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Assessment of Adama City Flood Risk Using Multicriteria Approach

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Abstract

Flooding belongs to the most threatening natural hazards causing immense economic and social losses especially in urban areas. Flood risk assessment is an essential part of flood risk management. Few empirical studies have been conducted in relation with urban flood risk assessment at different areas. However, vulnerability should be considered in a broad context, encompassing specific physical location of the area and human, socio-economic, and environmental factors. Moreover, a proper urban flood risk assessment is challenging and more multi-facetted as existing common methods do not usually incorporate social and ecological impacts but exclusively assess economic damages. Hence, the research assessed all three dimensions of flood risk level in Adama City using multicriteria approach. The results reveal that 10.4% of total area of the City is within high flood hazard zone; 32,670 residents distributed in 8 Kebeles are living in flood risk area; 867.6 ha of land functioning for different land uses located at different parts of the City indicates significant economic risk. Moreover, 167.73ha of land with erosion potential identified at southern part of the City highlights ecological flood risk of the City. The study also indicates that flooding in the City is primarily attributed to low drainage density, low elevation, and impervious surfaces due to urban land use. On top of this, closed/obscured existing storm drainage lines have significant contribution for flood risk level in the City. The findings of the study would provide a base to formulate flood mitigation plans, enhance preparedness, response and recovery, and effective utilization of funds for holistic flood risk reduction.

Key words: *Flood, Vulnerability, Hazard, Multicriteria, Risk*

1. INTRODUCTION

Flooding belongs to the most threatening natural hazards causing immense economic and social losses throughout the world. Flood hazard is expected to increase in frequency and severity, through the impacts of global change on climate, severe weather in the form of heavy rains and river discharge conditions (Dihn et al., 2012). Surface water flooding (urban flood) occurs due to a complex interplay of factors, including the precise location, intensity and duration of rainfall, the characteristics of urban land surfaces, and engineering design of the surface drainage and sewer system (Jenkins et al., 2016). Surface water flooding tends to be most severe during intense rainfall downpours, which is often, but not exclusively, associated with convective rainfall events.

In Ethiopian context, floods at a time of unusually high rainy days overtop the normal flood ways and create a lot of calamity to the residents. In Adama City, flood has been the most severe natural hazards resulting in enormous risks in recent past. For instance, floods occurred in 2008, 2009, and 2016 caused huge costs in different parts of the City. Observations from time to time reveal significant increase of social, economical and ecological flood damages. This is due to lack of integrated early warning system for flood risk management in the current practice of Adama City administration. Such problems obviously require an ongoing improvement of analysis, mitigation and management (Ebert et al., 2009).

Flood risk management process should be comprehensive understanding, analysis and assessment before flood mitigation measures are planned and implemented. It is the only way to provide planners with information about the component of risk that is prevailing in the area under consideration. On top of this, methodologies to support decision making should be based on much broader concept of risk i.e. economical, social, and ecological. This allows us to analyze the combined effect of hazard and vulnerability so that a wide range of options can be accounted.

Among few studies conducted in relation with urban flood risk assessment at different areas, Morita (2014) determined flood risk impact factor for comparatively evaluating the main causes that contribute to flood risk in urban drainage areas; Yashon and Ryutaro (2014) provided methodological overview for urban flood vulnerability and risk mapping by taking Eldoret municipality

in Kenya as a case study assessment; Jenkins et al.(2016) used an Agent-Based Model approach to assess surface water flood risk and management strategies under future climate change. However, vulnerability should be considered in a broad context, encompassing specific physical location of the area and human, socioeconomic, and environmental factors. Moreover, a proper urban flood risk assessment is challenging and more multi-facetted than in rural areas because common flood risk analyses methods do not usually incorporate social and ecological impacts but exclusively assess economic damages (Haque and Etkin, 2007). Above all, as to our knowledge, specific study that deals with flood risk assessment in Adama City has not been conducted yet.

Hence, this study focused on the assessment of urban flood risk level in Adama City using Analytical Hierarchical Process (AHP) and multicriteria approach. With this aim the study was carried out (i) to identify major contributing factors to surface water flood in the City; (ii) to identify different levels of flood hazard zones; and (iii) to asses economical, social, and ecological flood risk in the City.

2. MATERIALS AND METHODS

2.1 Description of the study area

Adama City is one of fast growing cities in the country with an estimated total population of 343,212 (CSA, 2009). It is situated in Rift valley within Awash River Watershed in Oromia Regional State of Ethiopia. It was established in 1916 on flat terrain characteristics and surrounded by plateaus, mountainous and ridged topography along Addis Ababa to Harar road at distance of about 96 km. It is located between $8^0$26'15"–$8^0$37'00"N, $39^0$12'15"-$39^0$19'45"E. Altitude of the area ranges from 1489 m-1976 m a.s.l. Average annual rainfall of Adama City is about 866.25 mm. Most of the rain occurs in rainy season (June to September). The minimum wind speed occurs during September (1.65m/s), while the wind with high velocity occurs during December, January and February (3.05-3.2 m/s). The mean temperature in the City varies from 11.5 °C to 31 °C. Flooding is a significant natural hazard in Adama City mainly attributed to its location within the flat lying rift and its urban impervious surface (Seid, 2005).

2. Methods

Methodological background of this study is a multicriteria approach for flood risk assessment and mapping developed by Meyer et al. (2009a, b). It covers the three dimensions of vulnerability: social, economic, and ecological.

The study involves identification and mapping of flood hazard zones, flood risk mapping by superimposing considered hazard zone with existing land use of the City in Geographical Information Systems (GIS) environment. The general procedure used for the case is the following:

1. With reference to reviewed literatures including (Meyer et al., 2009a; Kubal, 2009; and Morita M. 2014), and based on existing condition of study area, five most significant flood causative factors were selected: land use land cover, drainage density, slope, elevation, and geology.
2. Thematic layer of each factor was prepared and standardized by assigning new pixel value. Reclassification was done based on estimated significance towards flood generation within a factor.
3. Relative significance (weight) of all factors contribute to flooding was determined through pairwise comparison techniques
4. Weighted spatial overlay analysis was conducted in GIS environment to produce resultant map
5. Pixels of the resultant map were categorized based on their cumulative pixel value, and then flood hazard zones were determined in different levels.
6. Field verification of the result with areas experienced past historical flood events was conducted and hazard level to be considered for venerability analysis was determined
7. Considered hazard zone was superimposed with map of elements at risk, then flood risk maps were prepared
8. Extent of each risk was assessed and analyzed using elements at risk in terms of defined damage unit of measurement

2.2.1 Selection of causative factors and standardization

- ***Land use***

The land-use and land-cover data of the study area is the most important factor for flood hazard zoning as it reflects the current use of the land pattern, type of its use, and soil stability and infiltration capacity of the area. For instance, land-cover like vegetation cover of soils, whether that is permanent grassland or the cover of other crops, has an important impact on the ability of the soil to act as a water store. Runoff of rainwater is much more likely on bare fields than those of agricultural area. On the other hand, impermeable surfaces of urban area are considered as resistance cover increase the peak discharge of water that enhances flooding. However, urban land use zones such as commercial areas and residential areas will not equally decrease the penetration capacity of the soil and increase the water runoff. Hence, land use and land cover are important factors in determining the occurrence of flood in urban area.

In this study, land use land cover map was prepared from digital orthophoto and round surveying techniques. Based on their estimated relative infiltration capability, new pixel values were assigned. Maximum value was assigned for the most impervious land use type (commercial land use), and minimum value was assigned for land use type with estimated high infiltration capability (agricultural land).

- ***Drainage density***

Drainage is an important ecosystem controlling the flood hazards. An area with higher drainage density is relatively less susceptible to flooding than an area with less drainage density. Spatial analyst, line density module was used to compute drainage density from drainage feature class. This module calculates the density of drainage features in the neighborhood of each output raster cell. Density was calculated in units of length per unit of area. It is further classified into 9 sub classes. The maximum value was assigned for pixels in lower drainage density class interval and minimum value was assigned for pixels within higher drainage density class interval.

- ***Slope factor***

The slope influences the direction and amount of surface runoff or subsurface drainage reaching a site. Steeper slopes are more susceptible to surface runoff, while flat terrains are susceptible to water-logging.

Therefore, an area with low gradient is highly vulnerable to flood occurrences compared to high gradient slopes since excessive water is always gathered in an area where the slope is usually low. Accordingly, the slope factor was derived from contour feature class of the study area having 5m contour interval. First it was converted to raster format by using elevation attribute as a source. Next using 3D analyst tools in ArcGIS, Digital Elevation Model (DEM) of the area was created and the rate of change between each pixel and its neighbors was calculated using spatial analyst module. The slope raster layer was further reclassified in 9 sub classes. New values were assigned using inverse weighting i.e. maximum value was assigned for pixels within the sub class having the lower slope values and minimum value was assigned to pixels within the area with steep slopes.

- ***Elevation factor***

In pluvial flood local depressions, i.e., DEM cells with lower elevation than the surrounding ones are susceptible for flooding since water always gathered at cells with lower elevation. Pixels of this layer were grouped into 9 interval sub-classes based on elevation information. New pixel values were assigned. Higher value was assigned for pixels in lower elevation range and minimum value was assigned for pixels within higher elevation range.

- ***Geology factor***

The geology feature class of the area was converted to raster by specifying cell size equal to the other factors (10 m). New pixel values were assigned to all geologic type based on relative estimated significance to the objective.

