inputs and outputs to measure efficiency. For instance, studies conducted in Eritrea (Kiriga and Asbu, 2013), Botswana (Tloglego et al., 2010), Benin (Kiriga et al., 2010), and Burkina faso (Marschall and Flessa, 2009) are among the few. Moreover, most of the studies focused on measuring the first stage of efficiency analysis. Very few studies conducted the second stage analysis to examine the determinants of technical (in) efficiently using panel data.

In the case of Ethiopia, few studies have been conducted to examine efficiency of hospitals. Therefore, this study seeks to analyze the technical efficiency and productivity of hospitals in eastern Ethiopia. The findings will also deepen the understanding of the extent of inefficiency and its causes in eastern Ethiopia.

1. Methods and Materials

This study was conducted on selected hospitals in eastern Ethiopia. The selected hospitals are from Eastern Hararge, Harari region, Somali Region, and Dire Dawa administration council. The included hospitals are both public and private. Panel data were collected from 12 hospitals for the period 2007/08 to 2012/13. The inputs include (beds, health staff and drug supplies) while the outputs include (outpatient visits, inpatient days and surgery).

* 1. Method of Data Analysis
     1. Data envelopment analysis (DEA)

DEA involves the use of linear programming methods to construct a non-parametric piece-wise surface (or frontier) over the data (Coelli et al, 2005:162). DEA is based upon a comparative analysis of observed producers to their counterparts (Greene, 2007).Charnes, Cooper and Rhodes (1978) first coined Data Envelopment Analysis which had an input-oriented model with constant return to scale (CRS). Subsequently, variable returns to scale (VRS) model was also developed and introduced to the DEA literature by Banker, Charnes and Cooper (1984). Furthermore, chance-constrained efficiency analysis was also integrated (Land et al., 1993) to the DEA model.

1. CRS vs. VRS models

The assumption of CRS may not feasible due to the presence of imperfect competition, government regulations and constraints on finance that force firms to be run at suboptimal scale (Coelli et al., 2005). For this reason, Banker, Charnes and Cooper

(1984) developed a variable returns to scale (VRS) which enables to capture the magnitude of “scale effect”. Linear programming model of VRS is quite similar to the CRS with some modification.

The mathematical relationship between VRS and CRS efficiency measurements can be illustrated as (Coelli et al., 2005)

t = -":\_:X SE, (SE denotes scale efficiency) which means that CRS technical efficiency of a firm can be decoupled into pure technical efficiency and scale efficiency (SE).

1. Malmquist productivity index

It is the measure of the relationship between the outputs of a hospital and the inputs used to produce those outputs. Productivity increase is manifested by a rise in output per health worker hour and/or the use of more and/ or better health technology. In general, a productivity index is defined as the ratio of an output quantity index to an input quantity index, i.e.:



Where: Pt is a productivity index; time period t = 0,...,T; Yt is an output quantity index and Xt is an input quantity index. Each index represents accumulated growth from period 0 to period t.

DEA-based Malmquist Productivity Index (MPI) is often opted to study efficiency and productivity changes over a period of time. The model is preferred for a number of reasons: it does not require information on the prices of inputs and outputs rather on quantities of inputs and outputs; imposition of functional form of production technology is not required; it easily accommodates multiple hospital inputs and outputs; and it can be broken down into the constituent sources of productivity change - i.e. efficiency changes and technological changes (Grifell-Tatje E, Lovell CAK, 1997).

Malmquist DEA is applied to panel data to calculate indices of changes in Total Factor Productivity (TFP), technology, technical efficiency and scale efficiency. The Malmquist Productivity Index (MPI) takes a value of more than one for productivity growth, a value of one for stagnation and a value of less than one for productivity decline. The output-oriented MPI is defined as the geometric mean of two periods’ productivity indices, subsequently broken down into various sources of productivity change (Fare?/ a/, 1994).

1. Specification of the DEA model

The DEA model that was adopted based on Asbu (2000), Talluri (2000) and Osei et al., (2005) and many other model specifications that are applied in the health sector.

A. The constant returns to scale (CRS) model:

The efficiency score of a decision making units employs multiple input and output and is defined as:

*weighted sum of outputs*

*Efficiency* = **, — —**

*weighted sum of inputs*

The relative efficiency score of hospital P can be solved by using the following model:

Eff=



£r=L s

*S.t*

**y™ v** y-

^L=t *VT^LJ*

Ur, Vi> 0 ; Vr, Vi (1)

The functional programming model of equation (1) can be converted to a linear programming model by introducing the following constraint:

*T=i VtX^* =1

Thus, the relative efficiency score of hospital p can be obtained by solving the following equation:

**Eft** = *M\*x^yJZ=lUrYrp ^VtXtv* = *l*

Ur, Vi > 0; Vr ,Vi (2)

The first constraint implies that all hospitals are on or below the frontiers while the second constraint implies that the weighted sum of inputs for the particular hospital equals one.

B. The variable returns to scale (VRS) model

To separate the technical and scale efficiency scores, variable returns to scale (VRS) model is considered. in variable returns to scale, the data are enveloped more closely than the CRS model. The main advantage of the VRS model is that it enables an inefficient firm to be relatively compared with efficient firms of the same size only. Therefore, the relative efficiency score of hospital p can be obtained by solving the following equation:

***Eff*** = ***MaxUtV\_H-\_****1****UrYrr*** + ***Uc***

**\*■\*5=1** *urK, -***2”** 1*V, x,j + u,<o* ^\*1^ = 1

Ur, Vi> 0; Vr, Vi (3)

Where: Uo is the convexity constraint and its sign determines the returns to scale. If Uo< 0 it indicates increasing returns to scale, if Uo> 0 it is decreasing returns to scale and if Uo= 0 it is constant returns to scale. The other notations are as given in the case of CRS model.

1. DEA like Malmquist model

DEA like Malmquist model is used to obtain the DEA efficiency scores of all the sample periods observations simultaneously. The model applies for panel data and calculates indices of total factor productivity (TFP) change, technological change, technical efficiency change and scale efficiency change. The output based Malmquist productivity change index of Fare et al (1994) is specified as follows:

**C\*V**[[25]](#footnote-26)

Mo(y1+ \

**n£(«\*V+1)**

A **nt + -**

(4)

Where: Mo measures productivity of the production point (xt+1, yt+1) relative to the production point (xt, yt) ; D0t (xt+1, yt+1) represents the distance from the period t+1 observation to the period t technology; and Dot+1 (xt,yt) represents the distance from period t observation to the period t+1 technology. If the value of M0 is greater than one it shows the existence of positive total factor productivity from period t to period t+1 while a value less than one indicates a decline in total factor productivity. Further decomposition of equation (4) provides measures of efficiency change and technical change separately.

M o(y f-1J x t+1, ytrxf) =

*-x*

**‘)**

*-x-*

**V+V+1>**

*Df0+1*

(5)

The first term measures efficiency change while the second term measures technical change in the two periods. An improvement of efficiency occurs from period t to period t+1 if the ratio is greater than 1 (one). The output-oriented DEA model was estimated for CRS DEA and VRS DEA models.

2.1.3. Specification of the regression model

The DEAP efficiency scores was analyzed by regressing them against some characteristics of the hospitals to examine how these factors affect the (in) efficiency of hospitals. The censored Tobit model was used since the dependent variable is censored at zero from below. Like the studies of Asbu (2000) and Linna (1997), in this study also the DEA scores are transformed in to inefficiency scores using the following formula:

Inefficiency score— (1/DEA score)-1

The model is specified in the following form: yi \*= Pi xi + ui; yi = yi\* if yL >0; and yi = 0 if y\* <0

Where ui ~ N (0,82), and yi is the observed inefficiency score; ^ is a kxl vector of unknown parameters; and xi is a kxl vector of explanatory variables

Therefore the empirical regression model is specified as:

INEFF— a*o* + size +@*s*BOR+ fi*j*Teacstat + @*4*dcstaf +@*s*opinpdays+@dmpdoc + e*t* (7)

The variables in the model are defined as follows:

INEFF: inefficiency scores

Size: The natural logarithm of numbers of bed is taken as a proxy to measure hospitals’ size (Diacon, 2001).

BOR: It is the ratio number of inpatient days multiplied by 100 and divided by the available hospital beds multiplied by number of days in a year.

Teachstat:It is teaching status dummy variable. It is 1 if it is teaching hospital and 0 other wise.

Docstaff: This variable is measured by dividing the total number of medical doctors by the total staff of the hospital.

Opinpdays: It is the outpatient visits as a proportion of inpatient days Impdoc: It is the proportion of inpatients per medical doctor.

a0, ^1, ^2, ^3, ^4, ^5, and ^6, are coefficients to be estimated and st is the random

disturbance term 3

Table 1. Basic characteristics of hospitals and average yearly inputs 2007/2008­2012/2013.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Staff |  |  | Average |  |  |  |
| Name of hospital | Estab  lishm  ent | Heal  th | Ad  mini  strat  ive | Tota  l | Salary | Drug | Recurren  t | Bed |
| France | 1911 | 14 | 23 | 37 | 591637 | 381532 | 414248 | 68 |
| Hiwot  Fana | 1941 | 225 | 196 | 421 | 6406047 | 1765662 | 6278350 | 204 |
| Jeg°l | 1951 | 151 | 112 | 263 | 3495719 | 831116 | 3899048 | 118 |
| Dil Chora | 1951 | 184 | 77 | 262 | 7646767 | 2600874 | 8027770 | 85 |
| Karamara | 1956 | 214 | 140 | 354 | 7608026 | 1401988 | 2045428 | 193 |
| Bisidimo | 1958 | 56 | 137 | 194 | 280200 | 1100000 | 317410 | 116 |
| Police | 1965 | 69 | 72 | 141 | 2222641 | 484050 | 1083953 | 82 |
| Army | 1975 | 73 | 77 | 150 | 2519660 | 593810 | 1327650 | 97 |
| Yemariam  work\* | 2007 | 15 | 12 | 28 | 550832 | 580028 | 651801 | 29 |
| ART\* | 2007 | 20 | 5 | 25 | 1914318 | 560297 | 1168419 | 28 |
| Yimaj\* | 2006 | 45 | 10 | 55 | 982006 | 113572 | 3877606 | 54 |
| Bilal\* | 2000 | 43 | 50 | 93 | 1576075 | 3470000 | 2840759 | 40 |

*Source: various reports of hospitals and own computation. Note \*Private hospitals.*

Among the hospitals, eight were publicly owned while four were privately owned. In Harari region, 5 hospitals were selected for the analysis. Among the hospitals, Hiwot Fana, Jugal, Police and Army were public hospitals while Yimaj hospital was privately owned. From Dire Dawa, five hospitals were included. Dilchora and France hospital were public hospitals whereas Bilal, Yemariamwork and ART hospitals were privately owned. The other public hospitals considered in the analysis were Bisidimo and Karamara hospitals from East Hararghe zone of Oromia and Somali region respectively. With respect to their year of establishment, France and Hiwot Fana hospitals were among the oldest hospitals where as ART and Yemariamwork were the youngest.

Taking the average for the study period, Hiwot Fana hospital had the highest total staff which is 421 (196 administrative and 225 health staff) followed by Karamara, whereas ART had the lowest total staffs (5 administrative and 20 health staff) followed by Yemariyamwork hospital. Regarding the average yearly expenditure on salary, Dilchora hospital incurred the highest followed by Karamara hospital. The lowest expenditure on salary was incurred by Bisidimo. With respect to expenditure on drug, Bilal incurred the highest while Yimaj incurred the lowest. On the other hand, the average for yearly recurrent expenditure of the hospitals revealed that Dilchora hospital incurred the highest followed by Hiwot Fana. The lowest recorded was for Bisidimo followed by France.

The average number of bed for the study period revealed that Hiwot Fana had the highest number of bed followed by Karamara and Jugal. The lowest recorded was for ART followed by Yemariamwork hospital.

Table 2. Hospitals average outputs 2007/2008-2012/2013.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name of  hospital | France |  | <3  s  IX  %  P | &  qj | <3  U  O  X  u  r=a  q | Karamara | Bisidimo | qj  \_U  'o  X | D  s  i  $ 1 H L)  < ^ u | | ART | Yimaj | 13  m |
| Outpatient  Visits | 8,740 | 35,424 |  | 26,191 | Cl  CN^  VD | 28,484 | 00  00 | UP  H | 12,518  5,602 | | 5,797 | 6,832 | VD  Up  CNJs  of  T 1 |
| g  Inpatient  Days  V-< | OC  o  CO^  VO | 26,520 |  | 13,789 | 44,233 | 24,122 | 3,914 | 7,207 | 5,354 | 1,979 | 00  COs  T 1 | 7,914 | 8,838 |
| Surgery  z | CO T 1 | 949 |  | 1,356 | 3,825 | 00  o  <0  T 1 | T 1  CO | H | 00 T 1 | Cl  o  T 1 | Cl | 443 | 393 |

*Source: various reports of hospitals and own computation.*

In this study, three major outputs of hospitals were considered for technical efficiency evaluation of hospitals. These three outputs were total yearly outpatient visit, total yearly inpatient days and total surgery performed in the respective hospitals. From Table2, we can see that Dilchora had the highest average total outpatient visit followed by Hiwot fana and Karamara hospitals. The lowest was recorded by Yemariamwork followed by ART and Yimaj.

When we consider the total average yearly inpatient days, Dilchora had the highest average yearly inpatient days followed by Hiwot fana and Karamara. The lowest was for ART followed by Yemariamwork and Bisidimo. With regard to surgery, Dilchora had the highest total average yearly surgery followed by Jugal and Karamara. On the other hand, the lowest was recorded for ART followed by Yemariamwork and Police.

Proceedings of the 33rd Annual Research Review Workshop, April 21-23, 2016 Table 3. Means of outputs and inputs of the hospitals based on their ownership.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No |  | Variable | Mean |  |  | Maximum |  | Minimum |  |
|  | All | Public | Private | Public | Private | Public | Private |
| I. Outputs | 1 | Outpatie nt visit | 19016 | 24712 | 7622 | 64273 | 12256 | 7488 | 5602 |
| 2 | Surgery | 751 | 1000 | 253 | 3825 | 443 | 149 | 73 |
| 3 | Inpatien t days | 12631 | 16431 | 5029 | 44234 | 8839 | 3914 | 1384 |
|  | 1 | Health  Staff  Capital | 93 | 124 | 31 | 225 | 45 | 14 | 16 |
| II. Inputs | 2 | Input(Be | 93 | 121 | 38 | 204 | 55 | 68 | 28 |
| 3 | ds)  Drug  Supplies | 1156911 | 1144879 | 1180974 | 2600874 | 3470000 | 381532 | 113572 |

Table 3 shows that in the sampling period (2007/08-2012/13), the average yearly output of the hospitals were 19,015 outpatient visits, 12,630 inpatient days and 750 number of surgeries, whereas the average yearly input of the total health staff, number of beds and expenditure on drugs was 92, 93 and birr 1,156,910 respectively.

Overall, the public hospitals on average accounted for about 24,712, 999 and 16431 outpatient visit, number of surgeries and inpatient days, respectively. Regarding inputs, on average over the sample period public hospitals accounted for about 123, 120 and 1,144,879 numbers of health staff, bed, and amount of birr of drug expenditure, respectively. From the above data, we can see that the share of the public in terms of average outputs and inputs is higher than the private hospitals except in drug expenditure.

1. Technical and Scale Efficiency

The CRS assumption is appropriate only for hospitals that are operating at an optimal scale (Asbu, 2000). If hospitals are not operating at optimal scale, the technical efficiency measure can be decomposed into pure technical efficiency and scale efficiency. Hence in a situation where CRS does not hold, the technical efficiency measure will be mixed with scale efficiency measure. To separate the effects of scale efficiency, it is necessary to use a DEA model with variable return to scale assumption. To measure the technical and scale efficiency of hospitals, input and output data was gathered and analyzed using DEA model. The detail result for each year under consideration is presented as follows.

Table 4 and Table 5 present individual hospital’s technical and scale efficiency for the year 2007/08 to 2012/13. They reveals that in year 2007/08 and 2008/09 out of 12 hospitals 3 (25 %) registered a constant returns to scale technical efficiency (CRSTE) score of 100%. Therefore, 9 (75 %) of hospitals in both 2007/08 and 2008/09 period has been run inefficiently given the assumption of constant return to scale.

On the other hand, 6 (50%) hospitals in the year 2007/08 and 7(58.33%) of hospitals in the year 2008/09 registered a variable returns to scale technical efficiency (VRSTE)

score of 100%. Moreover, out of 12 hospitals, 3 hospitals (25 %) in the year 2007/08 and 3 hospitals (25%) in the year 2008/09 were scale efficient. Regarding returns to scale, 3(25%) of hospitals in the year 2007/08 and 3(25%) of hospitals in the year 2008/09 manifested increasing returns to scale respectively. Moreover, 7(58.33%) and 6 (50 %) of hospitals manifested decreasing returns to scale in the respective periods.

Individual hospitals’ technical and scale efficiency for the year 2009/10 and 2010/11 indicated that out of 12 hospitals, 5 (41.67 %) registered a constant returns to scale technical efficiency (CRSTE) score of 100 %, whereas in the year 2010/11 again 5 (41.67%) hospitals registered a constant returns to scale technical efficiency (CRSTE) score of 100 % . Therefore, 7(58.33 %) of hospitals in the year 2009/10 and 7(58.33 %) of hospitals in the year 2010/11 were inefficient given the assumption of constant return to scale.

On the other hand, 9(75 %) of hospitals in both periods registered a variable returns to scale technical efficiency (VRSTE) score of 100%. Moreover, out of 12 hospitals, 5 hospitals (41.67 %) were scale efficient in both periods. Regarding returns to scale, 2(16.67 %) of hospitals and 1 (8.33%) of hospitals manifested increasing returns to scale in the respective periods. However, 5(41.67 %) of hospitals and 6 (50 %) of hospitals manifested decreasing returns to scale in the respective periods.

Individual hospitals’ technical and scale efficiency for the year 2011/12 and 2012/13 showed that out of 12 hospitals, 5(41.67%) of the hospitals in 2011/12 and 4 (33.33%) in 2012/13 registered a constant returns to scale technical efficiency (CRSTE) score of 100 %, respectively. Therefore, 7(58.33 %) of hospitals in the year 2011/12 and 8 (66.67%) of hospitals in the year 2012/13 run inefficiently.

On the other hand, 8(66.7 %) and 9(75 %) of hospitals in the respective periods registered a variable returns to scale technical efficiency (VRSTE) score of 100%. Moreover, out of 12 hospitals, 5(41.67%) and 4(33.33%) of hospitals were scale efficient in respective periods. Regarding returns to scale, 1 (8.3 %) of the hospitals in both periods manifested increasing returns to scale whereas 6(50 %) of the hospitals in 2011/12 and 7(58.33%) in 2012/13 manifested decreasing returns to scale.

The average scale efficiency score was 93%, 86%, 89%, 91%, 91%, 87% in the respective years between 2007/08-2012/13.This indicated that there is a scope to increase hospitals’ output by approximately 7%, 14%, 11%, 9%, 9% and 13% for the respective years between 2007/08-2012/13.