2.1.1 Ranking causative factors

Every causative factor has different level of significance compared to other factor resulting in flooding. For instance, if we consider drainage density and elevation factors, an area with poor drainage density might be flooded than an area within lower elevation as lower areas with dense drainage is less susceptible. From this, drainage density factor is more important than elevation factor in flood hazard factor rating. Accordingly, probability rating of flooding was done by considering all causative factors. Their significance was indicated by weighting computed by pairwise comparison using nine point continuous rating scale (table 1).

Table-1: Scale for pairwise comparison (Saaty and Vaargas, 1991)

Intensity of importance	Definition	Explanation
1	Equal importance	Equal importance or indifference
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between adjacent scale values	-
Reciprocals	For inverse comparison	-

Pairwise comparison matrix was prepared (table-2). Next, relative weights were determined in weight module of IDRISI 3.2 software package. In *Analysis* menu *decision Support system* was fed with the pairwise comparison matrix file and the best fit set of weight was produced.

Pairwise comparison in AHP provides weight of each causative factor with consistency ratio to indicate the level of subjectivity in comparison of factors. Poor comparison made between factors will have the value greater than 0.1 and vice-versa. The computed eigenvector is used as a coefficient for the respective causative factor.

Table 2: Pairwise comparison matrix

	Elevation	Slope	Geology	Land use	Drainage density
Elevation	1				
Slope		1			
Geology			1		
Land use		3	7	1	
Drainage density	2	5	7	2	1

2.2.3 Flood hazard zoning

Flood hazard zoning is the process of determining the degree of susceptibility of a given place to flood and indicated by the resultant values of pixels. In the present study, the net probability of occurrence of flood in each pixel was estimated from the weighted sum of the values of particular pixel in causative factors considered. The resultant pixel value for estimating the probability of flooding in a particular pixel is equal to the sum of the product of the value of particular pixel in every causative factor (v_i) and weight of the causative factor (w_i).

$$Resultant value of\ i^{th} cell = \sum_{i=1}^{n} w_i v_i$$

Where

n is number of causative factors

w_i *is weight of each factor*

v_i *is value of* i^{th} *pixel in each factor*

Flood hazard map was produced by weighted spatial overlay of thematic layers in ArcGIS using spatial analysis module. The raster map thus produced shows the resultant value of each pixel. The higher value indicates the high susceptibility of the pixel to flooding. The resulted layer further reclassified into 5 classes using natural break interval. Then relative flood hazard levels were assigned to each class qualitatively form 1 to 5. In other words, 5 is assigned for a class with high resultant pixel values and 1 is assigned for a class with least resultant pixel values.

2.1.2 Flood risk assessment

Flood risk assessment was conducted for flood hazard zone considered based on field verification and study of areas that experienced past flood events. The risk assessment covers the three dimensions of vulnerability: social, economic and ecological (table-3).

i) Social risk

Regarding high density of population in urban areas, measurement of potentially endangered inhabitants is crucial. Hence, number of population is considered as tremendously important. To quantify population living in flood risk zone, first,

residential and mixed land uses within considered flood hazard zone is extracted by spatial overlay analysis of land use map and flood hazard map. Second, extracted residential and mixed land uses are spatially overlaid with map of Adama City Kebele administrations boundary and spatial extent of prone area per Kebele was obtained. Third, Population density per each Kebele was computed from registered demographic data as of 2015 acquired from each Kebele administration and total residential and mixed built up in the Kebele. Finally, population density and extracted area of residential and mixed land use within considered hazard zone in particular Kebele were multiplied to determine number of people living in flood risk zone. In this regard, assumption was made that all buildings within the particular Kebele have the same number of floors and population density is uniform within a particular Kebele.

Table-3: dimensions of risk assessment (Kubal et al., 2009)

Flood risk dimension	Evaluation criteria	Sub-criteria	Elements of Risk	Spatial unit	Damage unit
Economic	Aggregated economic risk	Transport	All types of road	Line	km
		Housing	Residential land uses	Area	ha
		Industrial	Manufacturing and storage	Area	ha
		Mixed built up	Mixed land use buildings	Area	ha
		Recreation	Garden and recreational area	Area	ha
Social	Population		Population per residential and Mixed land use buildings	Area	No
Ecological		Soil erodibility	Unsealed areas with erosion potential	Area	ha

ii) Economical risk

In this study, economic flood risk was characterized by aggregated economic risk based on five land use classes: residential, industrial, mixed land uses, recreational, and transport.

Map of these land uses is spatially overlaid with map of considered flood hazard zone. Then spatial extent of each element within considered hazard zone is computed in damage unit assigned to highlight economic flood risk.

iii) Ecological risk

Besides economic and social risk, floods may also influence environment and thus reduce or even enhance biodiversity and ecosystem functionality (Apel et al., 2004).

Moreover, Kr¨uger et al. (2005) were able to demonstrate with the Elbe in 2002 that floods can redistribute existing soil pollutants, particularly in urban areas. However, due to scope of the study and type of past floods and their consequences, soil erodibility was selected as an important variable to asses ecological flood risk in Adama. In this regard, map of considered hazard zone was spatially overlaid with non-sealed surfaces with erosion potential. Then using spatial analysis tool of ArcGIS, extent of each piece of land was determined.

3. RESULTS AND DISCUSSIONS

3.1 Relative significances of causative factors

Relative significance of each causative computed from pairwise comparison is indicated (table 4). The level of subjectivity in comparison of the factors is 0.05. Consistency ratio is much lower than the threshold value (0.1). This indicates a high level of consistency in the pairwise comparison judgments, and thus determined weights are acceptable.

Among causative factors, drainage density is found the highest contributing factor to flooding in the study area followed by elevation and land use factors.

Table 4: weight of each causative factor determined from pairwise comparison matrix using IDRISI 3.2

Factor	Weight (%)
Drainage density	39.08
Elevation	30.03
land use	18.94
Slope	8.31
Geology	3.64

Computed consistency ratio = 0.05

3.2 Flood hazard zones

Weighted spatial overlay results a single map (figure-1) from the combination of all analyzed causative factors. The map shows different flood hazard zones in different level. This resultant map is known as flood hazard map.

The result shows that sites covering 1385 ha (10.4%) of the total study area are within high flood hazard zone. These areas are spatially located at the central and southern parts of the City. They are generally laying at low elevation within paved regions. In addition, sites covering 2643 ha (20%) of land are located in moderately flood hazard zone. They are spatially adjacent to high hazard zone and stretched in north and south west - part of the City. Further, 5153 ha (38.9%), of the study area is located in low flood hazard zone. These areas are considered as the area where lessdevelopments have taken place. The rest areas with 4103.5 ha (30.7%) of land is located in very low and outside of hazard zones. These areas tend to be on the highergrounds

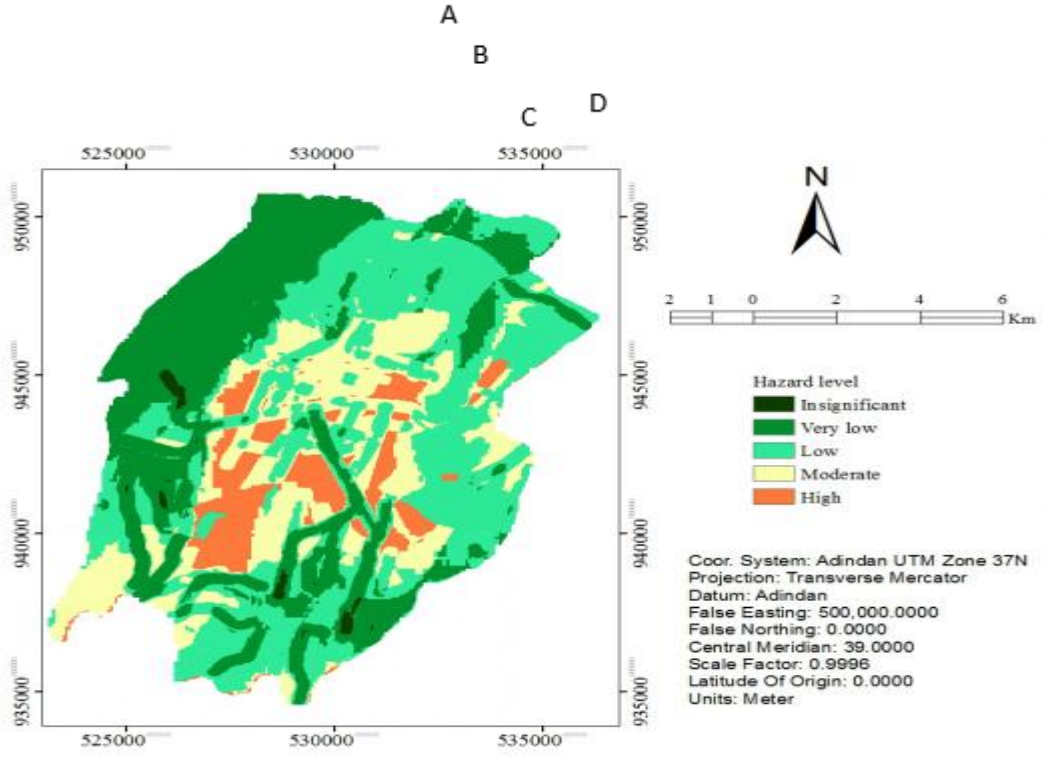

Figure-1: Flood hazard zones in Adama City in different hazard level

Field verification of the result of flood hazard zoning revealed that sites frequently experienced past flood events, labeled in figure-1 are spatially located in high flood hazard zone identified in this study.

Site-A is around Metal and Engineering Corporation formerly known as "Tractor Assembly". It is an area where potential flood occurred during flood event in 2016. The area is mainly characterized by industrial developments (figure-2).