Table 4. Hospital’s technical and scale efficiency for 2007/08 to 2009/10.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 2007/08 |  |  |  | 2008/09 |  |  |  | 2009/10 |  |  |  |
| Hospitals | CRSTE | VRSTE | Scale | RTS | CRSTE | VRSTE | Scale | RTS | CRSTE | VRSTE | Scale | RTS |
| France | 0.52 | 0.72 | 0.72 | drs | 0.71 | 0.86 | 0.83 | drs | 0.57 | 0.81 | 0.7 | drs |
| Hiwot Fana | 0.54 | 0.55 | 0.99 | drs | 0.55 | 0.59 | 0.93 | drs | 0.86 | 0.88 | 0.98 | drs |
| Jegol | 0.85 | 0.9 | 0.94 | drs | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS |
| Dil Chora | 0.76 | 0.77 | 0.99 | drs | 0.75 | 0.78 | 0.96 | drs | 0.97 | 1 | 0.97 | drs |
| Karamara | 0.98 | 1 | 0.98 | irs | 0.39 | 1 | 0.39 | irs | 0.58 | 1 | 0.58 | irs |
| Bisidimo | 1 | 1 | 1 | CRS | 0.78 | 1 | 0.78 | drs | 1 | 1 | 1 | CRS |
| Police | 0.85 | 1 | 0.85 | irs | 0.83 | 1 | 0.83 | irs | 0.7 | 1 | 0.7 | irs |
| Army | 1 | 1 | 1 | CRS | 0.89 | 1 | 0.89 | drs | 1 | 1 | 1 | CRS |
| Yemariamwork | 0.26 | 0.31 | 0.84 | drs | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS |
| ART | 0.62 | 0.7 | 0.88 | irs | 0.19 | 0.24 | 0.77 | drs | 0.47 | 0.52 | 0.92 | drs |
| Yimaj | 0.96 | 1 | 0.96 | drs | 0.73 | 0.82 | 0.89 | irs | 1 | 1 | 1 | CRS |
| Bilal | 1 | 1 | 1 |  | 1 | 1 | 1 | CRS | 0.83 | 1 | 0.83 | drs |
| Mean | 0.78 | 0.83 | 0.93 |  | 0.73 | 0.86 | 0.86 |  | 0.83 | 0.93 | 0.89 |  |
| SD | 0.24 | 0.22 | 0.09 |  | 0.25 | 0.23 | 0.17 |  | 0.2 | 0.15 | 0.15 |  |
| Min | 0.26 | 0.31 | 0.72 |  | 0.19 | 0.24 | 0.39 |  | 0.47 | 0.52 | 0.58 |  |
| Max | 1 | 1 | 1 |  | 1 | 1 | 1 |  | 1 | 1 | 1 |  |

*Source: Own computation*

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hospitals | CRSTE | VRSTE | Scale | RTS | CRSTE | VRSTE | Scale | RTS | CRSTE | VRSTE | Scale | RTS |
| France | 0.71 | 0.71 | 0.99 | drs | 0.72 | 1 | 0.72 | Drs | 0.79 | 1 | 0.79 | drs |
| Hiwot Fana | 0.71 | 0.71 | 0.99 | drs | 0.53 | 0.54 | 0.99 | Drs | 0.56 | 0.62 | 0.9 | drs |
| Jegol | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS |
| Dil Chora | 1 | 1 | 1 | CRS | 0.8 | 0.8 | 0.99 | Drs | 0.67 | 0.69 | 0.97 | drs |
| Karamara | 0.52 | 1 | 0.52 | irs | 0.64 | 1 | 0.64 | Irs | 0.66 | 1 | 0.66 | irs |
| Bisidimo | 0.75 | 1 | 0.75 | drs | 0.86 | 1 | 0.86 | drs | 0.82 | 1 | 0.82 | drs |
| Police | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS |
| Army | 0.85 | 1 | 0.85 | drs | 1 | 1 | 1 | CRS | 0.75 | 1 | 0.75 | drs |
| Yemariamwork | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS |
| ART | 0.52 | 0.54 | 0.97 | drs | 0.58 | 0.64 | 0.91 | drs | 0.5 | 0.65 | 0.77 | drs |
| Yimaj | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS |
| Bilal | 0.88 | 1 | 0.88 | drs | 0.54 | 0.67 | 0.81 | drs | 0.73 | 1 | 0.73 | drs |
| Mean | 0.83 | 0.91 | 0.91 |  | 0.8 | 0.89 | 0.91 |  | 0.79 | 0.91 | 0.87 |  |
| SD | 0.18 | 0.16 | 0.15 |  | 0.2 | 0.18 | 0.13 |  | 0.18 | 0.16 | 0.13 |  |
| Min | 0.52 | 0.54 | 0.52 |  | 0.53 | 0.54 | 0.64 |  | 0.5 | 0.62 | 0.66 |  |
| Max | 1 | 1 | 1 |  | 1 | 1 | 1 |  | 1 | 1 | 1 |  |

Table 5. Hospital’s technical and scale efficiency in 2010/11 to 2012/13.

Hospitals Efficiency 2010/11

Hospitals Efficiency 2011/12 Hospitals Efficiency 2012/13

*Source: Own computation.*

1. The Required Change in Input and Output to make Inefficient Hospitals Efficient

Table 6 shows the required change in input reduction or output increase to make inefficient hospitals efficient for the study period. For example, in the year 2012/13, if inefficient hospitals were concerned with the output side, the inefficient hospitals would have increased outpatient visit by 3554, inpatient days by 1837 and surgery by 770 to become efficient. On the other hand, if hospitals were concerned with the level of inputs, the inefficient hospitals should have decreased their bed by 93 to be efficient.

Table 6. The Required Change in input and output to Make Inefficient Hospitals Efficient.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Output |  |  | Input |  |  |
|  | Year | Values | Outpatient  Visit | Impatient  days | Surgery | Bed | Drug  Expenditure | Health  Staff |
| Required Change in input and output for all Hospitals for study period |  | Total | 8424 | 26291 | 2711 | 77 | 1007946 | 70 |
| 2007/08 | Mean | 702 | 2191 | 226 | 6 | 83995 | 6 |
|  | Total | 11310 | 15599 | 5186 | 72 | 1872247 | 16 |
| 2008/09 | Mean | 942 | 1300 | 432 | 6 | 156021 | 1 |
|  | Total | 0 | 8659 | 38 | 130 | 626184 | 57 |
| 2009/10 | Mean | 0 | 722 | 3 | 11 | 52182 | 5 |
|  | Total | 3656 | 3256 | 0 | 118 | 0 | 15 |
| 2010/11 | Mean | 305 | 271 | 0 | 10 | 0 | 1 |
| 2011/12 | Total  Mean | 6979  582 | 8142  678 | 877  73 | 170  14 | 689659  57472 | 14  1 |
| 2012/13 | Total  Mean | 3554  296 | 1837  153 | 770  64 | 95  8 | 0  0 | 0  0 |
| Total |  |  | 33923 | 63783 | 9581 | 662 | 4196035 | 172 |
| Mean |  |  | 471 | 886 | 133 | 9 | 58278 | 2 |

*Source: Own computation.*

For hospitals with outputs that fall short of DEA targets, health policymakers could improve efficiency by improving access to and utilization of underutilized maternal and neonatal health and other services that has been underutilized. This may call for a multi­pronged strategy involving:

* Utilizing health promotion strategies and techniques such as: social

mobilization, advocacy; social marketing; information, education and communication (IEC); regulation and legislation; partnerships and alliances with public, private, non-governmental organization and civil society: and

intersectoral action to address determinants of health to improve the use of underutilized health services (WHO, 2009).

* It is also possible to provide access to universal health services through pooled pre paid contribution collected on the basis of ability to pay through the tax based funding (WHO, 2008).

The other alternative, if it is not possible to solve the inefficiency problem through the improved utilization of hospital health services, is to transfer the excess health staff, beds and drugs to health clinics, health posts and other health stations located in remote areas. However, this should be guided by an efficiency analysis of these lower level health facilities.

1. Malmquist Total Factor Productivity Change

The study analyzed the differences in productivity over time based on Malmquist Total Factor Productivity (MTFP) index taking the year 2007/08 as the technology reference (Table 7).

Table 7. Malmquist index summary of geometric annual means (Output oriented).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year | Efficiency cIhange [A= (C\*D)] | Technical  change  [B] | Pure  Efficiency change [C] | Scale  Efficiency  change  [D=(A/C)] | Malmquist index of Total factor productivity change [E=A\*B] |
| 2008/09 | 0.923 | 1.01 | 1.036 | 0.891 | 0.932 |
| 2009/10 | 1.23 | 0.791 | 1.123 | 1.096 | 0.973 |
| 2010/11 | 1.01 | 0.898 | 0.99 | 1.02 | 0.907 |
| 2011/12 | 0.938 | 1.044 | 0.949 | 0.988 | 0.979 |
| 2012/13 | 0.988 | 1.047 | 1.031 | 0.958 | 1.034 |
| Mean | 1.012 | 0.953 | 1.024 | 0.988 | 0.964 |

*Source: Own computation.*

Table 7 presents the Malmquisit index summary of annual geometric means. In the last row (last column), we observe that on average MTFP decreased slightly by 3.6 % over sample period. On average, the deterioration in MTFP was due to technical change rather than efficiency change. Hospital efficiency increased by 1.2%, technical change decreased by 4.7 %. The efficiency change was attributed to an increase in pure efficiency of 2.4 % and a decline in scale efficiency of 1.2%.

MTFP change was the highest in 2012/13 (MTFP =1.034) and the lowest in 2010/11 (MTFP =0.907). The average MTFP of 0.964 for hospitals in eastern Ethiopia was comparable to those obtained in China inland of 0.9853 (Ng YG, 2008), Greece of

O. 986-0.988 (Karagiannis R and Velentzas K, 2010), Ireland country of 0.977 (Ouellete

P, and Vierstraete V, 2004), South Africa of 0.879 (Asbu et al, 2001), and Taiwan 0.7877(Chang et a.l, 2001). Unlike hospitals in Eastern Ethiopia, a number of countries hospitals had an average MTFP score greater than one signifying productivity growth. Portugal had 1.042 (Barros et al., 2007), Ireland regional hospitals had 1.028(Ganon B., 2008), India district hospital had 1.2353(Dash U., 2009), Angola municipal hospital had 1.045(Kiriga GM.et a/.., 2008) and China coastal hospitals had 1.1207 (Ng YC., 2008).

Table 8. Malmquist Index Summary of firm means.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year | Efficiency change [A= (C\*D)] | Technical  change  [B] | Pure  Efficiency change [C] | Scale  Efficiency  change  [D=(A/C)] | Malmquist index of  Total factor productivity change [E=A\*B] |
| Karamara | 1.062 | 0.947 | 1.067 | 0.995 | 1.006 |
| Army | 1.007 | 0.962 | 1.025 | 0.982 | 0.969 |
| Jugal | 1.034 | 0.973 | 1.022 | 1.012 | 1.006 |
| Police | 0.975 | 0.977 | 0.978 | 0.997 | 0.952 |
| ART | 0.925 | 0.904 | 1 | 0.925 | 0.836 |
| France | 1 | 1.019 | 1 | 1 | 1.019 |
| Yemariyam work | 1.032 | 1.173 | 1 | 1.032 | 1.211 |
| Yimaj | 1 | 0.972 | 1 | 1 | 0.972 |
| Dilchora | 1 | 0.787 | 1 | 1 | 0.787 |
| Bisidimo | 1.12 | 0.846 | 1.135 | 0.987 | 0.947 |
| Bilal | 1.102 | 0.978 | 1.074 | 1.026 | 1.077 |
| Hiwot Fana | 0.91 | 0.946 | 1 | 0.91 | 0.86 |
| Mean | 1.012 | 0.953 | 1.024 | 0.988 | 0.964 |

*Source: Own computation.*

Table 8 provides a summary of the annual geometric mean values of the Malmquist Productivity Index (MPI) and its components for each hospital. Five (42%) out of 12 hospitals had MPI score greater than one, indicating growth in productivity. The hospitals include Karamara, Jugal, Bilal, France and Yemariam work and their respective score is 0.6 %, 0.6%, 7.7 %,1.9 % and 21.1%. The productivity growth in France was attributed to technical change only. Meanwhile, the productivity growth in Karamara, Jugal, Yemariaamwork and Bilal was due to improvements in efficiency only.

On the other hand, 7(58 %) out of the 12 hospitals had Malmquist index score of less than one, indicating deterioration in productivity. Overtime productivity regression in Yimaj, Dilchora and Bisidimo was due to solely deterioration in technical progress. However, productivity regression in the case of Police, ART and Hiwotfana was due to decline in efficiency and technical progress. In the case of Army, the productivity regression was due to solely decline in efficiency.

Pure efficiency change

As shown in Table 8, 5 hospitals had an average pure efficiency change (PECH) score of greater than one. Hospitals registering a pure technical efficiency increase included Karamara (6.7%), Army (2.5%), Jugal (2.2%) Bisidimo (13.5%) and Bilal (7.4%). On the other hand, ART, France, Yemariamwork, Yimaj, Dilchora and Hiwotfana registered a PECH score of one, indicating no change in efficiency at those hospitals between the study periods. However, Police experienced a decline in PECH of 2.3%. The average PECH score for the entire sample was 1.024.

Scale efficiency change

Scale efficiency change (SECH) is expressed as a value less than, equal to, or greater than one if a hospital scale of production contributes negatively, not at all, or positively, respectively, to productivity change (Dash U., 2009).The scale of production in Jugal, Yemariamwork and Bilal contributed positively to TFP change by a factor of 1.2 %, 3.2 % and 2.6% respectively.

France, Yiimaj and Dilchora had a scale efficiency index value of 1 meaning that those hospitals scale of production did not contribute to MTFP change. On the other hand, the SECH score for 5 hospitals was less than one indicating that the scale of production in kararmara, ART, Army, police and Hiwotfana contributed negatively to productivity change by 0.5%, 7.5%,1.8% ,0.3 % and 9 %, respectively.

Technical change

Ten hospitals (83%) registered technical change (TECH) of less than one indicating a decline in technical progress. The lack of technological progress in Karamara, Army, Jugal, Police, ART, Yimaj, Dilchora, Bisidimo, Bilal, and Hiwotfana led to decrease in TFP (Total Factor Productivity) of 5.3%, 3.8%, 2.7 %, 2.3%, 9.6%, 2.8%, 21.3%, 2.2%, 5.6% and 5.4 % respectively. France and Yemariamwork registered technological growth or progress between the period t and t+1 of 1.9% and 17.3%, respectively.

Technological progress or regression in the health system is determined by the availability of appropriate health technology (i.e ecologically relevant and easily adaptable or requiring lesser skills) in addition to other complementary inputs and institutional changes. Moreover, other pivotal factors include the existence of close coordination, cooperation and communication between health policy makers and the management of hospital; access to new technologies at reasonable prices; the provision of relevant training to enable health workforce acquire new skills to use the new technology; and the availability of fund to undertake the needed health technology investment are essential factors that determine the technological progress (Killick, 1981).

1. Regression Model Results

To analyze the determinants of inefficiency of hospitals, the technical efficiency score of hospitals was converted to inefficiency score of hospitals. Subsequently, the inefficiency score was used as a dependent variable and regressed against hypothesized determinants (Size, Teachstat, BOR, Dcstaf, Opvinpdays and impdoc) using a censored Tobit model. Table 9. indicates that among the explanatory variables included in the analysis, four of them (Teachstat, Dcstaff, Opinpdays, impdoc) were found statistically significant while the remaining two were insignificant.

Table 9. Summary of the Censored-Tobit regression analysis.

|  |  |  |  |
| --- | --- | --- | --- |
| Explanatory Variables | Coefficient | Std. Err | Z |
| Lsize | -1.715701 | 2.451574 | -0.7 |
| Teachstat | 3.034462\*\* | 1.340485 | 2.26 |
| BOR | -0.0065286 | 0.0048885 | -1.34 |
| Dcstaf | -26.65755\* | 7.197905 | -3.70 |
| Opvinpdays | -0.3298481\*\*\* | 0.1885694 | -1.75 |
| Impdoc | -4.807009\* | 1.479342 | -3.25 |
| Constant | 23.71757 | 6.968924 | 3.4 |
| observations 72; | 29 left-censored | observations at Ineff > | 0 ;43 uncensored |

observations

0 right-censored observations chi2 (7) = 28.87 Prob > chi2 0.0002

Teachstat: Teaching status of the hospital is negatively related with inefficiency score at 5 % probability level. This implies that being a teaching hospital decreases the expected inefficiency score by 3.03.This might be related to the focus that this hospitals are given in terms of materials and other necessary inputs. These hospitals also offer specialized services that attract patients.

Dcstaff: The proportion of medical doctors to the total staff is negatively related with inefficiency and statistically significant at 1% probability level. For a one unit increase in Dcstaff ratio, there is a 3.75 unit decrease in inefficiency score. This might be related to the improvement that might occur in facilitating service delivery associated with increasing of doctors as their quantity is few in developing country compared to the number of patient each serve. In contrast to this result, a study conducted in West Bengal in India by Arijita et al.(2014) discovered that doctor staff ratio negatively affected the technical efficiency of hospitals.

Opinpdays: The coefficient for Opinpdays has a negative sign that is consistent with our a priori expectation and significant at 10% level. A one unit increase in the ratio of outpatient visit to inpatient days would lead to a decrease in hospital expected inefficiency score by 1.75.This result also agrees with the result obtained by Asbu (2013) in the study of determinants of technical efficiency of hospitals in Eritrea. Similarly, Asbu (2000) also discovered the same result in the case of determinants of technical efficiency of hospitals in South Africa.

Impdoc: The coefficient of the proportion of inpatients treated per medical doctor is negatively related to inefficiency score and statistically significant at one percent level. It shows that the number of inpatients per medical doctor has negative relationship with inefficiency score. This implies that a one percent increase in the ratio of impatient per doctor would drop the predicted value of inefficiency score by 3.25 percent.

1. Conclusion and Recommendation

The objectives of the study were estimating the relative technical and scale efficiencies of 12 hospitals, quantifying the magnitudes of output increases or input reductions needed by inefficient hospitals between 2007/08-2012/13, and estimate factors affecting hospital’s inefficiencies using Tobit regression analysis. Under variable returns to scale assumption, 6 (50 %) ,5 (41.7 %), 3 (25 %) ,3 (25 %) ,4 (33.3 %) and 3 (25 %) of the 12 hospitals were run inefficiently between 2007/08 and 2012/13. Butunder constant returns to scale assumption, 9 (75 %), 9 (75%), 8 (66.66 %), 7 (58.33 %), 7 (58.33 %) and 8 (66.66 %) hospitals were run inefficiently between 2007/08 and 2012/13. The results also indicate that 9 (75 percent) ,9 (75 %), 7 (58.33 %) ,7 (53.33 %) ,7 (58.33 %) and 8 (66.66 %) of the 12 hospitals were scale inefficient between 2007/08 and 2012/13. In 2012/13, for example, the inefficient hospitals, taken together, would need to increase the number of outpatient visits by 3554 (1.39 %) , inpatient days by 1836 ( 1.4 percent) and surgery by 770 (11.49 percent) in order to become efficient.

Alternatively, in 2012/13 policy makers may consider boosting the quality of services provided by primary health care facilities by transferring 93(8.14%) of beds to primary health level facilities. Hospitals with outputs that fall short of DEA targets, health policy makers could improve efficiency by promoting the use of underutilized health sector services to the public. Hospitals with excess inputs, policy makers could transfer the excess resources to lower level health facilities so that they may deliver better services.

Among the 12 hospitals, seven (58.3 percent) experienced MTFP deterioration over the six years. The sources of inefficiencies were discovered to be either adverse change in pure efficiency, scale efficiency and/or technical efficiency. In this regard, it is crucial to institutionalize efficiency monitoring of health facilities within health management information system.

Among factors that determine technical inefficiency, the teaching status of the hospital, medical doctor to total staff ratio, the proportion of outpatient visit to inpatient days and the proportion of inpatients treated per medical doctor were negatively related with technical inefficiency of hospitals. Policy interventions that increase utilization of underutilized hospital outpatient health services and reduce the average length of stay, increase doctor to other staff ratio and also the number of inpatients treated per doctor would contribute to improve the technical efficiency of hospitals.

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1. Impact of Cooperatives Membership on Economy in Eastern Oromia: The Case of Haramaya Agricultural Farmers’ Cooperative Union (HAFCU)

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Abstract: The study was conducted to analysis impact of cooperative on rural economy in Eastern Oromia East Hararghe zone of Haramaya woreda. Primary cross sectional data collected from both cooperative member and non-cooperative member household heads were analysed to achieve objective of the study. Income, agricultural productivity, marketed surplus and saving were used as poverty indicator variables. PSM (Propensity Score Matching) estimation indicated that being cooperative member brought significant impact on income, agricultural productivity, and saving of households in the study area. Thus, policy action that further strengthen and expands the existing rural organizations through training and capacity building programs; that establishes new rural based organizations and attracts rural households would make easy business in rural areas thereby reduces poverty by increasing small holders’ income, productivity and capital accumulation.

Keywords: cooperatives; impact; propensity score matching; rural

1. Introduction

In rural Africa membership based rural producer organization (RPO) like cooperatives, peasant associations and unions can help alleviate rural poverty (World Bank 2007; Chen et al. 2006). Particularly agricultural cooperatives can help smallholders achieve scale of economies in input provision and output marketing (World Bank 2003, Berdegue 2001, Collion and Rondot 1998).In addition, governments, donors, and multilateral agencies in developing countries have regained interests to develop collective action mechanisms of agricultural cooperatives for improving smallholder productivity and commercialization, scarce natural resources managing, and strengthening local governance systems (Collion and Rondot 1998, World Bank 2003). Recognizing this reality, Government of Ethiopia (GoE) also placed high priority on promotion of cooperatives in agriculture and rural development as an engine of pro-poor growth. In this regard, Agricultural Development Led Industrialization (ADLI) policy of Ethiopia, which puts forward in 1993 to bring about a structural transformation in the productivity of the peasant agriculture, commercialization of smallholder surpluses to reduce rural poverty, and to streamline and reconstruct the manufacturing sector that makes extensive use of the countries natural and labor resources, put cooperatives at a cornerstone (MoPED 1993). Studies also urge specific strategies meant to increase yields through intensive use of modern inputs in cereal production, or commercialization of surpluses from smallholder production through cooperatives are required (Bernard, Gabre-Madhin and Taffesse 2007, Byerlee et al. 2007, DSA 2006).

As a result of the initiatives taken by the GoE, more than 21 different types of co­operatives are established and engaged in different activities (FCA 2006). As of 2005/06 the cooperative coverage in Ethiopia is estimated at less than 35 percent of all kebeles[[26]](#footnote-27), with only 17 percent of households living in a given kebele actually participating in a cooperative.

Though GoE is promoting cooperatives development, what remains to be seen is whether the rapid implementation of cooperative development and promotion is contributing to improving rural livelihoods in the country. Few studies on impact of cooperatives indicate mixed results. Getnet and Anullo (2012) indicated a positive impact of cooperatives on rural income and savings; and negative impact on productive asset accumulation in Ethiopia. Zeweld, Van Huylenbroeck, and Buysse (2015) found that cooperative member households have significantly higher income (47%), expenditure (32%) and more number of non-poor households (15%) than the non­cooperative member households in northern Ethiopia.

Getnet and Anullo (2012) studied that the effect of cooperative services is in favor of the users in terms of income (composite income mainly from crop sales, livestock sales and petty trade) growth in Ethiopia. They also showed that the use of cooperative services positively influenced the income generated by farm households from crop sales and miscellaneous income.Cooperative membership increases farm income from 40% to 46%; and reduces the likelihood of being poor from 10% to 14% points in Rwanda (Verhofstadt & Maertens, 2014a). Though there is no information on whether cooperative member and non-cooperative member households were from villages, Verhofstadt & Maertens (2014) found that cooperative membership in general has a positive impact on farm performance (agricultural intensification, market orientation, farm revenue, and income) of rural households in Rwanda.

Bernard et al (2008) recognized the potential contribution of smallholder cooperatives to agricultural production and marketable surpluses in rural Ethiopia and, in the long run, to overall agricultural development, economic growth and poverty reduction. Bernard et al., (2008) found that cooperative membership does not have an impact on the share of production sold (measures marketed surplus). But Francesconi and Heerink (2010) found that marketing cooperatives have smallholder commercialization impact in Ethiopia. Though the result might be biased due to externalities, Abate, Francesconi, and Getnet (2013) indicated that there is a positive impact of agricultural cooperatives on members’ levels of technical efficiency (productivity) in Ethiopia. Toluwase and Apata (2013) indicate that there is significance difference between farmer’s cooperative and non-member on productivity in Nigeria. However they did not indicate the impact of the cooperatives on agricultural productivity. Addai et al (2014) in contrast indicate that there is no impact of farmer based organization on technical efficiency of maize farmers in Ghana.

Given these limited and mixed findings, this study tried to analysis whether there is impact of cooperatives on rural economy in terms of income, productivity, marketed surplus and saving in Haramaya district. To the best of our knowledge no work has been done to rigorously analyse the net impact of the cooperatives on households’ livelihoods in study area.

1. Materials and Methods
   1. Description of the Study Area

The study was carried out in the Oromia region of Ethiopia in East Hararghe Zone Haramaya district. Haramaya district lies between 90 09’ and 90 32’ N latitude and 41050’ and 42005’ E longitude to the west of Harar town. It is bordered by Dire Dawa Administrative council (to the north) Kombolcha district (to the north east), Harari Regional state (to the east), Fedis district (to the south east), Kurfachele district (to the south west) and Kersa district (to the west).

Haramaya district has an area of 561.6 km2 and a rural population of 154,690 (EPS, 2007) and is found in the northern central part of the Zone. Its capital city, Haramaya is about 19kms far away from Harar town to the west direction along Addis Ababa — Harar main road. The district has in general 33 rural and 4 urban kebeles. The district is part of the Ethiopian highland system, and lies in the semi-arid tropical belt of eastern Ethiopia. Haramaya is characterized predominantly by Woinadega (middle land) agro­ecology and mixed crop-livestock farming is the dominant production system.

* 1. The data

Structured interview schedule was used to collect primary data from sampled household heads. Secondary data was collected from books, articles, government reports. Focus group discussion (FGD) and key informant interview (KII) were conducted with experienced and knowledgeable expertise in cooperatives in the study area and the data generated through these tools were used to complement and support the findings obtained from the household survey data.

Multistage random sampling was used to draw sample for the study. Sampled farmers were both members of cooperatives and nonmembers of cooperatives. To select members and nonmembers, stratified random sampling was used. First, a complete list of 26 cooperatives that are members of Haramaya Agricultural Famers’ Cooperative Union (HAFCU) was obtained. Out of these, 4 cooperatives from three kebeles were purposively selected. From these 4 cooperatives, 124 member household heads were randomly selected. In two kebeles of the study area, cooperatives were not established and in one kebele cooperative was inactive (not operational). From these two kebeles 176 non-cooperative member farmers households were randomly selected. Thus, the total sample consists of 300 farmer households. Two questionnaires were not correctly filled due to this fact only 298 observations were used for analysis.

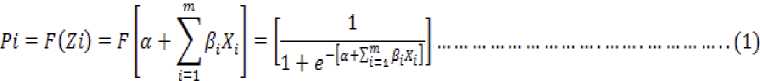
* 1. Data Analysis Method
     1. Descriptive statistics

For this study, descriptive statistics such as percentages, frequencies, standard deviation, independent sample t-test, and chi square test were used.

* + 1. Propensity score matching model

This study used both with and without treatment approaches.to measure impact of cooperatives on variable of interest. This approach best suits the purpose of this particular study because it simplifies cooperative member and non-member comparison by using propensity score matching (PSM) method. The first step in estimating the treatment effect is to generate propensity score. Logit or probit model was used to generate propensity score. Since the likelihood to be cooperative member was unknown, the first task in matching was to estimate the propensity. Any resulting estimates of cooperative effects rest on the quality of membership estimate. The estimation of the propensity score can be done using either logit or probit choice model since the two model produce similar results. In this model, the dependent variable was cooperative membership that took value one if the household is cooperative member, zero value otherwise. The independent variables were the factors that influence membership and outcome variables.

Cumulative logistic probability function is specified (Pindyck and Rubinfeld, 1981) as:



Where: e represents the base of natural logarithms=2.718...

Xi: the ith explanatory variable

Pi: the probability that household is cooperative member a and Pi: are parameters to be estimated.

This model can be written in terms of odds ratio (Gujarati, 2004). Odds ratio is the ratio of the probability that household will be cooperative member (Pi) to the probability the household will not be cooperativemember (1-Pi) specified as:



Where: /., = a +'£?=1PiXi Then the odds ratio is given by:



Taking the natural logarithm of the odds ratio the logit model was specified as:



If we consider the error termui, the logit model becomes ■m

*L;=* ***a+Yp^+u,* (S)**

**:=1**

Thus, the binoaery logit model became:

Pr (PCM) = f(X) where PCM is probability of cooperative member, f(x) was dependent variable cooperative membership, and X was vector of observable covariates of the household.

After obtaining propensity score values conditional on observable covariates from binary estimation, matching was done based on matching algorithm that was selected based on required criteria. Then the impact of cooperative membership on outcome variables (income, productivity, marketed surplus and saving) was specified as:



Where is treatment effect (effect due to participation in cooperative), Yt is die outcome on household i, Dt is whether household i is cooperative member or not (i.e., if household is member Dt = 1, if not Dt = 0). However, one should notice that Ys(Dl= 1} and Yi(DL= 0) cannot be observed for the same household at the same time. Depending on the position of the household in the treatment (participation in cooperatives) either Ys(Dl= 1} or Yi(DL= 0) is unobserved outcome (called counterfactual outcome). Due to diis fact, estimating individual treatment effect is not possible and one has to shift to estimate the average treatment effects of the population than the individual one. Two treatment effects are most frequently estimated in empirical studies. The first one is the (population) average treatment effect (ATE), which is simply the difference of the expected outcomes of cooperative members and non-cooperative members.



This measure answers the question what would be the effect if households in the population were randomly assigned to treatment. But, Heckman et al, (1997) note that, this estimate might not be of importance to policy makers because it includes the effect for which the intervention was never intended. Therefore, the most important evaluation parameter is the so called average treatment effect on the treated (ATT), which concentrates solely on the effects on those for whom the program/interventions are actually introduced. It is given by:



By rearranging, and subtracting E(Y0/D = 0) from both sides of equation (8), one can get the following specification for ATT.

**Eft/D = 1) - E(Y0/D = 0) = tATr + E(Y0/D = 1) - E(Y0/D = 0) (9)**

Both terms in the left hand side are observables and ATT can be identifiedif and only if -ij 1^= - — - i; B = .- = -(i.e., when there is no self-selection bias). This

condition can be ensured only in experiments where treatments are assigned to units randomly (i.e., when there is no self-selection bias). In non-experimental studies, one has to introduce some identifying assumptions that conditional on some covariates X, the outcome Y is independent of treatment D to solve the selection problem. In this case application of matching to the consistent evaluation of impact of programme/interventions made the following two assumptions.

Firstly, conditional independence assumption states that given a set of observable covariates X that are not affected by treatment, potential outcomes Y are independent of treatment assignment T. If ^/represent outcomes for participants and ^outcomes for nonparticipants, conditional independence implies -L iXj.This assumption

is also called unconfoundedness (Rosenbaum and Rubin 1983), and it implies that uptake of the program is based entirely on observed characteristics.

A second assumption is the common support or overlap condition: 0 <Pr (Ti= 1|Xi) < 1. This condition ensures that treatment observations have comparison observations “nearby” in the propensity score distribution (Heckman, LaLonde, and Smith 1999). Given above two assumptions, the PSM estimation of average treatment effect on treated (ATT) can be written as:



Where pr(x) propensity scores; the PSM estimator is the mean difference in outcomes over the common support region weighted by the propensity score distribution of the cooperative members.

1. Results and Discussions
   1. Descriptive Analysis

From Table 1, it is evident that cooperative member mean values for education of household head, credit access, mobile ownership, social participation, radio ownership, land size, number of ox, tropical livestock unit(TLU), saving, productivity, marketed surplus, irrigation use, and modern fertilizer use is greater than that of non-cooperative members. While non-cooperative member mean values for age of household head, family size, sex of household and agricultural experience were greater than that of cooperative member. The maximum, minimum, and standard deviation for variables included are detailed in the Table 1 for each group and pooled sample. Table 2 indicates that the mean differences in outcome indicators are significant at less than 1% levels significance.

Table 14. Descriptive Statistics Result.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variables | Members(n—123) |  | Not member(n—175) |  | Pooled sample(n—298) |  |
|  | Mean(SD) | Min/Max | Mean(SD) | Min/Max | Mean(SD) | Min/Max |
| Age HHH | 35.49(10.03) | 15/68 | 40.87(10.01) | 21/80 | 38.65(10.35) | 15/80 |
| Sex HHH | 0.87(0.34) | 0/1 | 0.92/0.27 | 0/1 | 0.90/0.30 | 0/1 |
| Family size | 7.02(2.57) | 2/14 | 7.35(1.96) | 3/12 | 7.21(2.23) | 2/14 |
| Education HHH | 3.96(3.88) | 0/15 | 1.70(3.00) | 0/13 | 2.63(3.56) | 0/15 |
| Credit access | 0.51(0.50) | 0/1 | 0.32(0.47) | 0/1 | 0.40(0.49) | 0/1 |
| Mobile ownership | 0.86(0.35) | 0/1 | 0.53(0.50) | 0/1 | 0.66(0.47) | 0/1 |
| Social participation | 0.96(0.20) | 0/1 | 0.69(0.46) | 0/1 | 0.80(0.40) | 0/1 |
| Radio ownership | 0.32(0.47) | 0/1 | 0.09(0.28) | 0/1 | 0.18(0.39) | 0/1 |
| Land size | 0.41(0.49) | 0.03/38 | 0.31(0.19) | 0.01/1 | 0.35(0.35) | 0.01/4.38 |
| Ox | 0.13(0.44) | 0/2.00 | 0.03(0.18) | 0/1 | 0.07(0.32) | 0/2 |
| TLU[[27]](#footnote-28) | 1.87(1.90) | 0/11.74 | 0.69(0.82) | 03.98 | 1.17(1.49) | 0/11.74 |
| Savings | 5799.51 | 0/200000 | 318.00 | 0/15000 | 2580.50 | 0/200000 |
| Productivity | (19888.76)  97193.98 | 2168.95/ | (1549.20)  29167.54 | 1842.11/510000 | (13084.37)  57245.56 (86236.87) | 1842.11/ |
| Agricultural | (112293.2)  20.41 | 988461.6  2/53 | (43948.7)  23.54 | 3/50 | 22.24 | 988461.6 2/ head 53 |
| experience Marketed surplus | (10.68)  18765.2 | 0/109700 | (9.71)  4667.09 | 0/75000 | (10.22)  10486.11 | 0/109700 |
| Nonfarm income | (18434.57)  0.22(0.41) | 0/1 | (8330.07)  0.27(0.44) | 0/1 | (15119.06)  0.25(0.43) | 0/1 |
| participation Irrigation use | 0.52(0.50) | 0/1 | 0.05(0.22) | 0/1 | 0.24(0.43) | 0/1 |
| Modern fertilizer use | 0.97(0.18) | 0/1 | 0.78(0.42) | 0/1 | 0.86(0.35) | 0/1 |

*Source: Own computation, 2015.*

Table 15. Mean difference in outcome indicators between the two groups.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Member(175) | | Not member(123) | | Mean | t- |
| Variables | Mean | SD | Mean | SD | Ditteren  ce | value |
| Per-capita | 6594.56 | 8798.84 | 1641.44 | 2084.75 | 4953.12 | 7.17 \* |
| income | | | | | | |
| Productivi | 97193.98 | 112293.20 | 29167.54 | 3322.21 | 68026.40 | 7.26\* |
| ty  Marketed | 18765.20 | 18434.57 | 4667.09 | 8330.07 | 14098.10 | 8.901\* |
| surplus  Savings | 5799.51 | 19888.76 | 318.00 | 1549.20 | 5481.51 | 3.63\* |

Source: Own computations 2015.

Note \*, \*\* and \*\*\* indicates significance level <1%, 5% and 10% respectively.

* 1. Econometrics Analysis
     1. Factors affecting cooperative membership (Estimation of propensity scores)

Probit regression model is used to generate p-score. Table 3 shows the estimation results of the probit model. The estimated model appeared to perform well for our intended matching purpose. The pseudo-R2 value was 0.47. According to Pradhan and Rawlings (2002), a low pseudo-R2 value shows that being cooperative member has been de facto random. In other words, a low pseudo-R2 value means that program households do not have much distinct characteristics overall and as such finding a good match between cooperative member households and non-cooperative households becomes easier. The pseudo-R2 indicated how well the regressors explain the participation probability. After matching, there should be no systematic differences in the distribution of covariates between both groups and therefore, the pseudo- R2 should be fairly low (Caliendo and Kopeinig, 2005).

The probit estimation results (Table 3 ), indicated that cooperative membership was significantly influenced by sex of household head, age of household head (negatively), education of household head, irrigation use, improved seed use, social participation, radio ownership and tropical livestock unit (positively ).

Proceedings of the 33rd Annual Research Review Workshop, April 21-23, 2016 Table 16. Probit estimation results of household cooperative membership.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variables | Types and | Measurement | Coff. | Robust | Z |
|  | definition |  |  | Std. Err. |  |
| Sexhhh | Sex of household | 1 if male 0 | - | 0.35 | -2.52\*\* |
|  | head | otherwise. | 0.895 |  |  |
| Agehhh | Age of household | Years. | - | 0.06 | -3.04\* |
|  | head |  | 0.175 |  |  |
| Agehhh2 | Age of head square |  | 0.002 | 0.00 | 2.74\* |
| Eduhhh | Education of head | Years. | 0.089 | 0.03 | 3.00\* |
| Famsize | Family size | In number. | 0.032 | 0.05 | 0.62 |
| Nonfpart | Non-farm partition | 1 if member | - | 0.25 | -0.66 |
|  |  | participated, 0  otherwise. | 0.166 |  |  |
| Landsize | Land size | In hectare. | - | 0.25 | -1.17 |
|  |  |  | 0.295 |  |  |
| Irrga | Irrigation use | 1 if use irrigation, 0 otherwise. | 1.377 | 0.28 | 4.92\* |
| Agrexp | Agricultural  experience | Years. | 0.002 | 0.02 | 0.09 |
| Modfer | Modern fertilizer us | 1 if use modern | - | 0.37 | -0.11 |
|  |  | fertilizer, 0  otherwise. | 0.042 |  |  |
| Imprseed | Improved seed use | 1 if use improved seed, 0 otherwise. | 0.377 | 0.22 | 1.71\*\*\* |
| Credacces | Credit access | 1 if took credit, 0 otherwise. | 0.228 | 0.21 | 1.07 |
| Mobile | Mobile ownership | 1 if at least member owns 0 otherwise. | 0.271 | 0.23 | 1.17 |
| Socialpart | Social participation | 1 if participated, 0 otherwise. | 1.351 | 0.41 | 3.28\* |
| Ox | Ox | Number. | 0.370 | 0.27 | 1.36 |
| Radio | Radio ownership | 1 if family owns radio, 0 otherwise. | 0.559 | 0.31 | 1 82\*\*\* |
| Tlu | Livestock(excluding | Tropical Livestock | 0.319 | 0.10 | 3.28\* |
|  | oxen) | Unit. |  |  |  |
| \_cons |  |  | 1.832 | 1.23 | 1.49 |

Wald chi2(17) = Prob> chi2 =0.00 Log pseudo likelihood —108.04

98.91 Pse. R2 = 0.47 Observation = 298

*Source: Own computations 2015 Note \*, \*\* and \*\*\* indicates significance level at <1%, <5% and <10% respectively.*

Table 4 shows the summary of predicted propensity scores which vary between 0.000153 and 0.979871 (mean = 0.199824) for cooperative member or treatment households and between 0.022651and 0.999999 (mean = 0.716165) for non-cooperative (control) households. The common support region would then lie between 0.022651and 0.979871. As a result of restriction, 26 cooperative member households were discarded and not used in computing the impact estimator.