Figure-2: Site-A, around Tractor assembly

Beside high surface runoff from upper catchment, limited drainage with low slope range of the area contributed to water accumulation in the site causing flood.

Site-B is located in central part of the City in Kebele 09 around "Organ" Hotel. This area is perceived dense residential area situated on low elevation range with limited drainage lines (figure-3). On top of this, existing storm water drainage lines are closed with different urban wastes and construction for crossing utilities. This explained why potential flood events occur every year in the area.

Figure-3: Site-B, around Organ Hotel

Site-C is located at southern part of the City around "Tikur Abay" Hotel. The area is suited on low elevation range and characterized by low drainage density and illegal residential developments (figure-4). The combined effect of these factors contributes to flooding at this area. This explained why frequent flood events occur in this area every year.

Figure-4: Site-C, around "Tikur Abay"

Site D is located around "Migira" pond in Kebele 02 (figure-5). It is characterized by low elevation with insignificant drainage density. These factors highly contribute to flooding in the area, as runoff from all directions around the area flows towards the cell with low elevation.

Figure-5: Site-D, around "Migira" pond

Other sites classified in high flood hazard zone are mainly characterized by low elevation and limited drainage networks.

During field verification, it is also observed that some areas that experienced past floods in the City are identified within moderate flood hazard zone. This might be because of two reasons: the first is most cobble stone roads constructed in residential areas hindering runoff water infiltration, the road side drainage lines and the existing crossing drainage structures (culverts) are under

capacity as compared with discharge expected to pass through it. Second, these structures are closed with different solid wastes and construction in storm water drainage lines for crossing utilities reducing efficiency of the structures. This explained why flood in June 2016 occurred in different parts of the City where there is better drainage density and relatively high ground. In general, the result indicates that natural and manmade factors seem to contribute to past flood events in the City.

3.3 Flood risk

In this study, for flood risk assessment only high flood hazard zone is considered since spatial location and extents of vulnerable areas due to past historical floods are within this zone. Hence, for each of the three dimensions of vulnerability, a separate risk map is prepared by intersecting considered hazard zone with map of elements at risk.

- ***Social risk***

The result depicted in figure-6 and table-5 demonstrates that the level of social flood risk in the City by indicating the number of people living in flood prone area distributed in different administrative units. The risk case obtained from Kebele 09 is the highest and followed by Kebele 03 and Kebele 02. The less affected administrative units are Kebele 14, Kebele 10, Kebele 13, Kebele 05, and Kebele 11.

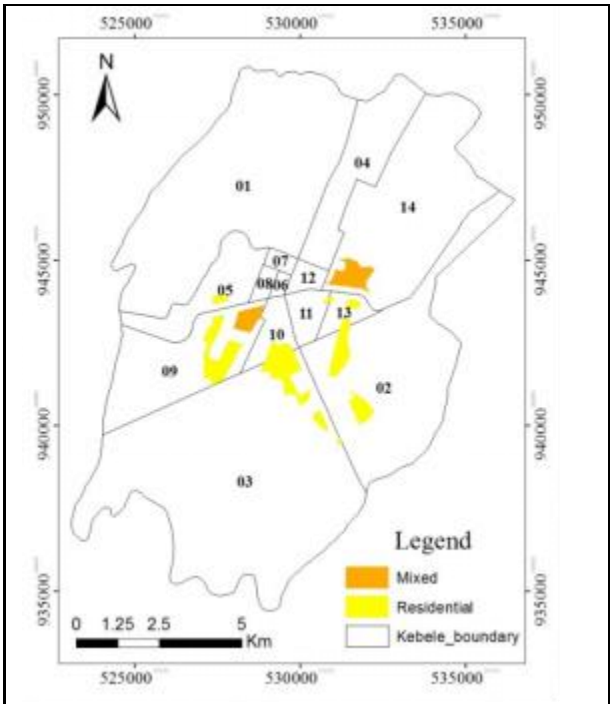

Figure-6: Social flood risk map of Adama City

Table 5: Number of people in flood prone area of Adama city

Kebele	affected Area (ha)	Popn Density (No/ha)	Total Popn
09	152.84	73	11,158
03	106.80	86	9,185
02	68.78	65	4,471
14	75.64	58	4,349
10	26.17	58	1,505
13	18.32	69	1,264
05	8.84	67	592
11	2.28	65	147
Sum			**32,670**

On top of this, majority of the sites located in Kebele 02 and kebele 03 are illegal developments usually characterized by high population density and lack of transportation access. These also increase the risk level during flood incident.

- ***Economic risk***

Economic flood risk is depicted in figure-7. This includes 176.1 ha industrial, 571.1 ha residential, 120.4 ha mixed built up, and 1.8km paved road.

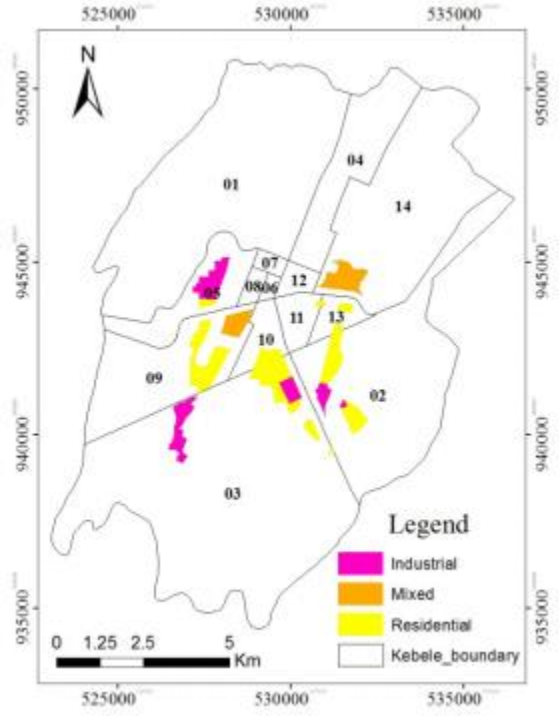

Figure-7: Economic flood risk map of Adama City

Further analysis reveals that industries own high value assets including buildings, machines, equipments, and production. Besides, such large developments create employment opportunity for the residents of the City and its surroundings. Thus, the damage of such developments will result in high economic loss for developers and economic crises for employees in particular and for the country in general.

Moreover, the economic flood risk is also not limited to industrial site. It also damages of residential buildings; different small scale enterprises, related social services, and infrastructures located within mixed built up areas are also results significant economic lose.

- ***Ecological risk***

With regard to ecological aspect, the assessment indicates 138.1 ha of land with erosion potential is identified at southern part of the City (figure-8). Easily erosion of this site would result in formation of number of gullies which encourages transportation of soil from the area and deposit in main streams passing though the City and crossing structures. This causes additional rehabilitation works and clearing of stream bed.

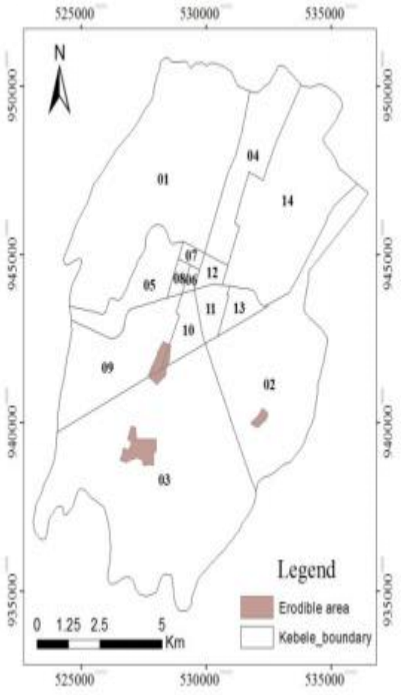

Figure-8: Ecological flood risk map of Adama City

Despite it's location in considerable hazard zone, 231.8 ha of land is free of the three dimensions of venerability used in this study. Out of this 176.44 ha is located in Kebele 03 mainly characterized by bare land and the rest 55.4 ha located in Kebele 02 is cultivated land at the outlet to Assela City. Even though currently there is no development in the areas, they are proposed for residential and mixed land use by Adama City administration master plan 2004. This may increase social and economical risk of the City.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This study adopted AHP and multicriteria approach to identify flood susceptible areas in Adama City and assess the potential flood risk in the area. The result reveals that major factors contributing to flooding in Adama City are drainage density, elevation, and land use. Conversely, the contribution of slope and geological factors is less significant. Furthermore, the result demonstrates that the 10.4% of the study area composed of different urban land uses lies in high flood hazard zone distributed in central and southern part of the City. In addition, the result of risk assessment indicates that 32,670 residents distributed in 8 Kebeles are living in flood risk zone. On the other hand 867.6 ha of land composed of different urban land use with significant economic potential is indentified as associated economic flood risk. Moreover, 167.73ha of land with erosion potential

identified in southern part highlights ecological flood risk level in the City.

4.2 Recommendations

This study provides important information on the major contributing factors; spatial extent and distribution of flood hazard zones in different level; level of flood risk in terms of number of people living in flood prone areas; spatial extents and types of land use; and spatial extent of erodible soils within considered hazard zone. However, the results should be considered only an initial step towards understanding Adama City flood risk. Hence, further researches are required on several fronts. First, the study assessed social risk in terms of total number of population living in considered flood hazard zone. This was done by considering population density is uniform for specific Kebele, and numbers of floors of residential buildings area are the same.Hence, other studies must be conducted to assess the risk in terms of different age groups, as the vulnerability of children and elders is high; population density may vary from place to place within each Kebele; and number of floors of residential buildings may affect the density of the population. Second, economical risk is assessed in terms of spatial extent and selected land use type. Further studies are required for detail quantitative analysis at household level using detail land use function in monetary terms and considering additional land use types and facilities that would provide an increased understanding of potential risk. Third, this research assessed the three dimensions of vulnerability. Hence, the study should be conducted to assess the combined effect of all dimensions with appropriate scale. Finally, only soil erodiblity factor is used to highlight ecological flood risk in the area. Hence, further studies must be conducted using more indicators to assess environmental flood risk level in the City.