Table 17. Distribution of Propensity score.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Group | Observation | Mean | Stan. Dev | Minimum | Maximum |
| Not cooperative  member | 123 | 0.716165 | 0.283432 | 0.022651 | 0.999999 |
| Cooperative  member | 175 | 0.199824 | 0.214358 | 0.000153 | 0.979871 |
| Total | 298 | 0.412944 | 0.353212 | 0.000153 | 0.999999 |

*Source: Own computations 2015.*

The final choice of a matching estimator was guided by different criteria such as equal means test referred to as the balancing test (Dehejia and Wahba, 2002), pseudo-R2 and matched sample size. Specifically, a matching estimator which balances all explanatory variables, bears a low pseudo R2 value and also results in large matched sample size is preferable. Table 6 presents the estimated results of tests of matching quality based on the above mentioned performance criteria. After looking into the results, it was found that nearest neighbourhood matching was the best estimator for the data (see Table 5). As such, in what follows estimation results and discussion were the direct outcomes of the nearest neighbourhood matching algorithm.

* + 1. Testing the Balance of Propensity Score and Covariates

Table 6 shows that there is no significant difference in terms of pre-intervention characteristics of cooperative member and non-cooperative member households after matching was conducted.

The low pseudo-R2 and the insignificant likelihood ratio tests support the hypothesis that both groups had the same distribution in covariates after matching (see Table 7). This allowed us to compare observed outcomes for cooperative members with those of a comparison groups sharing a common support. These tests suggested that the matching algorithm we chosen was relatively the best one with the data we had at hand. Therefore, we can proceed to estimate ATT for households in order to answer the objectives of the study.

Table 5. Matching algorithm choice (comparisons).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Matching | Sam | Covariate | Joint test | Impact | on |  |  |
| algorithm | ple | s  balanced |  | Incom  e | Productivit  y | Surplu  s | Savin  g |
| NN(5) | 272 | 16/17 | satisfied | 2730\* | 39309\*\* | 4123 | 4422\*\*\* |
| Kernel | 264 | 16/17 | satisfied | 1896\* | 31512\*\* | 629 | 4739\*\*\* |
| Caliper(0.0  \_3) | 25  5 | 15/17 | satisfied | 1783 | 36280\* | 2930 | 4766 |

Source: Own computations 2015.

Note \*, \*\* and \*\*\* indicates significance level <1%, 5% and 10% respectively.

Table 6. Propensity score and covariate balance (mean difference test after matching).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Variable | Treated | Control | t- value | Variable | Treated | Control | t-  value |
| Sexhhh | 0.87 | 0.85 | 0.33 | Modfer | 0.96 | 0.97 | -0.64 |
| Agehhh | 36.60 | 38.30 | -1.16 | Imprseed | 0.70 | 0.78 | -1.31 |
| Eduhhh | 3.45 | 3.46 | -0.01 | Credacces | 0.47 | 0.42 | 0.75 |
| Famsize | 7.09 | 7.36 | -0.85 | Mobile | 0.84 | 0.87 | -0.77 |
| Nonfpart | 0.20 | 0.17 | 0.37 | Socialpart | 0.96 | 0.97 | -0.55 |
| Landsize | 0.41 | 0.33 | 1.37 | Ox | 0.07 | 0.04 | 0.85 |
| Irrga | 0.39 | 0.31 | 1.20 | Radio | 0.26 | 0.34 | -1.31 |
| Agrexp | 21.02 | 23.69 | -1 79\*\*\* | Tlu | 1.45 | 1.28 | 0.94 |
| Source: Own computations 2015; \*\*\* indicates significance level at < 10%. | | | | | |  |  |
| Table 7. Chi-square test for the joint significance of variables. | | | | | |  |  |
| Sample |  | Ps R2 |  | LR chi2 |  | p>chi2 |  |
| Matched |  | 0.061 |  | 16.42 |  | 0.424 |  |

*Source: Own computations 2015.*

1. Impact of cooperatives on outcome variables

PSM estimate indicateed that, on average, being cooperatives member increased per- capita income by 2,730 Birr or by (52%), productivity of the cooperative members households by 39,309 Birr or by 46% (see Table 8). Similarly, the result of impact estimation proved that the cooperative succeeded in increasing the participant household’s saving by 4,422Birr. However, the result showed that there was positive and insignificant difference between cooperative members and non-cooperative members in terms of marketed surplus.

Positive impact of cooperative on income, productivity and saving of the former cooperative member households may be due to the services that Haramaya Agricultural Farmers Union and basic cooperatives provide for their members. Farmers union and basic cooperatives supply modern fertilizer and improved seed to their members. Cooperative members thus easily get access to agricultural inputs in their respective locality through basic cooperatives. Cooperatives members can also get cooperative services because of their membership, even if they lack capital on credit basis. These cooperative services by reducing transaction cost motivated farmers to produce (invest) in their resources. Farmers get incentive to produce. Besides, farmers produce more as they get easy access to fertilizer; this fertilizer in turn improves the productivity of land. As income of the farmer largely comes from agricultural products, cooperatives have direct effect on it. It is obvious that saving is part of income of the household that would increases as income increases. Generally, cooperatives, by reducing transaction costs and making easy access to important agricultural inputs, motivate farmer households to produce more. Input supply increases the productivity of the land thereby production, income, and saving of the farmer households increses.

Table 8. Average Treatment effect on treated (ATT) for outcome indicators.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Treated | Controls | Difference | S.E. | T-Value |
| Per-capita income | 5209.95 | 2479.44 | 2730.51 | 784.89 | 3.48\* |
| Productivity | 85777.74 | 46468.32 | 39309.42 | 15729.36 | 2.50\*\* |
| Marketed surplus | 16447.42 | 12324.25 | 4123.18 | 3020.78 | 1.36 |
| Saving | 5201.44 | 778.68 | 4422.76 | 2225.49 | 1 99\*\* |

Source: Own computations 2015.

Note \*, \*\* and \*\*\* indicates significance level <1%, 5% and 10% respectively.

1. Sensitivity analysis

The estimation of treatment effects with matching estimators is based on the conditional independency assumption (CIA) that is selection on observable characteristics. However, if there are unobserved variables which affect assignment into treatment (cooperative membership) and the outcome variable simultaneously, a hidden bias might arise. Since it is not possible to estimate the magnitude of selection bias with non- experimental data, studies address this problem with the bounding approach proposed by Rosenbaum (2002). The basic question to be answered is, inference about treatment effects may be altered by unobserved factors. In other words, studies want to determine how strongly an unmeasured variable must influence the selection process in order to undermine the implications of matching analysis.

Table 9 shows sensitivity analysis based on Rosenbaum bounding approach. In a study free of hidden bias, i.e. where r (eT=1) (log odds of differential assignment due to unobserved factors=1), the t-hat+ test-statistic is 1899 and would constitute strong evidence that being cooperative membership causes increase in income. If we have a positive (unobserved) selection, in the sense that if those most likely to be cooperative member, also have a higher probability to get increased income, then the estimated treatment effects overestimate the true treatment effect. The reported t-hat+ (upper bound Hodges-Lehmann point estimate) test-statistic is then too high and should be adjusted downwards. Hence, we will look at t-hat+ andsig+ (p-value) in the output. The upper bounds on the significance levels for log odds of differential assignment due to unobserved factorsr(eT) = 1, 1.25, 1.50, 1.75, and 2, are 4.9e-07, .000036, and .000575, .003858 and .01504 respectively for income. For productivity, the upper bounds on the significance levels for T(eT) = 1, 1.25, 1.50, 1.75, 2, 2.25, 2.5, 2.75 and 3 are 0.00, 0.00, 0.00, 0.01, 0.04, 0.10, 0.19 0.30 and 1.00, respectively. The null hypothesis is there is hidden bias (overestimation) due to unobserved covariates is rejected at less than 5% level of significance at conventional gamma statistic (T(eT) = 2) for both income and productivity. The study is insensitive to a bias (no hidden bias) that would double the odds of being cooperative membership. Though, sensitivity analysis is no guarantee for existence (or nonexistence) of the hidden bias, saving fail to full fill the assumption.

Table 9. Sensitivity analysis using Rosenbaum Bounding method

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Outcomes | T(eT) = 1 | T(eT) = 1.25 | T(eT) = 1.50 | T(eT) = 1.75 | T(eT)  =2 | T(eT)  =2.25 | T(eT)  =2.5 | T(eT)  =2.75 | T(eT)  =3 |
| PCI | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.04 | 0.09 | 0.15 | 0.24 |
| Productivity | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | 0.10 | 0.19 | 0.30 | 0.41 |
| Saving | 0.11 | 0.37 | 0.66 | 0.85 | 0.94 | 0.98 | 0.99 | 1.00 | 1.00 |

*Source: Own computations 2015.*

1. Conclusion and Recommendations

Being cooperative member is significantly influenced by sex of household head, age of household head (negatively), education of household head, irrigation use, improved seed use, social participation, radio ownership, and tropical livestock unit (positively). Also, it has been observed that, on average, being cooperatives member has increased per-capita income (income per adult equivalent) by 2,730 Birr, increased productivity of the cooperative members households by 39,309 Birr and increased household’s saving by 4,422 Birr.

Based on the study, the following policy recommendations are forwarded: further improvement in the households’ per-capita income, productivity and savings from similar interventions could be pursued for rural poverty reduction by taking the following policy measures.

* Further developing and strengthening the existing rural organizations through training and capacity building programs so as to further enhance the rural livelihood.
* Expanding rural organization to different kebeles where cooperatives are not existing and incorporating all farmers in cooperatives so as to bring desired rural livelihood outcomes (higher production, productivity, marketed surplus and so on).
* Awareness creation by training and education about cooperation importance and impact would help farmers establish new rural organizations that achieve common objectives of small holders. It can also help non cooperative members join existing organisations.

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1. Value Chain Analysis of Tomato in Erer Valley, Eastern Ethiopia

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Abstract: Ethiopia is endowed with diverse climatic condition that supports the production of horticultural crops. Among these crops, tomato production is one of the lucrative ones. Though tomato is one of the most important crops in a household consumption and contributes in generating foreign currency, there are no enough multi-location studies made in its value chain. Intending to analyze the value chain of tomato with its attributes of actors’ linkage, benefit distribution and constraints and opportunities in Eastern Haraghe, Erer Valley, the study identified and used data from producers, wholesalers, retailers, and consumers in the analysis. The results showed that actors were linked in a multidirectional manner with actors. A gap exists between producers and wholesalers in the link. The chain was confronted with some constraints which include problems of disease/pest in production, lack of producers’ price satisfaction, rotting, shortage of place in the market. On the contrary, there were some opportunities, if properly handled, that could help in commercializing the sector. Consumers’ desire for quality, shortage during low supply season and irrigation facilities were some of them. The alleviation of the problems created by the constraints and the utilization of the opportunities would help in commercializing the chain. Areas for further research have been identified and proposed, organizing producers under cooperative, establishment of mini market within the community, introduction of production technology to improve quality and product were some of the recommendations made.

horticultural production shows that the production of horticultural crops has grown faster than that of cereal crops regardless of the vast resources channeled to improvement of cereal grains. Between 1960 and 2000, the area under horticultural crops worldwide grew more than double. While in 1970 only 3.9% of world arable land was under fruit and vegetable production, by the year 2000 this share had risen to 6.7% (Weinberger and Lumpkin, 2005:6-12).

Ethiopia has an immense potential to develop intensive horticulture on small as well as large scale. The diverse climatic condition of the country is suitable for the production of various horticultural crops. Regarding the production status of horticultural crops, CSA (2010) reported the area coverage of 90,584.55 ha of vegetables, 36,780.09 ha of fruits and 265,754.27 ha of root and tuber crops. All the three together, constituting about 4% and 18.3% of total crop area and production, respectively by 2001/02 production year. The report only addressed the private holding and did not include non­private holdings such as state farms.

Ethiopia has a variety of vegetable crops grown in different agro ecological zones. These crops are produced through commercial as well as small farmers both as a source of income as well as food. However, the type is limited to few crops and production is concentrated to some pocket areas. In spite of this, the production of vegetables varies from cultivating a few plants in the backyards for home consumption up to a large-scale production for domestic and export markets (Dawit et al, 2004).

The study area, banks of Erer valley being part of Babile woreda of Oromia and Harari region, is one of the potential tomato growing areas. The high irrigation potential (more than 2000 ha) has given better opportunity to farmers to produce different vegetable crops of which tomato is the major one. In an effort to improve the production and productivity of the crop, different improved tomato cultivars were introduced to the area by the research system. However, so far, there is no empirical study conducted in the area and hence there is no information about the value chain of vegetable and fruit crops in general, and tomato in particular. As a result, this study is designed to fill the gap with regard to what has been stated above.

Objectives of the Study

The jeneral objective of this study was intended to undertake value chain analysis of tomato crop in the study area. Along with this general objective, the achievement of some specific objectives was also part of the study. These specific objectives were:

* to conduct in-depth value chain analysis of tomato in the study area;
* to make comparative assessment of the profit margins of farmers and other actors in the value chain of tomato;
* to identify linkages among different actors and benefit distribution, and
* to analyze the constraints and opportunities for market oriented tomato production in the study area.

1. Research Methodology
   1. Research Design

Descriptive research design, preceded by an exploratory survey research with the help of a check list, was initially conducted with flexible sampling design representing different actors in the value chain, from producers up to final consumers. The necessary information was gathered to frame the descriptive research design.

Erer valley covering parts of Babile woreda of Oromia and of Harari region is selected purposively for two reasons; it belongs to the mandate area of Haramaya University and it produces a lot of tomatoes using irrigation from Erer River. Four PAs having tomato cultivation were selected for the study. The sampling frame for farmers’ related inquiry were farmers growing tomato in Erer valley. From this sampling frame, 120 farmers were selected randomly as sample respondents for the primary survey on production aspects. Since this is a value-chain analysis, other categories of respondents were also formed the sample of the study. Hence, wholesaler, retailer and consumers were added to the sample. Except for wholesalers’ category, 25 sample respondents were taken for data collection. In the case of wholesalers all the available were taken since they were 17 in number. Hence, the total sample respondents for primary data of this study were about 187 belonging to different categories of actors. In addition, qualitative data on market linkages, and constraints and opportunities for commercialization of this horticultural crop have been analyzed.

Primary data were collected from producers, intermediaries, and consumers and analyzed using appropriate statistical tools like chi-square test and independent sample t- test with the help of SPSS software. Qualitative data were analyzed using descriptions, narrations and interpretations.

1. Results and Discussion

This section provides the research results along with their discussion. In the first place, the nature of the link of the value chain of tomato in the study area will be presented. Then, profit distribution among actors of the value chain will be discussed. Thirdly, constraints and opportunities to commercialize tomato production in the study area will be illustrated.

* 1. Production/Business Facilities and Actors’ Decision

In this section, factors that at face value have relation with the efficiency of the value chain of tomato and the response of actors with respect to these factors will be presented.

* + 1. Farmland allocation by producers

At the production level, producer make decisions which may affect the nature of the value chain of a product. Among these, farmland allocation is one. Producers divide their farmland among alternative crops on the basis of their evaluative framework in making production decision. It was tried to determine the amount of farmland allocated

by producer for the production of tomato and a comparison was made between the total farmland size producers had and its proportion that was allocated for tomato production, Table 1.

Table 1. Farmland allocation for tomato production.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Type of | Obser | Mean | Std. | Std. | 95% | Confidence |
| farmland | ved |  | Deviatio | Error | Interval of the | |
|  |  |  | n | Mean | Lower | Upper |
| total land | 120 | 1.6115 | 1.68024 | 0.15338 | 0.78161  1.42860 |  |
| tomato land | 120 | .5064 | 0.62759 | 0.05729 |  |

Source: Own Survey result (2012).

Note: - \*\*\* statistically significant at 1% level.

One possible reason that could justify the lesser amount of farmland allocated to tomato crop could be the permanently occupied fragment of farmland that might be allotted to the "khaf crop which could be more preferred than tomato.

* + 1. Access to and ownership of water pump

Producers’ ability to efficiently utilize farmland contributes in improving profitability. To efficiently utilize farmland farmers who are engaged in the production of annual crops like tomato should be able to produce the maximum number of times possible in a year. Access to irrigation facilities play important role in this regard. The result obtained in relation to producers status to access and own water pump for irrigation is illustrated in Table 2 below.

Table 18. Producers access and ownership to water pump.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Status | Facility |  |  |  |
| Access to Water Pump\*\*\* | | Ownership of water pump\*\* | |
| Observed | Percent | Observed | Percent |
| Yes | 80 | 66.67 | 49 | 40.86 |
| No | 40 | 33.33 | 71 | 59.17 |
| Total | 120 | 100.0 | 120 | 100.0 |

Source: Own Survey result (2012).

Note: \*\*\*statistically significant a 1% level, \*\*statitically significant a 5% level.

* + 1. Production season

Given the condition of producers with regard to ownership and access to irrigation facilities like water pump, they tend to behave in some manner in relation to producing more than once in a year depending on the nature of the crop. Tomato is a crop which can be cultivated at least three times a year. Table 3 illustrates the result found in this regard.

Table 3. Number of times tomato is produce in a year.

|  |  |  |
| --- | --- | --- |
| Season of production\*\*\* | Observed | Percentage |
| One | 52 | 43.3 |
| Two | 47 | 39.2 |
| Three and above | 21 | 17.5 |
| Total | 120 | 100.0 |

Source: Own Survey result (2012).

Note: \*\*\*statistically significant a 1% level.

Even though almost all of the producers owned water pump; only less than 20% of them produce tomato three times a year. These contradictory results might reflect the priority that the "Khat" crop has in the study area. The mere ownership of water pump may not mean that it is as profitable to use pumps for tomato production as that for "khat".

* + 1. Post- harvest management issues

Among the factors that either encourage or discourage the commercialization of tomato production are the ways by which producers deal with the product after they harvest it. Since tomato is among the perishable crops, it needs careful post harvest management. Besides, the proportion of the produce that is marketed out can be an indicator for the tendency that the sector has for commercialization. In relation to these, sample producers were asked to crudely estimate the proportions of their produce that was consumed at household level, marketed out and wasted. These results are summarized in Table 4 below.

Table 4. Proportion of product marketed out by producers.

|  |  |  |  |
| --- | --- | --- | --- |
| Category | Proportion | Observed(N—120) | Percentage |
| marketed out\*\*\* | <25% | 5 | 4.17 |
|  | 25 - 75% | 6 | 5.0 |
|  | >75% | 109 | 90.8 |
| Consumed\*\*\* | <25% | 112 | 93.3 |
|  | 25 - 75% | 5 | 4.2 |
|  | >75% | 3 | 2.5 |
| Wasted\*\*\* | <25% | 112 | 93.3 |
|  | 25 - 75% | 5 | 4.2 |
|  | >75% | 3 | 2.5 |

*Source: Own Survey result (2012).*

Note: \*\*\*statistically significant at 1% level, N= Total number of observations in each category.

* + 1. Storage facility

In commercial agriculture, storage plays significant role for producers and other businessmen in the chain. In a market where the demand and price of a product vary frequently, access to storage facilities are basic requirements. The status of sample actors with regard to this important issue was assessed. The result found is shown in Table 5 below.

Table 5. Actors' access to adequate storage facility.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Actors |  |  |  |  |  |
| Presence of access to storage facility | Produces\*\*\*  (N=120) | | wholesalers  (N=17) | \*\* | Retailers\*\*\* | (N=25) |
|  | Observed | Percent | Observed | Percent | Observed | Percent |
| yes and it is enough | 5 | 4.2 | 5 | 29.4 | 0 | 0 |
| yes but not enough | 11 | 9.2 | 1 | 5.9 | 0 | 0 |
| no but I would need to | 104 | 86.6 | 11 | 64.7 | 25 | 100 |

Source: Own Survey result (2012)

Note: \*\*\* statistically significant at 1% level, \*\* statistically significant at 5% level, \*\*\*\* variable is constant.

* + 1. Value addition

Actors in a given value chain are assumed to perform something to add value on the product they handle in the chain. Variety selection, separation and grading and packaging, are some of the value addition processes that were considered in this study. Table 6 provides the response of sample actors on these activities of value addition.

Table 6. Value added by actors.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Actors |  |  |  |  |  |  |  |  |
|  | Produces (N= | | 120) | wholesalers (N= | | :17) | Retailers (N=25) | |  |
| value  addition | Respon  se | Ob  ser  ved | Perc  enta  ge | Respons  e | Ob  serv  ed | Perce  ntage | Respons  e | Obser  ved | Percen  tage |
| variety | Yes\*\*\* | 114 | 95.0 | Yes\*\*\* | 16 | 94.1 | Yes\* | 16 | 94.1 |
| selection | No | 6 | 5.0 | No | 1 | 5.9 | No | 9 | 5.9 |
| cleaning | Yes\*\*\* | 77 | 64.2 | Yes\*\*\*\* | 17 | 100.0 | Yes\*\*\*\* | 25 | 100.0 |
| produce | No | 43 | 35.8 | No | 0 | 0.0 | No | 0 | 0.0 |
| separatio | Yes\*\*\* | 107 | 89.2 | Yes\*\*\*\* | 17 | 100.0 | Yes\*\*\*\* | 25 | 100.0 |
| n and  grading | No | 13 | 10.8 | No | 0 | 0.0 | No | 0 | 0.0 |

Source: Own Survey result (2012).

Note:\* not statistically significant, \*\*\* statistically significant at 1 % level,\*\*\*\*variable is constant, chi- square test cannot be performed.

The above result shows that greater proportions of actors from all categories were involved in the indicated value addition activities. This might be an indicative of the notion that the actors have for the difference value makes in a market.

1. Variety selection

Value addition in the value chain of a given crop starts from the decision made on the variety of the crop to be cultivated. Producers add value on the crop through their decision of variety choice. The survey result in relation with this activity is given below in Table 7.

Table 7. Producers’ preference ranking to first rank tomato variety.

|  |  |  |
| --- | --- | --- |
| Variety\*\*\* | Observed | Percent |
| Kukurfa | 39 | 32.5 |
| Metehara | 26 | 21.7 |
| Roma vf | 24 | 20.0 |
| Areb | 22 | 18.3 |
| Others (Freng, Dedelo, Shashemene, Deilo, t-1) each contribute < 3%. | 9 | 7.5 |
| Total | 120 | 100.0 |

*Source: Own Survey result (2012).*

Note: \*\*\* statistically significant at 1% level.

1. Reason of variety choice

Among the activities, agricultural producers do in a value chain in the production of a crop is variety selection. A given variety was selected based on either some physical factors such as its availability or some other perceptual factors. Table 8 provides the reasons that producers have given for their preference of one variety over another.

Table 8. Reason given by tomato producer for tomato variety preference.

|  |  |  |
| --- | --- | --- |
| Reasons for variety of choice\*\*\* | Observed N | Percent |
| high demand | 45 | 37.5 |
| cheap production | 18 | 15.0 |
| easy seed availability | 10 | 8.3 |
| high seed quality availability | 8 | 6.7 |
| high yield | 39 | 32.5 |
| Total | 120 | 100.0 |

Source: Own Survey result (2012).

Note: \*\*\* statistically significant at 1% level.

The two most cited reasons (high demand and high yield) in variety selection were considered as indicative of the primary market orientation goal of producers in the production of tomato (Table 8). This result seems to coincide with the tendency of producers to market out greater proportion of the produce as indicated above in Table

4.

1. Motivational factors and actors behavior

Any of the conscious activities done by actor of the value chain of tomato is supposed to be motivated by some factors. Leaving alone the factors for which the actors might be unconscious, it deemed to be important to identify the other factors. On this basis the survey tried to get the response of respondents on this regard.

1. Importance attached with tomato value chain

One of the issue that might affect the behavior of actors in a given value chain was the degree of importance they attach with the produce compared with other competing alternatives. The importance that tomato value chain actors attached to tomato business was considered and presented in Table 9. In addition, Table 10 illustrated the rank that sampled tomato consumers give to the consumption of tomato in their diet.

Table 9. Importance of tomato business as perceived by actors.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | actors | |  |  |
| Level | Produces\* | (N=120) | wholesalers  (N=17) | \*\*\* | Retailers\* | (N=25) |
|  | Observed | Percent | Observed | Percent | Observed | Percent |
| most important | 59 | 49.2 | 12 | 70.6 | 9 | 36.0 |
| among the most important ones | 61 | 50.8 | 4 | 23.5 | 16 | 64.0 |
| not that important | 0 | 3.3 | 1 | 5.9 | 0 | 0 |

Source: Own Survey result (2012).

Note:\*\*\* statistically Significant at 1% level, \*\* statistically Significant at 5% level, \* not statistically significant.

The result shown above (Table 9) could not say conclusively that producers and retailers considered the chain of tomato as the most important or among the most important. The likely reason for this was that that producers may be compelled by the popularity and profitability of "Khat" whereas retailers, as they are involved in the retailing of diversified items, may have other comparable alternative like onion, for instance.

Table 10. Rank of tomato consumption compared with other vegetables as ranked by consumers.

|  |  |  |
| --- | --- | --- |
| Rank given\*\*\*\* | Observed | Percent |
| First | 24 | 96.0 |
| Second | 1 | 4.0 |
| Total | 25 | 100.0 |

Source: Own survey result (2012).

Note: \*\*\* statistically significant at 1% level.

1. Price satisfaction

It is believed that price plays an important role in determining the amount of product that producers are willing to bring to the market. Hence, the satisfaction that different actors get from the price of the produce they provide to customers at different level is among the motivational factors that influence the behavior of actors in the value chain of the product. The survey result of this motivational factor is illustrated in Table 11 below.

Table 11. Price satisfaction in selling as perceived by actors.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | actors |  |  |  |  |  |
| Price satisfaction | Produces\*\*\*  (N=120) | | wholesalers  (N=17) | \*\*\* | Retailers\* | (N=25) |
|  | Observed | Percent | Observed | Percent | Observed | Percent |
| Satisfied | 32 | 26.7 | 15 | 88.2 | 13 | 52.0 |
| Unsatisfied | 88 | 73.3 | 2 | 11.8 | 12 | 48.0 |

Source: own survey result (2012).

Note: \*\*\* statistically significant at 1% level, \* not statistically significant.

As it is evidenced by the result shown in the above table, the majority of producers were unsatisfied by the market price with which they trade tomato. One probable reason for this may be the inability of these producers to find a place in the market where they can store the produce. In this condition unless they are willing to sell with the price they are offered, it may be difficult to take it back home what they bring to market place. But bringing it back home may be another worse decision because they have to pay for transportation again.

1. Transportation

Transportation is among the backup services that support a value chain of tomato in the study area. Producers opt to use among the available transportation means to the chain. In this study, respondents were inquired regarding the transportation means they use. The survey result of this is summarized in Table 12 below.

Table 12. Usage of transportation means by producers.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Use | Transportation means | | |  |  |  |
| Animals\*\*\* | | Human labor\*\*\* | | Vehicle\*\*\* |  |
| Observed | Percent | Observed | Percent | Observed | Percent |
| Yes | 2 | 1.7 | 29 | 24.2 | 110 | 91.7 |
| No | 118 | 98.3 | 91 | 75.8 | 10 | 8.3 |
| Total | 120 | 100 | 120 | 100.0 | 120 | 100.0 |

Source: own survey result (2012).

Note: \*\*\* statistically significant at 1% level.

What the result tells is that more than 90% of producers were able to access vehicle transport facilities. This situation is very conducive to strengthen the value chain if other drawbacks can be tackled properly.

1. Actors’ Linkage

One of the characteristic features of a value chain is the kind and nature of the link that exists between actors. In this study, producers, wholesalers, retailer, broker and consumers have been found to be the main actors for examining the link. The kind and nature of the link were treated from the perspective of each actor’s preference of actors for business interaction, presence of multidirectional link among actors, and actor’s location preference.

1. Linkage pattern among actors

In a given chain, actors may have their own preference with which actor to be linked. The actor may prefer to get linked with one, two or more actors in the chain for some personal or interpersonal reasons. Here in this study the survey result indicated the presence of multiple ways of linkage between actors as shown in Table 13 below.

Table 119. Actors business contact linkage matrix.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Actors | Producers | Wholesalers | retailers | consumers | brokers |
| Producers | - | \* | \* | \* | \* |
| Wholesalers | \* | \* | \* | \* | \* |
| Retailers | \* | \* | \* | \* | \* |
| Consumers | \* | \* | \* | - | - |
| Brokers | \* | \* | \* | - | No |
|  |  |  |  |  | information |

Source: own survey result (2012).

\* indicates presence of business interaction among actors.

Even though actors seem to be linked with every other actor in the chain, it does not mean that the strength of those links are the same as measured by the ranking made by

the respective actor to their most preferred actor in the chain. Linkages among actors of the value chain are characterized by different forms of business interactions they make with other actors. As has been shown in Table 13 above, the linkage matrix tells that there exists multidirectional linkage among actors. This means that a given actor is interacting with remaining other and/or actors of same category with or without the need for other actors’ mediation. Hence, producers can directly sell their products either to consumers, retailer, and/or wholesalers independently. Though that is truly visible from the result of the survey, the same also tells that there is difference in the weights of preference actors attach with other actors. This is clearly shown in the ranking made by each actor to the most important actors for them in the chain.

The information presented on Table 14 and Table 15 illustrate the ranking made by producers and wholesalers to their customers and wholesalers and retailers’ preferred tomato providers, respectively. Table 16 shows location preferences of wholesalers for collecting tomato. Lastly, consumers’ preference ranking of market fragment, wholesale or retail, and criteria of choice in selecting tomato sellers were depicted in Table 17 and Table 18.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table 14. Preference ranking made by actors to tomato. | | | their respective | customers in selling |
| Preferred customer | Actors |  |  |  |
| Producers\*\*\* (N=120) | | Wholesaler | \*\*\*(N=17) |
| Observed | Percent | Observed | Percent |
| Consumer | 30 | 25.0 | 4 | 23.5 |
| Retailers | 55 | 45.8 | 6 | 35.3 |
| Brokers | 9 | 7.5 | 7 | 41.2 |
| Large suppliers | 26 | 21.7 | - | - |

Source: own survey result (2012).

Note: \*not statistically significant, \*\*\* statistically significant at 1 % level.

Producer put retailers as their first choice customers in the business interaction. Out of the total number of sample producers, around 46% of them indicated that choice while putting consumers and wholesaler in the second and third place leaving brokers as the least preferred actors in the chain. One plausible reason for producer to take brokers as the least preferred customer might be the low price offer brokers they make to producers as brokers are added in the supply chain and they should get their compensation by optionally reducing the price that producers get. Besides, the low operating cost that retailers may face which in turn enable them to make better price offer to producers could also be one likely reason for retailers to be most preferred by producers.

Table 15. Preference ranking made by actors to tomato providers in buying tomato.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Tomato Providers | Actors |  |  |  |
| Wholesaler\*\*\* | | Retailers\*\*\* | |
| Observed | Percent | Observed | Percent |
| Brokers | 16 | 94.1 | 23 | 92.0 |
| Large suppliers | 1 | 5.9 | 1 | 4.0 |
| Retailers | - | - | 1 | 4.0 |

Source: own survey result (2012).

Note: \*\*\* statistically significant at 1% level.

The other dimension with which linkage among actors were considered was the preference of actors to tomato providers. The result on this issue indicated that wholesalers depend on brokers to greater extent in procuring tomato. This is inferred from the fact that 94.1% of the wholesalers preferred brokers as their first rank tomato provider. Besides, wholesalers preferably procure from regions outside the study area which includes Adama, Bole, Meki and Ziway areas as responded by 88.2% of them. One likely reason for brokers’ domination might be due to producers’ dependence on brokers as producers lack bargaining skill and power with customers.

Table 16. Wholesalers' preference ranking of tomato buying location.

|  |  |  |
| --- | --- | --- |
| Buying location \*\*\* | Observed N | Percentage |
| within region | 2 | 11.8 |
| out of region | 15 | 88.2 |
| Total | 17 |  |

Source: own survey result (2012).

Note: \*\*\* statistically significant at 1% level.

The result found in the preference of wholesalers to tomato providers demonstrated one big problem reflecting the presence of a weak linkage between producers and wholesalers found within the study area. But for the value chain under consideration, strengthening and improving the linkage between these two actors is mandatory. Among the indicated reasons by wholesalers for this weak linkage is the inability of producers within the study area to provide the commodity with the required quality and quantity. One likely reason for producers’ failure to do so might be the importance they attach with tomato production since they probably have “khaf production as a better and lucrative optional crop. One finding of this survey that goes in line with this likely assumption is that the proportion of farmland size that producers allocate for the production of tomato. It is only around one third of the total farmland holding that is allocated for tomato production.

On the part of retailers, sample respondents preferred brokers as their first rank tomato providers with 92% of sample retailers showing their preference to brokers as their first rank tomato providers. Wholesalers and other retailers are all ranked second.

Table 17. Consumers ranking of fragment of market in buying tomato.

|  |  |  |
| --- | --- | --- |
| Market fragment\* | Observed N | Percentage |
| wholesale market | 11 | 12.5 |
| retail market | 14 | 12.5 |
| Total | 25 |  |

Source: own survey result (2012). Notice: \* not statistically significant.

Actor preference of customers in buying tomato was treated differently for some technical reasons. Instead of mentioning actors specifically, choices were provided as wholesale and retail market. This was because of the technical reason that consumers may not have the exact information to recognize produces from other retailers acting in the market. On the basis of this, sample consumers were found to be indifferent in getting the produce whether it is from the wholesale or retail market. Nevertheless, the reason they mention to go to either of the markets seem to be statistically different with 76% of the respondents saying quality as the main driving factor to the choice they make and the remaining 24% of them mentioned cheap price as the driving factor.

Table 18. Criteria used by consumers to select tomato sellers.

|  |  |  |
| --- | --- | --- |
| Criteria\*\*\* | Observed N | Percentage |
| quality of product provided | 19 | 76.0 |
| cheap price | 6 | 24.0 |
| Total | 25 | 100.0 |

Source: own survey result (2012).

Notice: \*\*\* result is statistically significant at 1% level.

1. Price setting

Price setting can be considered as one of the ways by which the linkage among actors of the value chain can be characterized. Along with price setting, actors may have different feeling towards the price set. The following tables, Table 19, and 20, display the response of actors on price setting when selling and buying tomato, respectively.

Table 19. Price setting when selling as perceived by actors.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Actors |  |  |  |  |  |
|  | Producers' | \*\*\*(N—120) | Wholesalers\*\*\* (N—17) | | Retailers\*\*\* | (N—25) |
| who set price | Observed | Percent | Observed | Percent | Observed | Percent |
| Me | 22 | 18.3 | 14 | 82.4 | 20 | 80.0 |
| Buyer | 35 | 29.2 | - | - | - | - |
| Bargaining | 58 | 48.3 | 3 | 17.6 | 20 | 80.0 |
| market  condition | 5 | 4.2 | - | - | - | - |

Source: own survey result (2012).

Note: \*\*\* statistically significant at 1% level.

Price setting is one of the most important factors which determine the nature of a given market. The results found in this survey shows that the majority (48.3%) of producers mentioned bargaining as the main role playing factor in price setting when selling the commodity. Lesser proportions of wholesalers (17.6%) and retailers (20.0%) mentioned it as a main factor in price setting. Greater proportions of the later two actors said that they set price without the influence of other parties in the deal. The likely reason for most producers in the study area to have the option of bargaining rather than simply delivering their produce to customers at a specified price might be that they have the choice of selling to wholesalers, retailers, brokers and consumers as well in the same market place.

Table 20. Price setting when buying as perceived by actors.

Actors

Wholesaler\*\* Retailers\*\*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| who set price | Observed | Percent | Observed | Percent |
| Seller | 13 | 76.5 | 18 | 72.0 |
| Bargaining | 4 | 23.5 | 7 | 28.0 |
| Source: own survey result (2012). | | | | |

*Note: \*\* statistically significant at 5% level.*

On the contrary, the opposite happens when both parties, retailers and wholesalers, buy the commodity. In that case greater proportion of wholesalers (76.5%) and retailers (72.0%) indicated that the power to set price is of the providers. In this case this may happen as brokers have the tendency of hiding information from other parties for the sake of manipulating prices as they want.

1. Benefit Distribution and Marketing Margins

There might be different ways to be employed to understand the nature of benefit distribution taking place among actors of value chain. Among them are profit distribution and marketing margin. This part, therefore, makes use of these two mechanism for presenting and discussing the result.

1. Profit distribution

The Profit that sampled actors gained in the production and/or marketing of tomato was compared in such a way that it is possible to weigh it against the cost incurred by each actor. To create a clear picture of this, the mean profit earned by each actor as percentage of the mean total cost incurred by the respective actor was calculated as shown in Table 23 below. This helps the comparison of the proportionate benefits earned by the actors.

Table 20. Comparison of the mean profit as percentage of total cost between actors.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Compared Category | N | Mean  Profit | Std. Deviation | Std. Error Mean |
| Producer\*\* | 120 | 82.6807 | 234.37416 | 21.39534 |
| wholesaler | 17 | 35.2200 | 26.65108 | 6.46384 |
| wholesaler\*\* | 17 | 35.2200 | 26.65108 | 6.46384 |
| Retailer | 25 | 44.2556 | 24.83129 | 4.96626 |
| Producer\*\* | 120 | 82.6807 | 234.37416 | 21.39534 |
| Retailer | 25 | 44.2556 | 24.83129 | 4.96626 |

Source: own survey result (2012).

Note: \*\* statistically significant at 5% level.

Producers seem to gain profit which is greater in percentage (82.68%) of the cost they incur. On the other hand, wholesalers and retailers gain 35.22% and 44.26 %, respectively. But this may not mean the money gains exactly corresponds the percentages indicated here since the percentage also depends on the amount of cost incurred. (Refer Table 27).

1. Marketing margins

In addition to the above information given on the profit distribution among the actor of tomato value chain, Table 24 provides the nature of marketing margin in the chain.

Table 22. Marketing Margins

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Mean  selling  price | Marketing margin | | |  |  |  |  |  |
| Actors | When | the | When | the | When | the | When | the |
| link is | “A” | link is | “B” | link is | “C” | link is | —D” |
|  | type |  | type |  | type |  | type |  |
| Producer | 7.09 | 0 |  | 35.37 |  | 48.40 |  | 48.40 |  |
| Whole-  seller | 10.97 | - |  | - |  | - |  | 20.16 |  |
| Retailer | 13.74 | - |  | - |  | - |  | - |  |
| Consumers | 10.95 | - |  | - |  | - |  | - |  |

Source: Own survey (2012).