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6. Reference

Apel, H., Thieken, A. H., Merz, B., and Bl¨oschl, G., (2004). Flood risk assessment and associated uncertainty, *Nat. Hazards Earth Syst. Sci.*, 4, 295–308.

Central Statistical Authority (CSA) Adama Branch. 2009. 2009 population and housing census of Ethiopia: results for Adama City. Adama, Ethiopia.

Dihn, Q.; Balica, S.; Popescu, I.; Jonoski, A., (2012). Climate change impact on flood hazard, vulnerability and risk of the Long Xuyen Quadrangle in the Mekong Delta. *Int. J. River Basin Manag., 10*, 103–120.

Ebert, A., Kerle, N., and Stein, A.,(2009) Urban social vulnerability assessment with physical proxies and spatial metrics derived from air- and space borne imagery and GIS data, *Nat. Hazards.* 48, 275-294.

Fedeski M. and Gwilliam J.(2007) Urban sustainability in the presence of flood and geological hazards: The development of a GIS-based vulnerability and risk assessment methodology. *Landscape and Urban Planning **83**, 50–61*

Haque, C. and Etkin, D., (2007) People and community as constituent parts of hazards: the significance of societal dimensions in hazards analysis, *Nat. Hazards*, 41, 271–282.

Jenkins, K., Surminski, S., Hall, J., and Crick, F. (2016). Assessing surface water flood risk and management strategies under future climate change: An Agent-Based Model approach, *Working Paper*, 1-30

Kr¨uger, F., Meissner, R., Gr¨ongr¨oft, A., and Grunewald, K.: Flood induced heavy metal and arsenic contamination of Elbe river floodplain soils, Acta Hydroch. Hydrob., 33, 455–465, 2005.

Kubal, C., Haase, D., Meyer, V. and Scheuer, S. (2009). Integrated urban flood risk assessment adapting a multicriteria approach to a City. *Nat. Hazards Earth Syst. Sci.*, **9**, 1881–1895.

Morita M. (2014). Flood Risk Impact Factor for Comparatively Evaluating the Main Causes that Contribute to Flood Risk in Urban Drainage Areas. *Water, 6*, 253-270.

Saaty, T.L. Vaargas, L.G. (1991). Prediction, Projection and Forecasting. Kluwer Academic Publishers, Dodrecht.

Seid Yhdego, (2005). Urban expansion and suitability analysis for housing of Adama city using remote sensing and geographic information system, M.Sc Thesis, Department of earth science , Addis Ababa University. Ethiopia.

Yashon O. Ouma and Ryutaro Tateishi. (2014). Urban Flood Vulnerability and Risk Mapping Using Integrated Multi-Parametric AHP and GIS: Methodological Overview and Case Study Assessment. *Water, 6*, 1515-1545.

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Change in Cation Exchange Capacity, Exchangeable Cations, and Available Phosphorus in Tropical Soil Amended With Differently Aged Composts.

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Abstract

Composting of coffee pulp waste which is abundant in Ethiopia could be a feasible alternative to solve waste management problem related to it and produce a valuable agricultural input used to improve soil quality. Efficient use, however, requires not only but, knowing the optimum composting time for greater soil chemical properties improvement. Therefore, in this study some major chemical properties and plant available nutrient content of composts and after its application in tropical Nitisol were studied. Different age Compost samples were collected, and an amount equivalent of 48 t ha^{-1} was added to a sample of a tropical Nitisol. The soil-compost-mixtures were incubated aerobically for 14 weeks. The compost samples and soil samples from the end of incubation were analyzed for cation exchange capacity (CEC), exchangeable nutrient contents (K, Ca, Mg & Na) and available P content using ICP-OES instrumentation. Chemical analysis showed the contents of the Mehlich 1-extractable exchangeable cations in the composts were in the order K > Ca> Mg > Na. Content of exchangeable Ca attained the highest value at the thermophilic phase of composting where as other exchangeable cations and CEC attained the highest concentration at the end of composting. In comparison to the control, all amended soils resulted in a significantly higher Ca & K content irrespective of the age of compost added. For instance application of COM 1 increased each of them by about 11% and 81%, respectively, while CEC was not significantly affected by any of compost amendments ($p<0.05$). The content of DCaL-P (ranged from 32.5 to 55.1 mg kg^{-1}) showed no specific trend with variation in the age of the compost. In general, composting increased the agricultural value of coffee pulp waste as it raised the exchangeable Ca, Mg and CEC values. Whereas, extended composting beyond thermophilic phase may be not necessary as it does not significantly affect the nutrient content of the compost and their availability to the plant. On the other hand, a relatively higher content of exchangeable Ca in relatively "fresh" compost has particularly important implications as its application in tropical Nitisols increase the availability of nutrients such as P that is otherwise strongly fixed by Al and Fe oxides.

Keywords: *Exchangeable cations, compost, coffee pulp, Soil chemical properties*

1. Introduction

Low soil fertility is a fundamental impediment to increasing food production and farm incomes in many parts of Africa (Sánchez et al., 1995; Shepherd and Soule, 1998). Limited data available at national level on soil fertility in Ethiopia suggested that these soils faced moderate to very severe fertility constraints affecting key farming regions (Stoorvogel and Smaling, 1990). This has increased more and likely worsened with the ongoing climate change, insufficient soil fertility management, high rates of soil erosion, increasing population density, farming without replenishing nutrients over time, and chemical imbalance issues (for example, acidity and salinity leading to fixation). Thus, there is an urgent need to improve soil fertility and nutrient management in the country.

Typical tropical Nitisols as used for this study constitute 12.2 % of the total area of Ethiopia. It is characterized as deep (>150 cm) reddish brown clays, highly weathered, acidic, high P-fixing and well drained soil. With proper fertilization and management it is inherently fertile and productive. But now its fertility has been depleted due to intensive cultivation, leaching and erosion (Nigussie and Kissi, 2012). However, under location specific management practice this depletion of soil fertility is minimized or reverted. Among the different management practices, composting has been adopted as a method of diverting organic waste materials from landfills while creating a product suitable for agriculture. As reported by several authors, the addition of compost can be a feasible option to improve the soil physical, chemical and biological properties (Morlat and Chaussod, 2008; Lima *et al.*, 2009). It is also evident that the incorporation of compost into soils results in an important supply of plant nutrient elements, such as nitrogen (N), phosphorus (P) and sulphur (S), exchangeable cations (calcium, potassium, magnesium and sodium) and micronutrients (Nardi *et al.*, 2004; Weber *et al.*, 2007). Particularly in highly weathered soils, composts can also decrease the rate of micronutrient leaching and level of P fixation in a soil (Obi and Ebo, 1995). Likewise composts can increase pH in acidic soils (Crecchio *et al.*, 2001; Haynes and Mokolobate, 2002) which enhances the availability of some nutrients and reduces the solubility of some toxic elements. All this possibly results in a reduction in the amount of mineral fertilizers to be used and related environmental problems (Grigatti *et al.*, 2007). On the other hand, compost application has led to local limitations such as increase in the salt content, the toxicity of heavy metals, unnecessary nutrient enrichments and subsequent leaching and immobilization of N (McConnell *et al.*, 1993; Inubushi *et al.*, 2000; Smith *et al.*, 2001). All these constraints questioned the feasibility of composting as a sustainable organic waste recycling technology. One way to avoid such problems is proper evaluation of compost effects on plant available nutrients (Bustamante, 2011). However, very few data on this particular characteristic of composts are available, and very likely those data need to be determined for each specific compost and characterization of its subsequent effectin different soil types.

At present considerable amounts of agro-industrial wastes such as coffee processing by-products like coffee pulp (40% of the wet weight) are generated in Ethiopia and other tropical regions, and become a source of severe environmental problems (Aranda *et al.*, 2009).

Proposed alternative uses for coffee pulp include direct use as a supplement for animal feed and soil amendment, as alternative energy resource, for the production of products (enzymes, citric acid, and flavoring substances, natural antioxidants), as a substrate for growth of mushrooms and uses as adsorbents (Pandey *et al.*, 2000; Salmones *et al* 2005, Negassa *et al.*, 2011). In Ethiopia, however, considerable amounts of these wastes are still mainly damped to water bodies, unsanitary landfills and cause freshwater eutrophication, health problems, require additional space for land filling as well as produce offensive odour and greenhouse gases when collected, transported and disposed. Moreover, the direct use of coffee pulp as a soil amendments and animal feed is restricted by the presence of toxic components such as polyphenols, tannins and caffeine as well as its adverse effects on soil properties such as induced anaerobic conditions and release of phytotoxic compounds (Pandey *et al.*, 2000; Gouvea *et al.*, 2009; Gezahegne *et al.*, 2011; Negassa *et al.*, 2011). On the other hand, the high organic matter, nitrogen and potassium content as well as low heating values (Orozco *et al.*, 1996; Pandey *et al.*, 2000) of coffee pulp opens up the chance for integrating agriculture and solid waste management by recycling the waste as compost for the improvement of soil fertility and as a mitigation measure of climate change.

Therefore, the objective of this study was to determine and compare the change in the available concentration of nutrients during composting and after its application in tropical Nitisol under controlled laboratory condition.