Note: “A” type link: Producer -^Consumer

“B” type link: Producer Wholesaler ^Consumer

“C” type link: Producer 'Retailer Consumer

“D” type link: Producer 'Wholesaler 'Retailer Consumer

The marketing margins of producers and wholesaler were calculated using data of the survey. The marketing margins were calculated considering all the possible ways by which the product can reach the final consumers. The results showed that there is money spent for marketing function which could possibly be earned by producer. But the decision to be made out of this result requires further research and careful analysis since marketing function has its own cost and there are efficiency issues that might be achieved through division of labor.

1. Constraints and Opportunities for Commercializing the Chain

Actors from different category ranked the constraints they experienced in undertaking tomato business. Producers mentioned disease/pest problems, poor access to irrigation and poor storage facility as the first with 45.0% vote, second with 19.2% vote, and third with 10.0% vote. Retailers on the other hand cited rotting, lack of area in the market, pressure from authority and lack of access to credit to be the top prioritized business constraints on equal basis. On the third place wholesalers put rotting and quality related problems, lack of space and access to credit and running cost to be the equally ranked business constraints they confront.

Proceedings of the 33rd Annual Research Review Workshop, April 21-23, 2016 Table 23. First rank constraints in the value chain as perceived by Actors

|  |  |  |  |
| --- | --- | --- | --- |
| Actors | Production constraints | Observed  N | Percent |
| Producers\*\*\* | Disease/pest | 54 | 45.0 |
|  | Poor access to irrigation | 23 | 19.2 |
|  | Poor storage | 12 | 10.0 |
|  | Others (Absence of market place, Poor access to high quality seeds, Poor access to credit, Poor access to transportation, Poor labor availability, Shortage of technical knowledge and skill, Shortage of labor, Shortage of land, Poor access to information) each contribute less than 8% to this category. | 11 | 25.8 |
|  | Total | 120 | 100.0 |
| Retailers\* | Rotting | 2 | 8.0 |
|  | Lack of space | 8 | 32.0 |
|  | Access to credit | 7 | 28.0 |
|  | Pressure from authority | 8 | 32.0 |
|  | Total | 25 | 100.0 |
| Wholesalers\* | Rotting and quality related | 7 | 41.2 |
|  | Lack of space | 7 | 41.2 |
|  | Running cost and access to credit | 3 | 17.6 |
|  | Total | 17 | 100.0 |

Source: own survey result (2012).

Note: \*\*\* statistically significant at 1% level,\* not statistically significant.

Price satisfaction of sellers is also a concern in sustaining a given chain. Here in this study, the result indicated that 73.3% of the producers were unsatisfied with the price of tomato they transact. On the other side, 88.2% of wholesalers said they are in general satisfied with the price in the marketing of tomato while the satisfaction level of retailers remained indeterminate. It should be noted that the starting point of the chain are producers. Therefore, the existence of the chain will be in question if this segment of the chain cannot be benefited. Hence, this situation should be taken as one of the challenges of an effort directed at commercializing the value chain of tomato in the study area.

The chain under consideration is not characterized only by the constraints rather there are also opportunities for commercialization. Concerning the weight consumers put on price and quality of tomato, 96.0% of them prefer quality to be the most important attribute which is indicative of the presence of market environment conducive to commercialize the sector since quality improvement is one of the ways by which we add value on a product.

Table 24. Weight consumers give to price and quality of tomato.

|  |  |  |  |
| --- | --- | --- | --- |
| Most important  Product\*\*\* | of Observed N | Percentage | cumulative percentage |
| Price | 1 | 4.0 | 4.0 |
| Quality | 24 | 96.0 | 100.0 |
| Total | 25 |  |  |

Source: own survey result (2012).

Note: \*\*\* statistically significant at 1% level.

Consumers’ preference in any of the features of a given product might be taken as starting point for the value addition function of entrepreneurs. Hence, the identification of those features can play a role in the efforts made to commercialize the production of tomato. The weights consumers attach with what they perceived as quality, the preference they give to quality and price and the extent to which they are able to manage purchasing the amount of tomato they need during low supply season were examined and presented in Table 27, Table 28 and Table 29 below.

Table 25. Consumers reaction to cheaper price of tomato.

|  |  |  |
| --- | --- | --- |
| Buy more if cheaper | Observed N | Percentage |
| yes, if good in quality | 14 | 56.0 |
| yes, regardless of quality | 2 | 8.0 |
| no, what I buy now is enough | 9 | 36.0 |
| Total | 25 | 100.0 |

Source: Own survey (2012).

Note: \*\* statistically significant at 5% level.

If it is somehow possible to implement a production technology that decreases production cost which increases production and improves quality, then the market may have absorptive capacity to the increased product with cheaper price. This is because 56.0% of the sample consumers were willing to increase purchase of tomato if they are cheaper and good in quality as well. Moreover, the commercialization of the sector could be backed up by the inability of the current market condition to satisfy the demand of consumers during low supply seasons since 92.0% of the sample consumers were not able to either partially or completely manage to get what they demanded during the season.

Table 26. Consumers ability to purchase the amount they need during low supply season.

|  |  |  |
| --- | --- | --- |
| manage to purchase during off­season | Observed N | Percentage |
| Yes | 2 | 8.0 |
| yes, but less than in the season | 20 | 80.0 |
| No | 3 | 12.0 |
| Total | 25 | 100.0 |

Source: Own survey (2012).

Note: \* statistically significant at 1% level

1. Conclusion

In the value chain of tomato, actors are found to be linked in multiple manners. A given actors can be linked with any other actors in the chain. Linkages among actors do not have the same strength as the strength of the linkage producers’ form with wholesalers and consumers might be different as measured by the percentage of producers who preferred any one of the two actors as the most important for them. The most important actors found in the value chain of tomato under consideration are Producers, wholesalers, retailers and brokers. The linkage between producers and wholesalers in the study area is found to be weak since wholesalers prefer to get the commodity from areas outside of the region.

In general, the three actors involved in the production or marketing of tomato seem to benefit from the chain as the benefit they get is measured in terms of the profit as percentage of the total cost they incur in the production or marketing of tomato. Producers get the greatest percentage followed by retailer while wholesalers earning the lowest percentage. But this may not be indicative of the amount of the real amount of money the actors earned since the percentage depends on the cost they incur.

In addition, there is money spent by consumers as marketing margins. The marketing margins depend on the kind of link established in delivering tomato to consumers.

The value chain has both constraints and opportunities to commercialize it. Some f the constraints are disease/pest, lack of area in the market and rotting and quality related problems are mentioned by the actors. Despite the constraints, the chain has many opportunities which could be utilized to commercialize it. These opportunities emanate from different corners, for instance consumers want to increase the purchase quantity if quality improved and price decreased. Most producers cultivate tomato more than once in a year. Besides, the market has additional absorptive capacity since it cannot satisfy consumers demand during low supply season.

1. Recommendation

The following recommendations were made based on the findings of the study.

♦ Although it is possible to speculate probable reasons for the presence of linkage gap among producers and wholesalers, speculation is not enough. Therefore it will

be necessary to conduct additional researches which deal with examining the proper reasons for this gap.

* Concerned bodies in the area should find a way by which produces can improve the quality of tomato they produce since quality is found to be a drive factor in choosing market segment by consumers.
* If there is an interest in improving the living condition of farmer producers, it will be necessary to improve their market power. Hence, necessary arrangement should be made to provide tomato producers with convenient selling location in Harar city in the absence of which they are forced to give their produce to either wholesalers or retailer or even consumers at a lesser price. One of the manageable ways to carry out this task could be through organizing tomato producer under producers cooperative and arrange a place in the central market where this producer can do their business.
* Concerned agricultural offices and research institution in the area should help producers through proposing workable solution for the problems of tomato disease/pest.
* The establishment of multi-location mini market in different places within the vicinity of dweller and provision of selling area to retailer could alleviate the pressure retailers have from the lack of area in the central market and the pressure they face from authority as a consequence of lack of area.
* Among the results found some urge the agricultural office in the area to find a technology that improves quality, reduce cost of production and increase production since an increased production with good quality and cheaper price can be taken up by consumers

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1. The Impact of Creativity and Innovation Based TVET Strategy on **Business** Performance of MSMEs in Eastern Ethiopia

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Abstract: The main purpose of this study was to analyze impact of creativity and innovation based TVET strategies on business performance of MSMEs in Dire Dawa, Harar and Jigjiga. The study used mixed research design whereby confirmatory approach of quantitative research embeds exploratory techniques. The data were mainly collected from randomly selected 146 MSMEs, which currently engage 960 employees in manufacturing, construction and urban agriculture sectors. Descriptive statistics, propensity score matching and causal inference econometrics models were used to analyse the quantitative data. The study hence found that creativity and innovation strategies are partially harnessed in the day- to-day business practices of trained MSMEs. Insignificant differences were observed between trained and untrained MSMEs in creative thinking, motivation, innovative practices and searching for innovative opportunities. The role of trainings in improving the practice and orientation of MSMEs to innovation had minimal level of significance. Analysis of business performance revealed that MSMEs’ growth in the amount of capital and asset gained was better, but the employment rate did not grow as per the rate of capital maximization. Correlation and regression analyses results showed that the trainings offered to MSMEs significantly changed performance of MSMEs owned by TVET graduates whereas the effect of trainings on the performance of MSMEs operated by non-TVET graduates (who get short-term trainings only) was slightly significant as compared to untrained MSMEs. It was finally implied that sustaining creativity and innovation based training and education strategies to business performance in Ethiopia has to be prioritized in individual, regional and national practice of enterprise development and transformation to industrialization.

Keywords: Creativity; Innovation; TVET; TVET strategy; Business

performance

1. Introduction

Business organizations undergo incessant changes as obsolete ideas fade and inventive ones profuse. New technologies and business ideas are diffused and adopted following worldwide access to information and advancement in creative and innovative behavior (Heinonen, Hytti and Stenholm, 2011; Jack and Anderson, 1999; Martins and Martins 2002). Unlike competitive companies which strive to maintain innovative culture, uncompetitive ones just stagger to cope up with inventive competitors in the global economic system and to reduce poverty and unemployment (European Commission Directorate-General for Research [ECDGR], 2007). To maintain economic competitiveness, countries are formulating policies and organizing, for example, Micro Small and Medium scale enterprises(MSMEs) which can maintain economic progress and citizens’ engagement in various sectors (Asmelash, 2002). According to European Commission (EC) (1995), renewing and enlarging the range of products and services and establishing new methods of production, marketing, working conditions and skills of the workforce are taken as considerable issues to promote MSMEs so that strategies are formulated to harness creativity and innovation based training and education, particularly in the TVET system.

Ethiopia is particularly striving to transform structure of the economy and reach middle income level by 2015(Ministry of Finance and Economic Development [MoFED], 2010). The plan to realize pillar transformational goals targets sustaining an industry lead economic system whereby large regional and national firms could be established stepwise. Escalating the manufacturing sector has been selected as policy prior agendum. This demands the massification and qualification of entrepreneurs who could own and operate micro small and medium scale enterprises [MSMEs] in the area. The fundamental task in such transformation encompasses upgrading the business performance of MSMEs (Ethiopian Science and Technology Innovation Agency [ESTIA], 2006). The achievement of MSMEs entails that 1.5 million job opportunities were created, 4 billion loan was provided and 5000 trained professionals and workers have been providing services in 825 one center services so that1.2 million beneficiaries(FSMEDA; 2011). There are, for example, about 1153 MSMEs officially registered and engaged in various sectors in Dire Dawa, Harari and Jigjiga between 1988-2014. Considering the contribution of MSMEs in this regard, recent organizational and structural modifications have been made to address the shortcomings of MSMEs. The TVET system is reorganized to capacitate enterprises as a center of training, adoption and technology transfer (FSMEDA, 2011). The Industrial Extension Service sections of TVET institutions are mandated to facilitate and implement various support ventures in collaboration with local and regional MSMEs Agencies. With this intent, TVET institutions organized creativity, technical skill, entrepreneurship, technology adaptation and kaizen trainings to build internal capacity by enhancing MSMEs’ creativity, innovativeness and performance. Institutes established with these intents graduated mid-level professionals persevering to establish their own business and many

MSMEs are established from this perspective. Assessing their contemporary status and capacitating MSMEs with creative and innovative strategies is hence recommended to be part of the research agenda in the country’s development arena (Lawson and Samson, 2001; Federal SME Development Agency [FSMEDA], 2011).

However, many MSMEs which are operated by trained and untrained entrepreneurs are closed and the rest are bankrupted due to internal and external determinants (Lawson and Samson, 2001). Experience also revealed that the organizational culture, creativity and innovative strategies needed for change are not developed as to the contemporary global competition. Learning-to-learn these strategies of innovativeness, however, need to become more and more important to the development of emerging MSMEs owned by trained and untrained ones (Lawson and Samson, 2001). It is mostly observable that the living condition of considerable operators is for subsistence, and little innovative products and services are discovered. Following this, the performance of enterprises undergoes declination as the practice and the different support schemes and alliance failed to harness creativity and innovative strategies. Their status of creativity and innovation to reform their business and improve performance is also inconsiderable; hence, the business leads the entrepreneur not vice versa. This is contrary to what Higgins (1995:34) justifies; “If firms are to survive and prosper in the 21st century, they must assess their innovative capabilities and take strategic action to improve their innovation skills”. The business may, in general, stagnate as it lacks frequent transformation. The exposure we have to different MSMEs in the region helped us to closely investigate the existence of incompatible practice and gaps between the ideal policy and the reality.

This study is, therefore, aimed to assess the extent to which-creativity and innovation practices were harnessed in trainings offered and practice implemented by trained MSMEs. Investigating performance differences among trained and untrained MSMEs was also prioritized. This would contribute to assess the role of creativity and innovation based trainings in supporting MSMEs. Analyzing the extent to which creativity and innovation based trainings impacted the business performance of MSMEs was also pertinent to draw policy implications on how harnessing creativity and innovation based training and education sustains improved business performance and industrialization in Ethiopia.

1. Research Methodology

The Eastern part of rural Ethiopia is generally known for its cash crop production, predominantly khat and coffee whereas service, trade and manufacturing businesses are engines to the urban economic system. There are three regions located in this socio­economic zone which have geopolitically and economically interlocked capitals: Dire Dawa, Harar and Jigjiga. Dire Dawa is an industrial center and home to several [markets.](https://en.wikipedia.org/wiki/Market_%28place%29) Harar has been a major commercial center, linked by the trade routes with the rest of Ethiopia. Jigjigais located on the main road between Harar and the Somalia city of [Hargeisa.](https://en.wikipedia.org/wiki/Hargeisa) The livelihood of most urban dwellers in the three regional cities is trade, manufacturing, service, construction and urban agriculture. The profile documents from the three cities roughly [as few problems of documentation may affect the number] shows 502, 385 and 266 MSMEs were formally established by regional MSMEs Agencies between 1988-2014 fiscal years in Dire Dawa, Harar and Jigjiga, respectively.

The study made use of mixed research approach and multistage sampling which used random and non-random techniques. To properly address the objectives of the study, 146 enterprises engaged in manufacturing, construction and urban agriculture were randomly selected. Close ended questionnaire was designed and administered to trained and untrained MSMEs so as to generate data concerning MSMEs’s state of harnessing creativity and innovation strategies in their business development practices. The role of creativity and innovation strategies acquired from trainings and experience were the focal point. The business performance of MSMEs in line with the categories of capital growth, level of transformation and number of employees since the establishment of enterprises was assessed. Qualitative data were also collected from experts working with MSMES offices, and industry extension service experts in TVET institutions were purposively selected for FGD and interview. Few trained and untrained operators were conveniently selected for FGD, interview, and their enterprises were observed.

The data collected from trained and untrained MSMEs operators through questionnaire were comparatively analyzed using descriptive statistics to verify if trainings have brought about significant differences in harnessing creative and innovative practices and orientations. The effect of trainings offered to MSMEs on their creativity, innovation and business performance was analyzed by adopting propensity score matching model. Causal inference econometric model was employed to assess the impact of these support ventures. The data from the interview, FGD and field observation were qualitatively analyzed using phenomenological analysis.

1. Result and Discussion
   1. Background of MSMES

The study encompassed 146 MSMEs which had 769 employees during establishment and 960 employees currently. The operators’ education, training and experience affect the practice of harnessing creativity and innovation within enterprises. Most enterprises were managed by individuals whose education level is below grade 11. A few TVET graduates were engaged in manufacturing, construction and urban agriculture priority areas, most of them (69.18%) are also private owned and a few (22.60%) were operated by cooperatives and in shares.Majority of the operators (54.8%) in each type of enterprise were high school graduates. This indicates that large proportion of the enterprises is not managed by trained individuals unless they do have short term trainings after they own the business. Based on the data collected from respondent, 58.22% of the MSMEs operators took either short-term or TVET type training, and more than 58% of those who participate in the training replied that the trainings were important for their business performance and to get additional knowledge. Significant number (64%) of the trainees replied as the trainings offered help them to develop their new idea generation capacity.

Table 1. Educational status of trained and untrained respondent.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Number | of Educational status of respondent | | | |  | Harar | Dire | Jigjiga |
| SMES | 1-4 | 5-8 | 9-10 | 11-12 Level 1-4 | Degree |  | Dawa |  |
| Trained | 4 | 16 | 28 | 16 18 | 3 | 31 | 45 | 9 |
| Untrained | 8 | 14 | 27 | 9 3 | 0 | 9 | 9 | 43 |

*Source: Own data collected in 2015.*

According to the result from Table 1, increment in MSMEs’ education and training exposure has positive effect on getting access to trainings. The attempt of training MSMEs by TVET institutions dictates students [who joined TVET institutions] to specialize in government priority areas and be self-employees. TVETs also extend trainings to MSMEs who are non-graduate ones. Field observation, in-depth interview and FGD results depicted that Dire Dawa TVET institutes were found better in this support scheme as compared to the rest two. This shows that the MSMEs sampled in the study are at different condition of getting support scheme which in turn may imply their different performance status.

* 1. The State of Msmes’ Creativity Strategies Harnessed in their Practices

Creativity as one pivotal component in business performance has been determined based on the enterprises’ critical engagement in idea generation and the motive of MSMEs to realize creative thinking to solve problems for business transformation. MSMEs’ understanding about the product, process, marketing strategy and management of the business are integral components. Thus, creativity is predominantly assessed by considering the predictors of knowledge, creative thinking and motivation. MSMEs perceived that they had technical and practical knowledge about the process, product and marketing strategy needed to run their enterprises. The differences among trained and untrained MSMES imply that the trainings offered by TVET institutes had some contributions. The variations observed were, however, insignificant may be due to the trainings ineffectiveness and the contribution of MSMEs’ business experience in the practical engagement.

The psychosocial business model dictates motivation as one important attribute which predict creativity in business enterprises. Motivational problems towards creativity and innovation were also marked as pertinent challenges for the development of creativity in MSMEs. It is assumed that the contemporary TVET strategy to empower MSMEs’ creativity and innovation could be supplemented through training and experience sharing support schemes. Motivating MSMEs to better creativity and innovation has magnificent role to enterprise performance.