2. Materials and Methods

2.1. Experimental setup

The soil was sampled from a coffee plantation farm located in the southwestern highlands of Ethiopia and belongs to the major Soil Unit "Nitosol"(FAO). The sampling area is situated 36°36'E longitude and 7°56'N latitude. The elevation varies between 1533-1548 m a.s.l. Mean maximum and minimum temperature range from 26 to 30 °C and 11 to 14 °C, respectively, and the mean of precipitation range from 1131 to 1150 mm. A total of 50 subsamples were taken from a total area of 5.91 h, traversed in a zig-zag pattern, from soil depth of 0–30 cm using a GPS and an Auger. The subsamples were well mixed in a plastic container and then a representative sample of 3 kg was placed in a labeled plastic bag. This soil sample was air-dried and milled to pass through a 2-mm-sieve. Its main characteristics were 84 % clay, 14 % silt and 1 % sand, pH ($CaCl_2$) 5.2, electrical conductivity 2.39 mS $(cm)^{-1}$, 3.9 % C_{org}, 0.3% N_t, C/N ratio of 12.0, and 0.1% S.

Composts were produced from fruit/vegetable wastes and/or wet coffee pulp waste in a method of small heap composting. Heaps were piled in a bamboo box of dimensions 1.5 m (l) × 1.0 m (w) × 0.8 m (h)). The platform used has been considered as pilot compost production unit by the Addis Ababa city council, EPA, Ethiopia. The average temperature is between 15 °C and 25 °C. Two piles were constructed for experimental purposes with duplicates each and monitored as treatment COM1 (where the main feedstock material was coffee pulp waste) and COM4 (prepared by mixing coffee pulp waste with fruit/ vegetable waste in which the

ratio was 50:50 by volume). About 5 % (w/w) soil and 10 % (w/w) of garden trimmings (dry leaves, and young tree branches) were added as additional source of microbial colonization and to improve the pile structure. The moisture content (MC) of the compost was manually estimated on site by hand squeezing the compost tightly. Moisture contents above 40% were indicated by a formation of a ball up on squeezing of the compost. Depending on the situation the piles were watered so as to always maintain > 40 % (w/w) moisture. Samples were taken once a week for pH and MC measurements in the laboratory. Temperatures were measured daily for the first two week and in a three-days-interval during the next period always in the early morning using digital thermometers (0.5 and 1.0 m in length) at 2 different points of the heaps (25 and 60 cm depth). The composting was considered to be finished when the temperature of the mixture remained stable and near ambient (about 21 °C).

Representative compost samples (about 1 kg) were taken by mixing nine subsamples from different levels of the section in the pile along the whole profile at different phases of the composting. Day 8 (thermophilic phase =COM-T), day 24/36 (mesophilic phase =COM-M, depending on the duration each treatment lasted in this phase), and 89/119 (final compost =COM-F, depending on the duration each treatment lasted in this phase). In this way composts of different age were obtainedfrom two different composting piles. The samples were air dried and ground to pass through a 0.5 mm sieve. Main characteristics was given in **Table 1**

Table 1. Chemical properties of raw coffee pulp waste and compost samples from different phases of composting coffee pulp waste. Different letters indicate that samples are significantly different ($P < 0.05$) according to Fisher LSD test with in a column and values followed by the same letters with in a column were not significantly different.

Compost samples	pH_{H2O}	$C_{org.}$ (g kg^{-1})	N_{tot} (g kg^{-1})	S (g kg^{-1})	C/N	EC (ms cm^{-1})
RCPW	5.81(0.01)d	397.0(1.6)f	21.1(0.3)e	3.10(0.2)e	18.86	6.73(0.0)d
COM1-T	8.81(0.03)ab	151.0(2.0)a	10.5(0.0)a	1.70(0.0)ad	14.37	1.99(1.3)a
COM1-M	9.29(0.03)a	149.0(4.0)a	12.7(0.5)b	2.22(0.0)b	11.72	2.13(0.0)a
COM1-F	9.07(0.02)ab	139.2(3.0)b	12.7(0.3)b	2.40(0.0)b	10.98	2.07(0.5)a
COM4 -T	8.05(0.01)c	107.9(3.0)d	8.74(0.0)d	1.40(0.0)c	12.35	1.36(0.0)f
COM4-M	8.65(0.02)b	93.3(1.0)e	9.32(0.1)d	1.70(0.0)d	10.01	1.07(1.0)c
COM4-F	8.55(0.05)bc	91.49(3.0)e	8.99(0.0)d	1.88(0.0)d	10.18	1.11(0.0)c

COM – compost; T – thermophilic phase; M – mesophilic phase; F – final stage; RCPW - raw (fresh) coffee pulp waste; C_{org}: total organic carbon; N_{tot}: total nitrogen; C/N: carbon to nitrogen ratio; EC: electrical conductivity and standard errors in brackets.

Aerobic incubation of the soil-compost-mixtures was done by mixing 10 g dry weight of sieved soil samples (<2 mm) with fresh and composted coffee pulp waste at desired application rates (48 t ha^{-1}) and placed in 100 ml incubation vessels in five replicates each. They were monitored as treatment S+RCPW, S+COM1-T, S+COM1-M, S+COM4-F S+COM4-T, S+COM4-M and S+COM4-F. Soil controls were run without any amendment. Distilled water (1 to 5 ml) was added to the mixtures to keep the moisture at 60% of water-holding capacity. The incubation was carried out in a temperature controlled incubator at 25 °C for 98 days. Subsamples (2 g) were taken destructively from each treatment at the end of incubation for chemical analysis.

2.2. Chemical analysis of soil and compost

The concentrations of total organic carbon (C_{org}), total nitrogen (N_t) and total sulfur (S_t) were determined for soil, compost and amended soil samples using a CNS analyzer (Vario EL III; Elementar Analysensysteme, Hanau, Germany). Available phosphorus was determined using the double Ca-lactate (DCaL), which is the standard method in Germany. Mehlich-I (1942) extraction method was used for determination of cation-exchange capacity (CEC) and exchangeable cations (Na, Ca, K, and Mg) in 0.2 N $BaC1_2$ extract buffered with triethanolamine to pH 8. They were determined by ICP-OES instrumentation.

2.3. Statistical analyses

Means and standard errors were calculated for chemical parameters. Data were subjected to One Way ANOVA test and Fischer LSD Test to compare mean results from amended and non-amended soils. Pearson's correlation coefficient was calculated to see how content of one nutrient added by the compost affect the availability of other nutrient in the amended soil. All statistics were computed using data analysis and graphic software (Origin 8.1G).

3. Results and discussion

As shown in the **Figure 1** the composts contained appreciable amount of CEC (>30 cmol kg^{-1}) and showed a significant increase during composting in the order RCPW< COM-T< COM-F. The increase in the CEC as composting process progresses indicated the degree of humification and the functional groups responsible for this may be the carboxyl and phenolic groups formed during oxidation and decomposition processes of the organic matter (Lax, 1986). The significant difference in CEC due to mixing of coffee pulp waste with equal proportions of fruit/vegetable waste become obvious by comparing the two composting mixtures COM1 (34.5 to 36.0 cmol kg^{-1}) and COM4 (37.3 to 38.9 cmol kg^{-1}) in a different phase of composting (**Figure 1**). This suggests that co-composting of coffee pulp waste with fruit and vegetable waste improves the humification process during composting.

The composts contained all the macronutrients that are necessary for plant growth (**Table 1, Figure 1**). The contents of the Mehlich 1-extractablenutrients in the compost were in the order K > Ca > Mg > Na(**Figure 1**). Their significant difference ($P < 0.05$) among treatments COM1 and COM4 (**Figure 1**) resulted from mixing of equal proportion of fruit/vegetable wastes with the coffee pulp waste. For instance, a relatively larger content of exchangeable Ca in treatment COM4 (ranged from 23.1 to 27.0 cmol kg^{-1}) as induced by larger mineral content of fruit and vegetable waste (Garcia *et al.*, 1993) is of great interest as nutrient deficiencies in tropical acidic soils were occurred when Al has taken the buffering role over Ca up on its depletion (Harter, 2002). However, significantly higher contents of exchangeable K and Na in treatment COM1 indicated their amounts were much higher in coffee pulp waste than fruit and vegetable waste (Pandey *et al.,* 2000; Eshetu *et al.*, 2008).

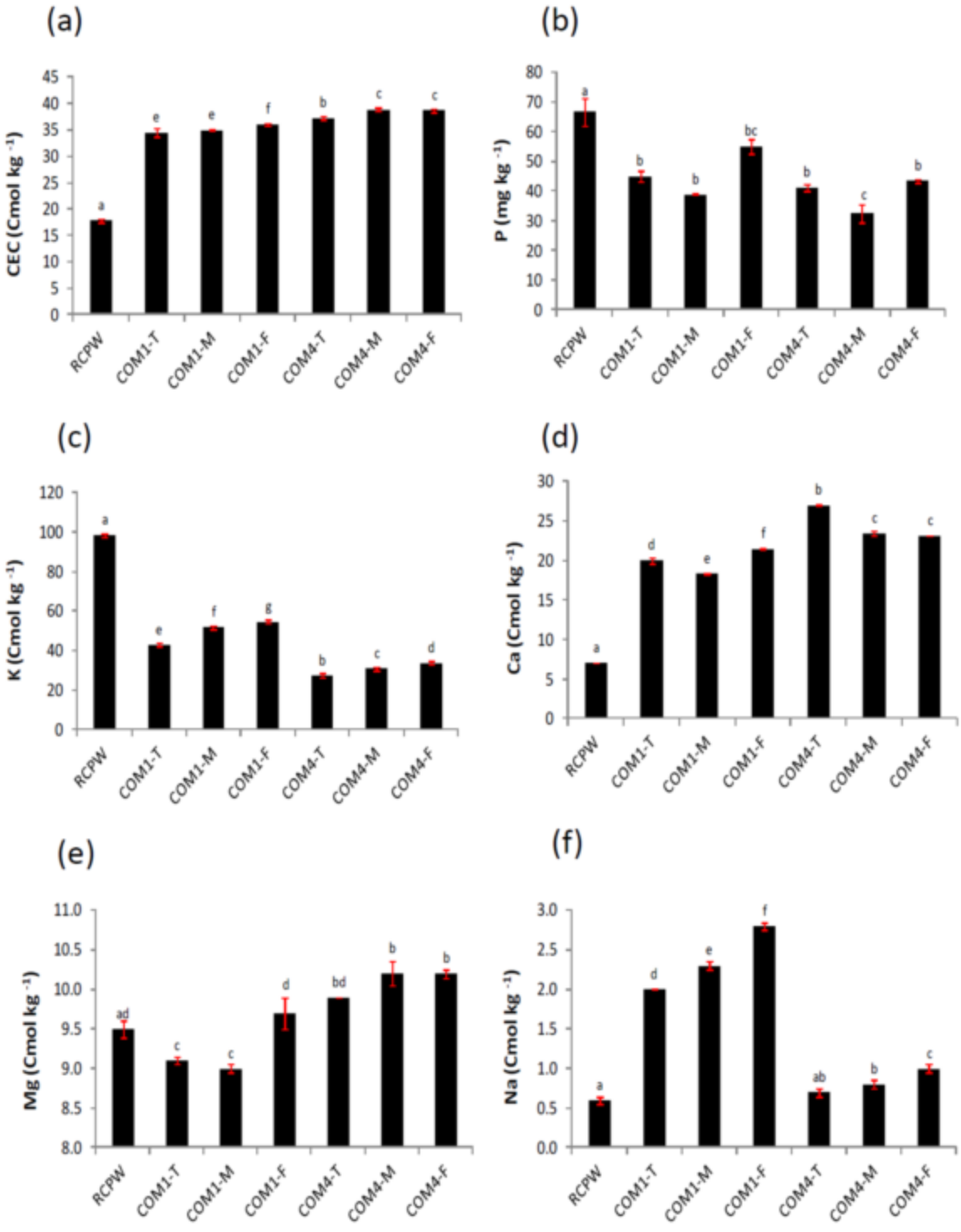

Figure 1. Cation exchange capacity (CEC), exchangeable cations (K, Ca, Mg and Na) and available P content in raw coffee pulp waste and compost samples taken in different phases of composting. Bars marked with different letters indicate statistically significant difference ($P < 0.05$) according to Fisher LSD test.

An increasing trend with respect to K and Na was observed during composting whereas other nutrients did not show a defined trend (**Figure 1**). Except Ca (which attain the highest value at early stage of composting), all macronutrients attained the highest concentration at the end of composting (**Figure 1**). This increasing trend of exchangeable cations likely resulted from the total weight loss from organic matter mineralization. Exchangeable Ca and Na contents were higher in the composts compared with the raw coffee pulp waste (**Figure 1**). However, reduction in exchangeable K by about 50% during composting as compared to its content in raw coffee pulp waste may have been related to a greater leaching of this nutrient.

The contents of the exchangeable K, Ca and Mg were higher than the value reported in various composts such as in a vermicompost made up of coffee pulp as reported by Orozco *et al.* (1996), food waste compost (Farrell and Jones, 2010), coffee waste compost and kitchen waste compost (Ebid *et al.*, 2007) as determined by extraction with ammonium Acetate (NH_4Ac). The vermicompost made of coffee pulp waste (Raphael *et al.*, 2012) also contained lower amounts of exchangeable K and Ca, whereas no difference with respect to exchangeable Mg was observed. Nevertheless, except the exchangeable K, the CEC and exchangeable nutrients (Ca, Mg and Na) were lower than those reported in other composts such as composted vegetal residues (Herencia *et al.*, 2011), composted pruning waste (Benito *et al.*, 2003) and composted urban refuses (Villar *et al.*, 1993). Compost made of green waste and chopped wood contained higher CEC but lower exchangeable cations as reported by Liu *et al.* (2011). This might be due to composition difference/variability among the composted material, the extraction method used, and the poor distribution of macro and micro fauna in the compost piles as they are generally grown on the upper layer of the composting piles of coffee pulp (Pandey *et al.*, 2000). However, vermi-composting with exploitation of different species of earth worms found in coffee pulp waste were recommended as the best solution to enhance exchangeable Ca and Na (Orozco et al., 1996; Aranda *et al.*, 1999).

The contents of available P (ranged from 32.5 to 55.1 mg kg^{-1}) in the composts showed no specific trend with variation in the age of the compost and composition of composting mixtures (Figure 1). However, its content in RCPW was significantly higher than the contents of P in the composts, perhaps due to its utilization or immobilization by microorganisms during composting. Available P (DCaL-P) content in RCPW and composts (COM1 and COM4) are much less than a value reported by Orozco *et al.* (1996) using the Bray II method in a vermicompost, Olsen-P in green waste and catering waste and a compost made up of mixing catering waste with green waste (Farrell and Jones, 2010), and Bray II-P in a compost made up of coffee waste and kichen waste as reported by (Ebid *et al.*, 2007). This difference in the concentration of available P may be primarily attributed to the differences in the extraction method. In addition, the higher pH of the compost samples in this study as compared to the others has favored P insolubility.

Table 2**.** Cation exchange capacity (CEC), exchangeable cations (cmol kg $^{-1}$) and available P content (mg kg^{-1}) in the control and amended soil at the end of incubation. Different letters indicate that samples are significantly different (P < 0.05) according to Fisher LSD test with in a column and values followed by the same letters with in a column were not significantly different.

Treatment	CEC	P	K	Ca	Mg	Na
Control	39.9 (0.65)a	BDL	1.1 (0.25)a	16.3 (0.1)a	3.7 (0.0)a	BDL
S+RCPW	37.5 (2.5)a	BDL	3.2 (0.05)b	17.1 (0.15)b	3.7 (0.0)a	BDL
S+COM1-T	36.9 (0.75)a	BDL	2.1 (0.1)c	18.2 (0.6)c	3.7 (0.0)a	1.9
S+COM1-M	39.3 (0.8)a	BDL	2.0 (0.05)c	18.1 (0.15)c	3.8 (0.0)ab	BDL
S+COM1-F	35.4 (3.1)a	BDL	2.0 (0.1)c	17.9 (0.05)c	3.9 (0.1)b	BDL
S+COM4-T	37.6 (1.75)a	BDL	2.3 (0.25)c	17.5 (0.05)bc	3.7 (0.0)a	0.01
S+COM4-M	39.5 (0.65)a	BDL	1.8 (0.0)c	17.1 (0.15)b	3.8 (0.0)ab	BDL
S+COM4-F	38.8(0.9)a	BDL	2.1(0.3)c	17.4(0.15)bc	3.9(0.05)c	BDL

S+COM – soil-compost mixture; T – thermophilic phase; M – mesophilic phase; F – final stage; S+RCPW – soil-raw coffee pulp waste mixture; BDL- below the detection level. Standard errors in brackets.

The main soil chemical parameters determined after four months incubation was shown in **Table 2**. In comparison to the control, all amended soils resulted in a significantly higher Ca and K content irrespective of the age of compost added. For instance, application of COM 1 increased each of them by about 11% and 81%, respectively, while CEC was not significantly affected by any of compost amendments ($p<0.05$, **Table 2**). The plant available P and exchangeable Na contents were below the detection limit in all amended soil and the control. Usually the DCaL extraction lowers available P when it is applied in tropical soils. However, strong positive correlation ($r =0.89$) between exchangeable Ca and available P as observed in treatment S + COM4. This indicated that the application of compost containing a larger concentration of exchangeable Ca (such as COM4-T) had a significant effect on the availability of P in tropical Nitisols. Furthermore, Kraus *et al.* (2003) reported that polyphenols, especially tannins which also exist in coffee pulp compost, may improve the P availability by interacting with metal oxides such as Al and Fe oxides that may otherwise fix P. No significant differences ($p<0.05$) in concentrations of the exchangeable cations and quantity of CEC were observed among the different compost treated soils **(Table 2)**. Despite of the composts had adequate CEC and Mg contents, its application to soil didn't increase above the level of the control. This may be due to the high level of CEC (40 cmol kg^{-1}) and Mg (3.7 cmol kg^{-1}) in

the control requiring larger compost additions to bring a significant change.

Increase of CEC, exchangeable cations (Ca, K, Mg and Na) as well as availability of P following compost addition in particular and organic matter amendments in general were already reported in various studies (Haynes and Mokolobate, 2002; Wright *et al.*, 2007, Weber *et al.*, 2007; Smith, 2009; Liu *et al.*, 2011; Ozores-Hampton *et al.*, 2011). However, it appears impossible to apply their results to the present problem because plants, type of vegetation, rate and method of application of the compost, and soil type were different.