Intrinsic desire to the business that entrepreneurs are engaged has paramount contribution in the practice of generating novel ideas. The results revealed that 77.5 % of trained MSMEs had high intrinsic motive to work in the enterprise they were operating. Most untrained MSMEs (55.7%, 34) also had high motivation to engage themselves in the business. The majority of trained MSMEs (67.05 %) were highly synergistic to getmotivated in their business practices. Minimal number of untrained enterprises (47.5%) had also high synergistic motivation. Most of the trained MSMEs (67.05%) had high non-synergistic motives. The response from trained MSMEs depicted that they were synergistic to overcome challenges from the external business environment. Both groups had in general moderate level of intrinsic motive which helped them to bear the various challenges experienced in their day-to-day business practices, but still trained enterprises were better motivated as compared to untrained ones. This indicates that the trainings have impacts in motivating MSMEs for creativity and innovation. Some insignificant differences and greater extents of motivation in untrained MSMEs devalue the effectiveness of the training and/or may be influenced by other challenges.

Creativity is the cognitive account of the human mind, and it is knowledge instigated and motivation ignited through creative thinking. Alike the former two predictors, creative thinking could be shaped through training and experience. The role of trainings on MSMEs creative thinking was assessed and in most of the predictors there is significant difference between trained and untrained MSMEsin creative thinking at 1% and 5% asymptotic significant value in the practice of relating problems with solutions (0.049\*\*), persevering through difficult problems ( 0.026\*\*), stepping away from challenging situations and return with a fresh perspective (0.037\*\*), redefining problems effectively think insightfully( 0.010\*), thinking insightfully by distinguishing information( 0.014\*\*) and applying intellectual skills in everyday contexts to “sell” creative ideas( 0.009\*). This implies that the trainings had brought some differences in creative thinking which ignites creativity.

* 1. State of Harnessing Innovation Practices in Msmes

Harnessing inquisitive and adoptive innovative practices has to be built on existing experiences. It has therefore been taken as one magnificent dimension in the support scheme of MSMEs. According to Table 2, though trained MSMEs had better practice of modeling different creative works, it was suggestive to justify that the contribution of trainings for MSMEs had little

Table 2.MSMEs innovative practices

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Predictors of innovative practices in operating  MSMEs | Trained MSMEs | | | |  | Untrained MSMEs | | | | | Asym.Sig.  (2-side) |
| 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |  |
| Modeling creativity from others | 11 | 14 | 15 | 32 | 13 | 2 | 6 | 13 | 21 | 19 | 0.054 |
| Building self-efficacy for creativity | 8 | 11 | 12 | 36 | 18 | 1 | 3 | 17 | 22 | 18 | 0.031\* |
| Questioning assumptions and realities | 5 | 21 | 18 | 33 | 8 | 0 | 7 | 31 | 16 | 7 | 0.001\* |
| Defining and redefining problems | 5 | 21 | 16 | 31 | 12 | 0 | 8 | 23 | 24 | 6 | 0.023\* |
| Encouraging idea  generation | 5 | 15 | 16 | 34 | 15 | 3 | 3 | 23 | 20 | 12 | 0.040\* |
| Cross-fertilizing ideas | 5 | 16 | 19 | 35 | 9 | 1 | 5 | 23 | 21 | 11 | 0.076 |
| Allowing time for creative thinking | 8 | 14 | 25 | 28 | 10 | 5 | 3 | 21 | 19 | 13 | 0.165 |
| Instructing and assessing creativity | 18 | 13 | 19 | 26 | 9 | 2 | 4 | 17 | 24 | 14 | 0.004\* |
| Rewarding creative ideas and products | 11 | 15 | 22 | 24 | 13 | 5 | 6 | 19 | 20 | 11 | 0.559 |
| Encouraging sensible risks | 9 | 19 | 23 | 19 | 15 | 7 | 10 | 20 | 17 | 7 | 0.664 |
| Tolerating ambiguity | 7 | 23 | 22 | 22 | 11 | 0 | 10 | 23 | 21 | 7 | 0.053 |
| Allowing mistakes | 3 | 11 | 26 | 30 | 15 | 3 | 5 | 17 | 26 | 10 | 0.824 |
| Identifying and  surmounting obstacles | 6 | 12 | 31 | 24 | 12 | 2 | 8 | 19 | 22 | 10 | 0.725 |
| Using profiles of creative people | 6 | 13 | 24 | 27 | 15 | 5 | 22 | 16 | 8 | 10 | 0.020\* |
| Encouraging creative  collaboration | 5 | 13 | 26 | 26 | 15 | 3 | 15 | 14 | 20 | 9 | 0.618 |
| Growing creatively | 3 | 18 | 19 | 26 | 18 | 3 | 16 | 19 | 15 | 8 | 0.501 |

*Source: Data collected by the researchers, 2015*

Note: 1.Never; 2. Rarely; 3Sometime; 4. Mostly; and 5„Always

Significance (0.056) as compared to untrained MSMEs, Building self-efficacy for the essence of creativity has pivotal role for innovation and business performance. The trainings offered to MSMES had significant roles in this regard. The data in Table 2 signify that difference in developing self-efficacy(0.031), the practice of questioning assumptions and realities (0.001), defining and redefining problems (0.023), encouraging idea generation (0.040), using the profiles of creative people(0.020) and instructing and assessing creativity(0.004) for innovative behavior were significant at p-value of less than 0.05. The contribution of the trainings to enhance MSMES’ innovative practice were insignificantly improved at p-value less than 0.05 through trainings offered to MSMEs in other attributes of innovative practices.

The data collected and analyzed to assess the MSMEs’ practice in searching for new opportunities was strongly aligned with enterprises innovativeness. It was found that there were little differences observed between trained and untrained MSMEs in their practice of searching for opportunities in general. But trained MSMEs were better in searching for innovative opportunities for their day-to-day challenges. The result was by far significant (at p-value less than 0.05) in attributes related with considering unexpected events to improve their business(0.007), ignoring new opportunities that they were not useful (0.004), suffering from unexpected circumstance(0.002), practicing for incremental innovation(0.038), endeavoring for breakthrough innovations(0.024) and endorsing efforts for radical innovations(0.001). It is hence justified that trainings contribute a lot in most attributes of searching for innovative opportunities.

* 1. Type of Enterprise and their Capital as Performance Indicator

The performance analysis of enterprises showed the existence of better performance differences all of the sectors. Given this, MSMEs engaged in production sector registered the best percentage improvement in capital formation followed by those in urban agriculture sector.

Table 3. Change in initial capital level.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Capital level | <100 | 100 to 200 | 200 to 300 | 300  400 | to 400 500 | to >500 | Total  No |
| NoMSMEs  initial | 135 | 8 | 2 | 0 | 0 | 0 | 145 |
| NoMSMEs  Current | 63 | 36 | 16 | 7 | 8 | 16 | 146 |
| Percentage  initial | 93.10 | 5.52 | 1.38 | 0.00 | 0.00 | 19.59 | 100 |
| Percent.  Current | 43.15 | 24.66 | 10.96 | 4.79 | 5.48 | 10.96 | 100 |

*Source: Own conversion, 2015.*

NB: Capital level is in thousands.

Table 4 implies that there was greater performance improvement in MSMEs that may or may be sourced from creativity and motivation of the members. Following this, according to the response from MSMEs, the majority of MSMEs were at micro enterprise level in their initial establishment and none of them were at medium level. During the study period, more than half of them were in small and medium scale enterprise levels, which was a tremendous change in their performance. Transformation rate of MSMEs from micro to small scale level was better as compared to the other rate of transfer[some system subjectivity in labeling may influence this as there are contradictions with definitions at different contexts]. Some of the enterprises, especially those located in Harrar and Dire Dawa, were transferred from micro to medium level within this short period of operation.

The performance of MSMEs was measured by considering the change in employment level and change in their capital level. Though there were some outliers in the initial as

well as current capital level, on average, the 32,336.62 initial capital invested was grown to 364,481.20 in the three towns. There were 97.26% MSMEs that showed positive increment in their capital formation and the remaining showed no change and reduction. Given this, 10.27% of them registered a capital increment of more than half a million birr. From the samples considered 57.53% got support from government in the form of loan for working capital that may result into better improvement where more 98.81% of those gain support showed positive improvement in their capital formation.

Table 4. Performance in capital formation of MSMEs in the three towns

|  |  |  |  |
| --- | --- | --- | --- |
| Location | Average  capital | initial Average capital | current Percentage change |
| Dire Dawa | 17,158.07 | 653,319.40 | 3707.65 |
| Harar | 37,102.75 | 313,850.00 | 745.89 |
| Msa | 44,432.69 | 103,480.80 | 132.89 |
| Total | 32,897.84 | 356,883.40 | 984.82 |

*Source: Own conversion, 2015.*

Table 4 shows that MSMEs located in Dire Dawa recorded the best improvement in their working capital formation as compared to the other towns, having the lowest amount of establishment capital but significantly increased their working capital within short period of time. MSMEs located in Jigjiga started with large initial working capital but the improvement in their working capital was very low as compared to enterprises in other towns.

As MSMEs’ employment is one parameter of measuring performance of enterprises, the number of employees increased from 759 to 960 or [5.2 to 6.6 average rates]. Based on information from discussants, one reason for not having huge increment in their employment capacity was due to some challenges related to shortage of land, limited access to input and output market, and some attitudinal problems.

MSMEs involved in production sector showed better performance in increasing their working capital as compared to MSMEs participated in other type of businesses. Better performance was observed in MSMEs located in Dire Dawa in all type of business managed. MSMEs participated in construction business showed the least performance especially in Jigjiga. If one compares MSMEs located in Jigjiga and engage in any of the business with other towns, performance of the former ones was lower in each business type. Regarding employment rate, one can argue that there is improvement in the performance of MSMEs in Dire Dawa if one considers working capital improvement or labor employment level as parameter of measuring performance of MSMEs.

Table 5 shows that majority of MSMEs were operated by individuals who did not have high school level certificate. Qualified and TVET or university graduates were not operating their own business as only 1.1% of the samples was owned by degree holders. This is contrary to what is stipulated in the policy document (FSMEA, 2011). The strategic support schemes are aimed to qualify TVET and university graduates and engage them in operating MSMEs of their own.

The best capital improvement registered was operated by MSMEs whose education level was at second cycle followed by those who had TVET level education. Level of education-has inverse relationship with change in capital level of enterprises. Thus, skill of making money and collecting profit is not based on level of education rather it is related with experience and having due intimate with the business.

1. Role of Creativity and Innovation based Training Strategy on Performance of Msmes

The majority of MSMEs took either short term or TVET level training on creativity, entrepreneurship, kaizen, financial and administrative works in their business to help them acquire additional knowledge and expand their business. MSMEs operators had better technical knowledge and ability to integrate different ideas and strategies in their work. They had relatively lower managerial capacity to scientifically administer their organization. More than half of the MSMEs operators had moderate and enough technical knowledge that is acquired through experience.

According to Table 5, around 58% of enterprises managed by trained individuals changed their status from micro to the next levels, which showed that there was better performance change in those enterprises as compared to the other group where on- which only 48% shifted to the next echelon. The shift from micro level to medium was also relatively better, which implies better performance of enterprises managed by trained individuals than those owned by untrained ones. Similarly, enterprises that reached medium level were those run by either TVET graduates or those who had access to short-term trainings.

Table 5. Change in business status of MSME’s owned by TVET Trained and Untrained operators.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Initial | Status change | for trained SMEs |  | Status change | for untrained SMEs |  |  |
| level in % | Micro | Small Medium | Total | Micro | Small | Medium | Total |
| Micro | 32(41.56) | 27(35.06) 18(23.38) | 77(90.59) | 30(52.63) | 22(38.60) | 5(8.77) | 57(95) |
| Small | 0(0.00) | 3(37.50) 5(62.50) | 8(9.41) | 0(0.00) | 0(0.00) | 3(100) | 3(5) |
| Total | 32(37.65) | 30(35.29) 23(27.06) | 85(100) | 30(50) | 22(36.67) | 8(13.33) | 60(100) |

*NB: Values in parenthesis are percentages converted from each respective total.*

1. Correlation of Trainings and Motivation with Performance of Smes

Correlation analysis indicated that knowledge of the work, motivation, innovation and creativity had strong and positive association with the two prominent (current capital level and gain) parameters of measuring performance of enterprises. Initial labor employment level and being TVET graduate had insignificant correlation with performance parameters of MSMEs. Need-based and demand-driven short-term trainings had positive and significant correlation with current capital accumulation level and amount of gain. Hence getting either TVET type or short-term trainings had strong correlation with knowledge of work, motivation to work and creativity. Correlation test of education with indicators of performance revealed that education of high school and preparatory had significant and positive correlation with performance parameters of including current capital, gain and current labor employment level. Motivation of MSMEs owners had strong correlation with current time labour employment and capital accumulation. The initial labour employment decision of MSMEs had negative correlation with motivation, innovation and creativity. The capital accumulation level, which was one best parameter in measuring performance, showed strong and positive correlation with motivation, innovation and creativity of the business owners. Thus, trainings that would result into increment in motivation, innovation and creativity may result into improvement in the performance of MSMEs.

Performance of MSMEs that were managed by elementary and junior level graduate had no strong correlation with innovation and creativity of the labor force. The owner’s motivation had strong and positive correlation with capital accumulation that would measure the performance of MSMEs. Given this, the number of employed labor had positive and significant correlation at 10% level of significance. Current time capital accumulation of MSMEs, which were administered by high school and preparatory level of education, had strong and significant correlation with knowledge, motivation, innovation and creativity as well as current labour employment level. Like that of MSMEs whose level of education was elementary, capital accumulation had not significant and strong correlation with innovation, motivation and creativity in MSMEs operated by TVET graduates. Capital accumulation of TVET graduate had negative correlation with creativity and current time labour employment. Thus, it is implied that level of education is least associated with capital accumulation.

1. Model Result and Discussion

To avoid endogeneity of variables, the researchers considered separate analysis for knowledge as a determinant of performance. Such analysis of performance determinants revealed that some variables have positive and significant effect on the outcome variable. Based on the model results presented in Table 6, long years of experience had significant effect on improving MSMEs’ performance that means it would increase both working capital accumulation and/or gain from the business. Increment in experience of respondents by one year then there would be improvement in the working capital accumulation and gain by more than 50%.

Improvement in the creativity and motivation of MSMEs had significant and positive effects on working capital accumulation of enterprises. Increment in the creativity of the operators within MSMEs had most significant effect in improving working capital of enterprises as compared to other determinants. Given these, financial and working area problems had significant and negative effect on working capital accumulation and net gain of MSMEs in Easter Ethiopian towns. Working and displaying area were two critical problems in order to expand their work and to fully utilize their potential. Respondents indicated during focus group discussion that they were are-using the small working areas as a places to display and sell products, which was perceived as a serious problem to expand their business.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variables | Current capital accumulation | |  |  | Gain capital |  |  |  |
|  | Coefficie. | Robust Std. Err | t-value | P-value | Coefficie. | Robust  Err | Std. t-value | P-value |
| Initia\_capita | 0.2962 | 0.0481 | 6.16 | 0.000\* | 0.10563 | 0.0776 | 1.36 | 0.176 |
| Experience | 0.5434 | 0.1494 | 3.64 | 0.001\* | 0.5578 | 0.2386 | 2.34 | 0.021\*\* |
| Inital\_labor | -0.1824 | 0.1195 | -1.53 | 0.129 | -0.2443 | 0.1705 | -1.43 | 0.154 |
| creative | 1.1518 | 0.5268 | 2.19 | 0.031\*\* | 1.52547 | 0.8401 | 1.82 | 0.072\*\*\* |
| motivation | 0.8935 | 0.5274 | 1.69 | 0.093\*\*\* | 1.53642 | 1.1283 | 1.36 | 0.176 |
| innovative | 0.0422 | 0.4174 | 0.10 | 0.920 | 0.11137 | 0.5835 | 0.19 | 0.849 |
| Financial\_prob | -0.6077 | 0.2310 | -2.63 | 0.010\* | -0.6946 | 0.3493 | -1.99 | 0.049\*\* |
| Work\_area | -0.3209 | 0.2277 | -1.41 | 0.161 | -0.5289 | 0.3162 | -1.67 | 0.097\*\*\* |
| Input\_prob. | 0.19717 | 1.3861 | 0.83 | 0.410 | 0.07934 | 0.3844 | 0.21 | 0.837 |
| Admini\_prob. | 0.23003 | 0.1849 | 1.24 | 0.216 | 0.41984 | 0.2723 | 1.54 | 0.126 |
| Demand\_prob. | -0.2500 | 0.2157 | -1.16 | 0.248 | -0.31355 | 0.2773 | -1.13 | 0.260 |
| Sex | 0.15329 | 0.2865 | 0.54 | 0.594 | 0.50115 | 0.3886 | 1.29 | 0.199 |
| Constant Prob> F | 5.39794  0.0000 | 1.0427 | 5.18 | 0.000 | 4.7778  0.0000 | 1.3238 | 3.61 | 0.000 |

*Source: Model result in 2015.*

*\*, \*\* and \*\*\* implies 1, 5 and 10% level of significance.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variables | Creativity |  |  |  | Innovation |  | Std. t-value | P-value |
| Coefficie. | Robust  Err | Std. t-value | P-value | Coefficie. | Robust  Err |
| Experienc | 0.00644 | 0.02111 | 0.31 | 0.761 | -0.0076 | 0.0336 | -0.23 | 0.822 |
| Have\_train | 0.050410 | 0.0270 | 1.87 | 0.064\*\*\* | -0.0947 | 0.0446 | -2.13 | 0.035\*\* |
| knowldge | 0.79911 | 0.05879 | 13.59 | 0.000\* | 0.7810 | 0.0923 | 8.47 | 0.000\* |
| Inital\_labor | -0.02285 | 0.0138 | -1.66 | 0.100\*\*\* | -0.0717 | 0.0212 | -3.38 | 0.001\* |
| Initia\_capita | -0.01401 | 0.0077 | -1.81 | 0.072\*\*\* | 0.00286 | 0.0114 | 0.25 | 0.803 |
| Edu2 | 0.03083 | 0.0312 | 0.99 | 0.325 | 0.0911 | 0.04918 | 1.85 | 0.066\*\*\* |
| Edu4 | 0.062367 | 0.0348 | 1.79 | 0.075\*\*\* | -0.0134 | 0.05155 | -0.26 | 0.796 |
| Constant | 0.29227 | 0.1186 | 2.47 | 0.015\*\* | 0.35842 | 0.19124 | 1.87 | 0.063\*\*\* |
| Prob> F | 0.0000 |  |  |  | 0.0000 |  |  |  |
| R-squared | 0.6476 |  |  |  | 0.4409 |  |  |  |

*Source: Model result, 2015.*

*\*, \*\* and \*\*\* implies 1, 5 and 10% level of significance*

The regression models (Table 7) are strong enough in explaining variability of the dependent variables by variation of the explanatory ones. As to the model, results getting access to training of either TVET or short-term types would increase probability of being creative and innovative strongly. If operators of MSMEs got access to training their probability of being creative and innovative would increase strongly and this circumstance would directly result in improvement in enterprise their performance. In the same fashion, better knowledge of the work increases creativity and innovation by owners and/or managers of enterprises. Large initial labour as well as starting capital did not encourage creativity and innovation the enterprise as depicted in Table 6Similarly, completing second cycle education level had strong effect in innovation of MSMEs and performance of them.

Table 8 displays the results of three stage least square regression. Current time capital accumulation of MSMEs, creativity and innovation of enterprise operators were endogenous variables determined within the model. This model considered to take into account indirect effect of trainings on performance of SMEs. According to the result in this model, short-term training or TVET level training type had indirect effect on performance through creativity and innovation capacity of operators. According to Table 7 indicated that increment in working experience and having lager initial working capital had significant and positive effect on performance of enterprises. As to the coefficients of the two variables, the former one has stronger effect in changing the performance of MSMEs in the three towns. Given this, one of the endogenous variables, creativity, was considered as explanatory for enterprises’ performance which had significant and positive effect. This implies that all the factors that had significant effect on creativity also had an indirect effect on the performance of MSMEs through changing creativity within enterprises.