4. Conclusion

In general, composting coffee pulp waste which is abundant in Ethiopia produce a valuable agricultural input and the product (compost) could supply all the macro-nutrients mainly K and N necessary for plant growth. However, exchangeable Ca, Mg and Na were not in high amounts as compared to other composts but they fit the minimum values. Furthermore, composting increased the agricultural value of coffee pulp waste as it raised the exchangeable Ca, Mg and CEC values. Extended composting beyond thermophilic phase may be not necessary as it does not significantly affect the nutrient content of the compost and their availability to the plant. On the other hand, a relatively higher content of exchangeable Ca in relatively "fresh" compost has particularly important implications as its application in tropical Nitisols increase the availability of nutrients such as P that is otherwise strongly fixed by Al and Fe oxides.Further study would focus on optimization of the composting process so as to minimize nutrient leaching such as K as well as to increase P and other nutrient availability. Moreover, the controlled laboratory experiment has limitations to get sufficient information on the agronomic value of coffee pulp compost under field conditions and it needs to be addressed in the forthcoming study.

References

Albiach, R., Canet, R., Pomares, F. and Ingelmo, F. 2001. Organic matter components and aggregate stability after the application of different amendments to a horticultural soil. *Bioresour. Technol.,* 76: 125-129.

Alemayehu, T., Esayas, K. and Kassu, K. 2007. Coffee development and marketing improvement plan in Ethiopia. In: Proceeding of national workshop. Four decades of coffee research and development in Ethiopia. Addis Ababa, Ethiopia, pp. 375-387

Aranda, A., Barois, I., Arellano, P., Irisson, S., Salazar, T., Rodriguez, J. and Patron J. C. 1999. Vermicomposting in the tropics In: Earthworm Management in Tropical Agroecosystems (Eds.) P Lavelle, L Brussaard and P Hendix, pp 253- 287.

Aranda, A., Duran, L. O. and Escamilla, E. P. 2009. Vermicomposting in coffee cultivation. In: Coffee growing, processing, sustainable production. Wintgens, J.N. (Ed). Wiley-VCH, Weiheim, pp 25-55.

Benito, M., Masaguer, A. Moliner, A., Arrigo, N. and Palma, R. M. 2003. Chemical and microbiological parameters for the characterization of the stability and maturity of pruning waste compost. *Biol. Fertil. Soils*, 37:184–189.

Bustamante, M. A., Said-Pullicino, D., Agullo, E. Andreu, J. Paredes, C. and Moral, R. 2011. Application of winery and distillery waste composts to a Jumilla (SE Spain) vineyard: effects on the characteristics of a calcareous sandy-loam soil. *Agric. Ecosyst. Environ.*, 140: 80–87

Crecchio, C., Curci, M., Mininni, R., Riccuti, P. and Ruggiero, P. (2001) Short-term effects of municipal solid waste compost amendments on soil carbon and nitrogen content, some enzyme activities and genetic diversity. *Biol. Fertil. Soils*, 34: 311-318.

Ebid, A., Ueno, H. and Ghoneim, A. 2007. Nitrogen mineralization kinetics and nutrient availability in soil amended with composted tea leaves, coffee waste and kitchen garbage. *Int. J. soil sci.*, 2(2): 96-106.

Eshetu, B. 2008. A study on composting potential of source separated fruit and vegetable wastes.LAP LAMBERT academic publishing GmbH & Co. KG, Saarbrücken, Germeny

Farrell, M. and Jones, D. L. 2010. Food waste composting: Its use as a peat replacement field trials. *Tappi J.*, 72 (6): 199–206.

Garcia, C., Hernandez, T., Costa, C., Ceccanti, B., Masciandaro, G. and Ciardi, A. 1993. Study of biochemical parameters of composted and fresh municipal wastes. *Bioresour. Techno*l., 44:17-23

Garcia-Gil, J. C.; Plaza, C., Soler-Rovira, P. and Polo, A. 2000. Long-term effects of municipal solid waste compost application on soil enzyme activities and microbial biomass. *Soil Biol. Biochem*., 32:1907-1913.

Goulet, E., Dousset, S., Chaussod, R., Bartoli, F., Doledec, A. F. and Andreux, F. 2004. Water stable aggregates and organic matter pools in a calcareous vineyard soil under four soil-surface management systems. *Soil Use Manage*., 20(3): 318–324.

Gouvea, B. M., Torres, C., Franca, A. S, Oliveria, L. S. and Oliveria, E.S. 2009. Feasibility of ethanol production from coffee husks. *Biotechnol Lett* , 31: 1315- 1319.

Grigatti, M., Giorgonni M. E. and Ciavatta, C. 2007. Compost-based growing media: influence on growth and nutrient use of bedding plants. *Bioresour. Technol.*, 98: 3526-3534.

Gezahegne, B. Fikre, L. and Mulatu, W. 2011. Exploring the suitability of coffee pulp compost as growth media substitute in greenhouse production. *Int. J. Agri. Res.*, 6(3):255-267

Harter, R. D. 2002. Acid soils of the tropics. ECHO Technical Note. 8pp. Accessible via http://echonet.org/tropicalag/technotes/Acidsoil.pdf (11 Jan 2009).

Haynes, R. J. and Mokolobate, M. S. 2001. Amelioration of Al toxicity and P deficiency in acid soils by additions of organic residues: a critical review of the phenomenon and the mechanisms involved. *Nutr. Cycl. Agroecosyst.*, 59: 47–63.

Herencia, J. F., Garcia-Galavisa, P. A., Doradoa, J. A. R. and Maquedab, C. 2011. Comparison of nutritional quality of the crops grown in an organic and conventional fertilized soil. *Scientia Horticulturae*, 129: 882–888

Inubushi, K., Goyal, S., Sakamoto, K., Wada, Y., Yamakawa, K. and Arai, T. 2000. Influences of application of sewage sludge compost on N_2O production in soils. *Chemosphere*, 2: 329–334.

Kraus, T. E. C., Dahlgren, R. A. and Zasoski, R. J. 2003. Tannins in nutrient dynamics of forest ecosystems. A review. *plant soil*, 256: 41-46

Lax, A. 1986. A method for determining the cation-exchange capacity of organic materials. *Plant Soil*, 94: 349–355.

Lima, G., et al. 2009. **Effects of organic and inorganic amendments on soil organic matter properties**. *Geoderma*, 150: 38-45.

Liu, J., Xu, X. -h., Li, H. -t., and Xu, Y. 2011. Effect of microbiological inocula on chemical and physical properties and microbial community of cow manure compost. *Biomass Bioenergy*, 35(8): 3433-3439.

McConnell, D. B., Shiralipour, A. and Smith, W. H. 1993. Compost Application Improves Soil Properties. *Biocycle*, 34: 61-63.

Mokolabate, M. S. and Haynes, R. J. 2002. Comparative liming effect of four organic residues applied to an acid soil. *Biol. Fertil. Soils*, 35: 79-85.

Morlat, R. and Chaussod, R. 2008. Long-term additions of organic amendments in a Loire valley vineyard. I. Effects on properties of a calcareous sandy soil. *J. Enol. Vitic.*, 59: 353–363.

Nardi, S., Morari, F., Berti, A., Tosoni, M. and Giardini, L. 2004. Soil organic matter properties after 40 years of different use of organic and mineral fertilisers. *Eur. J. Agron*., 21: 357-367.

Negassa,W., Baum,C. and Leinweber, P. 2011. Soil amendment with agro-industrial products: Moluclar-chemical compostions and effects on soil biochemical activities and phosphrous fractions. *J. Plant Nutr. Soil Sci*., 174: 113-120.

Nigussie, A and Kissi,E. 2012. Physicochemical Characterization of Nitisol in Southwestern Ethiopia and Its Fertilizer Recommendation Using NuMaSS. *J. Agri. Sci.,* 1(4): 066-073.

Obi, M. E. and Ebo, P. O. 1995. The Effects of Organic and Inorganic Amendments on Soil Physical Properties and Maize Production in a Severely Degraded Sandy Soil on Southern Nigeria. *Bioresou. Techno.,* 51: 117-123.

Orozco, F. H., Cegarra, J. and Trujillo, L. M. 1996. Vermicomposting of coffee pulp using the earthworm Eisenia fetida: Effects on C and N contents and the availability of nutrients. *Biol Fertil Soils*, 22:162-166.

Ozores-Hampton, M.,. Stansly, P. A. and. Salame, T. P. 2011. Soil Chemical, Physical, and Biological Properties of a Sandy Soil Subjected to Long-Term Organic Amendments. *J. Sust. Agri*., 35(3): 243-259.

Pandey, A., Soccol, C. R., Nigam, P., Brand, D., Mohan, R. and Roussos, S. 2000. Biotechnological potential of coffee pulp and coffee husk for bioprocesses. *J. Biochem. Eng.*, 6(2):153-162.

Raphael, K., Surekaand Velmourougane, K. 2012. Vermicomposting of Coffee Processing Wastes Using Exotic (*Eudrilus Eugeniae*) and Native Earthworm (*Perionyx Ceylanesis*) Species. DOI:10.1002/masy.201251008

Ros, M., Klammer, S., Knapp, B., Aichberger, K. and Insam, H., 2006. Long-term effects of compost amendment of soil on functional and structural diversity and microbial activity. *Soil Use Manage*., 22: 209–218.

Salmones, D., Mata, G. and Waliszewski, K. N. 2005. Comparative culturing of Pleurotus spp. on coffee pulp and wheat straw: biomass production and substrate biodegradation. *Bioresou. Technol*., 96: 537-544.

Sánchez, P. A., Valencia, I., Izac A. M. and Pieri C. 1995. Soil fertility replenishment in Africa. Nairobi, Kenya: ICRAF.

Shepherd, K. D. and Soule, M .J. 1998. Soil fertility management in West Kenya: dynamic simulation of productivity, profitability and sustainability at different resource endowment levels. *Agri. Ecosyst. Environ.*, 71: 131–146

Smith, D. C., Beharee, V. and Hughes, J. C. 2001. The Effects of Composts Produced by a Simple Composting Procedure on the Yields of Swiss Chard (Beta vulgaris L. var. flavescens) and Common Bean (Phaseolus vulgaris L. var. nanus). *Scientia Horticulturae*, 91: 393-406.