As presented in Table 8, motivation and knowledge level of owners or managers had significant effect on creativity and innovation within enterprise, and this condition would create conducive environment for expanding the performance of MSMEs. Creativity within MSMEs had strong relationship with being graduated from preparatory school—Similarly, TVET or short-term training had significant and positive effect on creativity. Effect of this co-factor on innovation capacity of SMEs is was in the opposite direction to creativity. This indicates that if the operators of MSMEs are well equipped and innovative enough in their work, then they would not be concerned about getting either short term or TVET type trainings.

Table 8. Three-stage least-squares regression.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Explanatory variables |  | Coefficient |  | Robust Std. Err. | | Z-value | P-value |  |
| initial\_labor |  | -0.19429 |  | 0.1039417 |  | -1.87 | 0.062\*\*\* |  |
| Experience |  | 0.48739 |  | 0.1495468 |  | 3.26 | 0.001\* |  |
| Initial capital |  | 0.308438 |  | 0.053582 |  | 5.76 | 0.000\* |  |
| innovative practice |  | -0.832957 |  | 0.8710115 |  | -0.96 | 0.339 |  |
| creative thinking |  | 2.741807 |  | 0.9983423 |  | 2.75 | 0.006\* |  |
| Financial problem |  | -0.595439 |  | 0.2007012 |  | -2.97 | 0.003\* |  |
| Work area problem |  | 0.318095 |  | 0.2204133 |  | 1.44 | 0.149 |  |
| Input problem |  | 0.176050 |  | 0.2109474 |  | 0.83 | 0.404 |  |
| Administr\_problem |  | 0.221889 |  | 0.1969369 |  | 1.13 | 0.260 |  |
| Demand\_proble |  | -0.312415 |  | 0.2096216 |  | -1.49 | 0.136 |  |
| Sex\_respondents |  | 0.134591 |  | 0.28956 |  | 0.46 | 0.642 |  |
| Constant |  | 5.80704 |  | 1.120547 |  | 5.18 | 0.000\* |  |
| Prob> chi2 |  | 0.0000 |  |  |  |  |  |  |
| Variables | Creative thinking |  |  |  | Innovative | practice |  |  |
|  | Coefficie. | Ro.Std. Err. | Z-value | P-value | Coefficie. | Ro. Std. Err. | Z-value | P-value |
| Have training | 0.048545 | 0.0243 | 2.00 | 0.045\*\* | -0.163133 | 0.035021 | -4.66 | 0.000\* |
| Motivate. | 0.18292 | 0.0762 | 2.40 | 0.016\*\* | 0.622949 | 0.110012 | 5.66 | 0.000\* |
| knowledge | 0.69364 | 0.0744 | 9.32 | 0.000\* | 0.413876 | 0.107441 | 3.85 | 0.000\* |
| Edu4 | 0.05557 | 0.0318 | 1.75 | 0.080\*\*\* | -0.013804 | 0.045722 | -0.30 | 0.763 |
| Constant | 0.05537 | 0.076 | 0.73 | 0.466 | -0.014039 | 0.10993 | -0.13 | 0.898 |
| Prob> chi2 | 0.0000 |  |  |  | Prob>chi2 | 0.0000 |  |  |

*Source: Model Result, 2015*

*NB: The above two tables are result of one model (three stage least square) and the second one is second and third stage of the regression for creativity and innovation with*

training

\*, \*\* and \*\*\* implies 1, 5 and 10% level of significance.

1. Training Effect

PSM can be calculated by considering the average gain or average performance measure of the trained and untrained MSMEs. The performance of MSMEs can be measured by considering net gain of enterprises in each category. The average treatment effect was 371648.90, that is, the difference between average net gains (487,422.50—115,773.60) in the two groups of MSMEs. The statistical test of the analysis of variance in the current time working capital available showed that there is statistically significant (f-value = 2.86) difference between the trained and untrained MSMEs. Absence of selection bias can be detected by considering the value of their performance in absence of treatment, here training. Thus, the difference between the two groups was small (below 7,000.00 i.e. 29,439.25—36,373.93) and statistically insignificant having f-value 0.53. The number of treatment cases should be considerably larger because the likelihood of finding very close matches increases with the number of control units (Rubin & Thomas, 1996).

Simple OLS regression of the performance indicator, capital accumulation, with the dummy variable that is access to training showed that average outcome for untreated units is 152,147.50 and average outcome for treated ones is 516,861.70 (364,714.20 + 152,147.50). The average outcome level of the treated ones indicate that the treatment is very critical because the expected average earning for treated is higher than for control. The propensity score that is the probability to be treated given observed characteristics of each observation X: E(X) = Pr(W = 1/X = x) = E[W/X = x\ for the whole observation is 0.58 that is a value more than 0.5, which indicated that majority of the observation got better probability of being treated. Given this, average probability of being trained based on the propensity score of each observation was 0.64. This means an observation had 0.64 probability of being trained having similar background with other observations that got the training of either short-term or TVET type. In the same fashion, the propensity score value calculated by the model showed that an observation having similar background with other observation had probability of 0.51 not being trained. Having this in mind, the propensity score calculation generated an outcome variable for every treatment observation that stores value of the matched outcome having an average level of 77,682.35 for only treated observations. There are maximum of 21 frequencies with which the observation is used as a match based on the weight output of the model. The Propensity score values of treated and non-treated observations result showed that majority of the untreated observation had propensity score value between 0.3 to 0.6 having high frequent probability of 0.4. Given this, high frequency of the treated ones showed probability of near to one as per the figure.

The balance between treatment and control group means equivalence of trained and non-trained SMEs on all the covariates considered in the regression. The t-stat value (Table 9) showed that participation in training had strong effect on capital accumulation of SMEs and there would be about 5% increment in capital accumulation because of participation in short term or TVET level of training.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | Sample | Treated | Controls | Difference | Sta.Err | T-  stat |
| Current capi | Unmatc | 516861.765 | 152147.541 | 364714.224 | 215577.838 | 1.69 |
| tal | hed  ATT | 516861.765 | 147588.235 | 369273.529 | 183169.732 | 2.02 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | Coefficient | Robust Std. Err. | Z-value | P-value |
| Own\_contribution | -0.0000129 | 0.0000123 | -1.05 | 0.294 |
| Expand\_business | 0.237013 | 0.6833322 | 0.35 | 0.729 |
| Status\_business | -0.0052224 | 0.1818198 | -0.03 | 0.977 |
| Edu2 | -0.2515112 | 0.3023746 | -0.83 | 0.406 |
| Age2 | -0.5422709 | 0.3352137 | -1.62 | 0.106 |
| Age3 | -0.1827076 | 0.2957633 | -0.62 | 0.537 |
| Total\_capita\_initial | 6.95e-06 | 0.0000123 | 0.57 | 0.571 |
| Experience | 0.1719622 | 0.1427107 | 1.20 | 0.228 |
| Experience2 | -0.0004474 | 0.0108868 | -0.04 | 0.967 |
| Input\_problem | 0.3592536 | 0.253015 | 1.42 | 0.156 |
| Capital\_Labour | 2.12e-06 | 1.17e-06 | 1.81 | 0.070 |
| Constant | -1.125829 | 0.819282 | -1.37 | 0.169 |
| Prob> chi2 | 0.0000 |  |  |  |

*Note: Treatment based on training either short-term or TVET.*

T-stat (Table 9) indicates what the unmatched/unadjusted values look like (i.e., comparison of all the unmatched to their nearest neighbour observation) and the value is smaller 1.96, which is the value at P-value = 0.05. Thus, there is not strong unmatched among the observations that have no match with the respective nearest neighbour. The t-stat value of average treatment effect on the treated only (ATT) indicated significance level of matching of observation with their corresponding nearest neighbour and this matching was significant at 5% level of significance since the value was greater than 1.96(equals p-value of 0.05). This value showed that the average treatment effect on the treated oneshad significant effect on the corresponding outcome. Here the t-test is higher than 1.96 suggesting there is statistically significant difference between matched treated and controls.

1. Conclusion and Recommendations

The results from these analyses leads to the conclusion conclude that there are differences in creativity, innovation and business performance between trained and untrained MSMEs in general. MSMEs were at better state of creativity and innovation practices during the study period in harnessing attributes that could be explained as improved expertise, high intrinsic motivation, better engagement in creative thinking practices, practical and strategic implementation of creativity and innovation strategies, and consistent perseverance in searching for opportunities due to trainings, especially TVET program level. It is also drawn that MSMEs’ business experience has significant contribution to harness these attributes of creativity and innovation. The existence of

insignificant differences in harnessing creativity and innovation practices among trained and untrained MSMEs implies that the trainings offered to MSMEs by different agents were not based on prefeasibility and need assessment.It is also implies that short-term or TVET trainings had indirect effect of performance through creativity and innovation capacity of enterprises operators. It was found that all the factors that had significant effect on creativity also had an indirect effect on performance of MSMEs through changing creativity within enterprises. MSMEs operators’ motivation and expertise had significant effect on creativity and innovation within enterprises, and this condition would create conducive environment for expanding performance of MSMEs, and being trained either in TVET or short-term trainings, has significant and positive effect on creativity. For those untrained MSMEs’ operators who were creative and innovative from experience, the effect of this co-factor on innovative capacity of MSMEs is in the opposite direction to creativity and performance changes.

Working and displaying area were two critical problems of the studied enterprises to expand their work and to fully utilize their potential. The insignificant performance differences between trained and untrained MSMEs implies that the challenges related to working and displaying land, shortage of finance and access to inputs and market networks downplay the positive effect of training support schemes offered by TVET industry extension service sectors. The balancing among matched observation after matching is strong if we consider TVET graduation alone as a parameter of treatment. This implies that there is very narrow gap in the capital accumulation of MSMEs that are owned by TVET graduate only. There is better balancing in the capital accumulation of trained (TVET graduate) observations after matching as compared with the treatment based on short-term and TVET level training. Consideration of short-term training and TVET graduation level as one parameter of interest for determining treated and non- treated group of observations results in lower balancing level after matching. Thus, researchers who are interested to have further study in this area should consider a strictly clear cut and similar type of parameter to categorize their treated and non-treated group of observations. There is difficulty of matching MSMEs that have access to short-term trainings with TVET graduate level, indicating that there should be provision of adequate training that would bring about excellence, parallel to the graduate level.

Trainings offered to MSMEs brought insignificant differences on the creative and innovative practices of trained and untrained enterprises due to trainings’ quality issues in addressing the attributes of creativity and innovation, and other outlier effect of land and finance related determinants. As these challenges are inevitable at any stage, working on the internal and synergistic capacity and persevering for change is demanding. The direction of TVET support venture is structurally prominent but the nature of the training should be shaped and contextualized to harness creativity and innovation orientations. Level of education has little contribution to business performance in the context of this study rather operators’ fertile experience, intrinsic motive and commitment should be focused on to cope up with everlasting challenges. The tripartite linkage between MSMEs Agency, MSMEs and TVET institutions is the right policy direction which should be strengthened to realize industrialization at local, regional and national levels.

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1. Interview with teachers, supervisors and school principals at Gumbi, Balo, Asebot, Gololcha, Brdoddee, Fayo, Hese Mandhera, Mieso, Waltane, Kurfa Sawa, and Qiqilftu indicates that school regulation is relaxed to entice, and to encourage more pastoral children to stay in school. [↑](#footnote-ref-2)
2. Classroom observation was effected at Bordodde as of 6 December 2012, and Gumbi and Gololcha as of 12 March 2013, and the school attendance was discouraging. [↑](#footnote-ref-3)
3. During classroom observation at Annanno on 4 December 2013, few schoolchildren were observed attending lesson in the classroom.

   Conspicuously, what can be concluded from Table 3 above is that less than 50% of enrolled children were able to complete the first cycle and less than 15% will endure to the end. As the school commenced in 2004/05, the total number of children enrolled was 181, of which only 45 (24.9%) were able to complete 4th grade and passed to 5th grade during academic year 2008/09. The number has shown sharp decline over years and only 26 (less than 15%) out of this cohort were able to complete the first eight years of schooling. Surprisingly, out of 100 girls enrolled to 1st grade in 2004/05, only 20 of them reached 4th grade; and only 9 of them able to complete 8th grade. This would point to the fact that education attendance in Mieso is characterized by high dropout rate, low completion rate, and huge gap in gender. When compared to 52.1% completion rate to grade 8, and 16.3% dropout rate for grade 1 — 8 computed at national level (MoE, 2012), this finding could spotlight where the pastoralists stand in terms of universalizing primary education.

   The shrinkage of their number as they move up the education ladder is so worrisome in some schools, as students never push further beyond grade 4, and leave school prior [↑](#footnote-ref-4)
4. During interview with supervisors at Bordodde, Gololcha, and Waltane CRCs, they noted that beyond 4th grade most children — specifically girls, never proceed to the 2nd cycle and dropout. [↑](#footnote-ref-5)
5. At Balo Primary School, an interview held with school principal and head teachers as of 12 March 2013, reveals closure of 7th grade as of September 2012. [↑](#footnote-ref-6)
6. As per the information from focus group discussion at Huse Mandhera, and Dagaa Daku and

   Annanno as of 3-4 December 2012, crop has entirely failed this harvest season, and hence there was extreme worry. [↑](#footnote-ref-7)
7. On focus group discussion held with parents at Hammetti on 6 March 2013, key informant interview at Huse Mandhera on 3 December 2012, Dhaga Daku 4 December 2012, Fayo, on 11 June 2012 revealed that many households have extreme worry in having something to eat during months to follow. [↑](#footnote-ref-8)
8. During an interview session with health extension workers at Kurfa Sawa health post as of 5 December 2012, 4 serious, and 22, medium acute malnutrition reported, but reported as 1 serious acute malnutrition, and 25 medium acute malnutrition; by Mieso Zone Health Office. [↑](#footnote-ref-9)
9. During farm observation at Hammetti Mata Deyma as of 12 March 2013, shocking crop failure noticed. [↑](#footnote-ref-10)
10. Focus group discussion held with parents at Hammetti on 6 March 2013 shows appalling water scarcity. [↑](#footnote-ref-11)
11. According to focus group discussion was held with PTA and students at Fayo (11 June 2012), at Mieso (12 June 2012), at Asebot (13 March 2013), at Annanno and Dhaga Daku (4 December 2012), at Borddodde (6 March 2013/2012) many parents oftentimes send their children to school without breakfast. [↑](#footnote-ref-12)
12. Focus group discussion at Kurfa Sawa, December 5, 2012 and at Waltane on 14 March 2013 shows milk is oftentimes exchanged for low cost food item to sustain life. [↑](#footnote-ref-13)
13. According to an interview with expert at Mieso District Water Mineral and Energy office, on June 2013, two new boreholes were dug at Waltane and Haramaro Deyma, and maintenance of the existing borehole underwent at Balo said to have improved water coverage of the district. [↑](#footnote-ref-14)
14. According to interview and focus group discussion at Hammetti, Waltane, Kurfa Sawa, and Qiqiliftu, as of 12 — 13 March 2013, water scarcity is the most excruciating problem where it oftentimes results in conflict with neighbouring Somali, and usually ends up costing human life. [↑](#footnote-ref-15)
15. Interview with teachers and Focus Group Discussion with PTA at Fayo, Asebot, Kurfa Sawa, Annanno, and Dhaga Daku primary schools show that students spend considerable time queuing for water. [↑](#footnote-ref-16)
16. NOAA panel guide on Arrow et **al** (1993) was used as criteria for selecting protest zero bidders. [↑](#footnote-ref-17)
17. ETB refers to Ethiopian currency [↑](#footnote-ref-18)
18. The LLC test may be viewed as a pooled Dickey—Fuller (FD) or ADF test, potentially with differing lag lengths across the units of the panel. It is applicable to small-large panels (small number of markets or regions and longer time series). [↑](#footnote-ref-19)
19. Adjustment factors are used to derive a test statistic that is distributed standard normal under the null hypothesis. In the use of the IPS test a group—mean bar statistic, where the statistics from each ADF test are averaged across the panel are used. Imet al. (2003) demonstrate that their test has better finite sample performance than that of LLC. [↑](#footnote-ref-20)
20. Relative price greater than or less than unity may not necessarily be an indicator of supply or destination regions. Relative prices of regions might be greater than or less than unity without trade relationships of the commodities if there are other interregional trade relationships. Price could also be indirectly related through the reference market in the absence of direct trade relationships. [↑](#footnote-ref-21)
21. The natural benchmark for RPit is zero. Identification of benchmark market requires the

    knowledge on supply and terminal markets for each type of commodity traded. [↑](#footnote-ref-22)
22. The closer the rate of convergence to zero, the longer is the estimated half-life of a shock. [↑](#footnote-ref-23)
23. Under the null hypothesis H0 : ft = 0, the regression statistic (t^ ) has a standard normal

    limiting distribution for the model that does not include both an individual specific mean and a time trend; however, it diverges to negative infinity for the model having an individual-specific mean, but does not contain a time trend and the model that contains both an individual-specific

    mean and time trend. To obtain a standard normal distribution, the t statistic can be adjusted \*

    (denoted as t-star. t^) using the ratio of longrun and shortrun standard deviations computed by the procedures of adjusting standard normal distribution for the LLC model (Levin et al, 2002).

    Notes: \*\*\* indicates 1% significance level. Source: Author’s computation.

    1. Panel Unit Root Tests

    Before estimating the rate and speed of monthly price convergence of commodities among regions in Ethiopia, the panel data set was tested for the presence of unit roots (Table 4). The study employed two widely applied methods of unit root tests in balanced and heterogeneous panels, the IM-Pesaran-Shin (IPS) and the Levin-Lin-Chu (LLC). The use of IPS panel unit root test in panel data accounts for the limitations of LLC

    Notes: \*\*\* indicates 1% significance level. Source: Author’s computation.

    1. Rate of Price Convergence

    The magnitude or rate of relative price convergence of commodities among the regions was measured by parameter estimates for lagged percentage relative price changes. The general dynamic panel model of relative price convergence (%) is a function of previous- month relative price (log) and the cumulative effects of its own lagged differences. The rate of convergence in this paper is defined as the effect of previous-month relative price (%) on the contemporaneous percentage relative price changes of a commodity over the years (months) and across regions. The model was estimated by the FE method since the inter-temporal price difference in each region has fixed-effects on the percentage relative price changes. Table 5 summarizes the FE estimation of rate of relative price convergence of commodities among regions in Ethiopia. The rates of convergence of relative price changes for the nine commodities are comparatively reported over the three periods. [↑](#footnote-ref-24)
24. The half-life method estimates only the time required to adjust to half of the initial relative price shock. The remaining half of the shock persists as a permanent shock which might not be adjusted among regions. [↑](#footnote-ref-25)
25. Result and Discussion

    1. Basic Characteristics of Hospitals

    Table 1 summarizes the basic characteristics of all hospitals and their respective average yearly inputs for the study period. [↑](#footnote-ref-26)
26. Kebeles are local administration units. [↑](#footnote-ref-27)
27. TLU is Tropical Livestock Unit excluding ox. [↑](#footnote-ref-28)
28. Introduction

    1. Background

    Fruits and vegetables production is usually lucrative compared to staple cereal crops. Horticultural product has high value addition and income generation potential. The production of fruits and vegetables has a comparative advantage particularly under conditions where arable land is scarce, labor is abundant and markets are accessible (Weinberger and Lumpkin, 2005: 19).

    Diversification into horticultural crops is becoming attractive for many poor farmers around the world. Worldwide production of fruit and vegetable crops has grown faster than that of cereal crops, albeit from a much lower base. Review of worldwide trends in [↑](#footnote-ref-29)