Smith, S. R. 2009. A critical review of the bioavailability and impacts of heavy metals in municipal solid waste composts compared to sewage sludge. *Environ. Int.*, 35 (1): 142–156.

Stoorvogel, J. J. and Smaling, E. M. A. 1990. Assessment of soil nutrient depletion in Sub-Saharan Africa: 1983-2000. Report 28, DLO Winand Staring Center for Integrated Land, Soil and Water Research (SC-DLO), Wageningen, Netherlands.

Villar, M. C., Beloso, M.C., Acea, M. J., Cabaneiro, A., Gonzalez-Prieto, S. J., Carballas, M., Diaz-Ravina, M. and Carballas, T. 1993. Physical and chemical characterization of four composted urban refuses.*Bioresou. Technol.*, 45 (2): 105-113.

Weber, J., Karczewska, A., Drozd, J., Licznar, M., Licznar, S. and Jamroz, E. 2007.Agricultural and ecological aspects of a sandy soil as affected by the application of municipal solid waste composts. *Soil Biol. Biochem., 39: 1294–1302.*

Wright, A. L., Provin, T. L., Hons, F. M., Zuberer, D. A. and White, R. H. 2007. Soil micronutrient availability after compost addition to St. Augustine Grass. *Compost Sci. Util.*, 15(2):127-134.

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Mineral Composition and Fatty Acids Profile of The Tubers of Plectrantus Edulis

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Abstract

Plectranthus edulis (Lamiaceae) is among underutilized tuberous plants growing in some parts of Ethiopia. Despite the significant contributions of tuberous crops towards food security, the food potential of P. edulis has not been fully utilized due to poor consumer awareness of its nutritional value. In view of this, the mineral composition including cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb) and zinc (Zn) were analyzed using atomic absorption spectrometer while the calcium (Ca), potassium (K), and sodium (Na) contents of the tuber of P. edulis collected from Walayta Sodo (WS), Bakko (BK) and Guliso (GU) were determined using flame photometer. The contents of Cr, Cu, Ni, Pb, Zn, Ca, K, and Na were found to be in the range of 0.008-0.030, 0.100-0.191, 0.330-1.065, 0.016-0.023, 0.135-0.357, 13.800-22.800, 325.00-502.50, and 12.80-13.50 mg/100g on the dry weight basis, respectively. Results showed that the tuber can contribute enormously to the supply of both macro and micronutrients in our diet. The ratio of Na/K in the tuber of P. edulis varies from 0.025-0.04. Results of the fatty acid profile obtained by analyzing the fatty acid methyl esters using GC-MS revealed the presence of essential fatty acids including palmitic, stearic, linoleic and oleic acid. The low values of the saturated fatty acids recorded in the present study in conjunction with the ratio of Na/K shows that the oil can be used by people with hypertension.Therefore, the nutritional profile recorded in the present study showed that the tuber of P. edulis can play a vital role in combating malnutrition and diseases.

***Key words**: Plactrantus edulis, tuber, minerals, fatty acids*

INTRODUCTION

Plectranthus edulis (Lamiaceae) is among tuberous underutilized plant species widely growing in the western and southern parts of Ethiopia (Makonnen, 2015). *P. edulis* is locally called *"Dinicha Oromo"* in Oromiaand *"*Ye Walayta Dinich" in Southern Ethiopia. It is one of the economically important tuberous crops of the genus *Plectranthus* (Taye et al., 2012). *P. edulis* is known in Ethiopia due to its horticultural uses since it is fast-growing, produces lovely flowers and is resistant to most pests and plant diseases. *P. edulis* is an indigenous plant which has been cultivated for its edible tuber in highly localized areas of south and west Ethiopia. To some extent, also, the leaves are eaten after cooking like vegetables in some Ethiopian regions. It is particularly important in local diets mainly between September and December since other food crops will not be ready for consumption. Beside its nutritional value, this plant is also used as a source of income in regions of Ethiopia where it is cultivated. Furthermore, the tubers are traditionally claimed to have good for people with asthma. Though the plant has significant application, the attention given to the plant in Ethiopia is very low likely due to poor consumer awareness of its nutritional value.

Despite the significant contributions of tuberous crops towards food security and income generation, the food potential of this crop has not yet fully been exploited and utilized. Furthermore there is no or little scientific information dealing with the fatty acids profile and mineral composition of the tuber of *P. edulis*. Hence the main purpose of this project is to examine the mineral contents and fatty acids profile of the tubers of *P. edulis*. The findings may create awareness amongst stakeholders regarding the potential of this crop both as food and medicine.

1. MATERIALS AND METHODS

2.1. Sample Collection and Preparation

The tubers of *P. edulis* were collected from Bako (Oromia), Guliso (Oromia) and Wolayata Sodo (southern Ethiopia), in the month of October 2015. All samples were collected from farm. The species were identified by Mr. Melaku Wondafrash of the National Herbarium of Addis Ababa University (Ethiopia), where

voucher specimen YD005 is deposited.The fresh samples collected were washed with water, peeled, washed, sliced to about 1 cm thickness and mixed manually. The sample was air dried and then grinded to obtain fine flour used for analysis.

2.2. Determination of Mineral Composition

The ground dried tuber of *P. edulis* was defatted with petrol using Soxhlet extraction to afford yellowish oil. The marc (5.0 g) was incinerated in a furnace at 500°C for 4 hours and the residue was then dissolved in 2.5% HNO_3 solution (50 mL). The metal contents (Cd, Cr, Cu, Ni, Pb and Zn) were determined using atomic absorption spectrophotometer (analytik jena:ZEEnit 700p, Germany) while the Ca, K and Na contents were determined using Flame Photometer (FP 902, PG Instrument, England) following the method of Angelucci et al.,1986 as cited in Berhanu Andualem and Amare Gessesse (2014). A calibration curve was prepared using standard metal solutions to test the linearity that is determined by calculating regression line (r^2).

Recovery study of the macronutrients (Ca, K and K) was made by using standard addition method.

The efficiency of the method was checked by adding known concentration of each metal in 5 g sample of *P.edulis* with the procedure shown as follows: 500 µg of 1000 mg/L Ca, K, and Na were spiked at once into 5 g of powdered tuber of *P.edulis* and incinerated in muffle furnace at 500 °C°C for four hours in the same way as the sample was treated. The incinerated sample was digested with 50 mL 2.5% HNO_3 and analyzed by using Flame Photometer (Minaleshewa Atlabachew, 2007). The experiment was done in triplicate.

2.3. Preparation of Fatty Acid Methyl Esters (FAME)

P. edulis oil (2 g) was placed in 25 mL round bottom flask which contained hexane (6 mL) to which 4 mL BF_3.MeOH solution was added. The reaction mixture was refluxed in water bath for 30 min. Then it was cooled to room temperature. To the cooled mixture, 5 mL of water was added with vigorous shaking and two layers were formed. The upper layer was separated by using separatory funnel, dried over anhydrous Na_2SO_4, filtered and concentrated to afford 500 mg (25%). A small portion of the methylated fatty acids was dissolved in hexane and analyzed using GC-MS

2.4. Gas Chromatography-Mass Spectrometer

GC-MS analysis were performed using Agilent Technologies 7820A gas chromatograph system equipped with HP-5 capillary column (30mx0.25; coating thickness, 0.25µm) and Agilent technologies 5977E mass spectroscopy ion trap detector. Analytical conditions were as follows: Injector and transfer line temperature are 220 and 260^{o}C, respectively; oven temperature programmed from 60^{o}C to 240^{o}C at 3^{o}C/min; carrier gas, helium at 1mL/min; injection 5µL; split ratio, 1:30. Identification of the constituents was based on search through mass\hunter\library\NIST11.Land mass\hunter\library\W9N11.

2. RESULTS AND DISCUSSION

3.1. Mineral Composition

Minerals are important component of diet because of their physiological and metabolic function in the body. They are used by human to perform certain chemical reactions which are essential for the normal functioning of our body. In the present work the levels of the micronutrients and macronutrients of the tuber of *P. edulis* collected from Bako, Guliso and Wolayata Sodo were analyzed and the results are presented in Table 1. The cadmium content of the tuber of *P. edulis* was below detection limits. Many literature reports showed that cadmium has no known nutritional value, and it is highly toxic to both plants and animals (Fifield et al., 1997). The seriousness of the acute cadmium poisoning in humans including kidney damage, destruction of testicular tissue and destruction of red blood cells were well established (Manahan, S., 2000). Because of the chemical similarity, cadmium may also replace zinc in some enzymes, thereby altering the stereostructure of the enzyme and impairing its catalytic activity. The very low value of cadmium in the tuber of *P. edulis* can be taken as one positive aspect of this plant as food.

The level of chromium content was in the range between 0.008 to 0.030 mg/100g. The value was found relatively superior in samples collected from WS compared with those samples collected from WW and BU. Chromium is among metals reported to potentiate insulin action and restores normal glucose tolerance. The estimated safe and adequate daily dietary intake recommendations are 0.050 to 0.200 mg/day for adult (Shils et al., 1999). The copper content of the analyzed sample was 0.100-0.191 mg/100g. The ability of copper to promote the development of connective tissues that allow for efficient bones, cartilage and blood vessels through all bodily systems is reported (Food Program, 2015). The level of this metal in the tuber of *P. edulis* is found out to be comparable with the values reported for potato tuber (0.1 to 0.3 mg/100 g) (Shils et al., 1999).

Table 1: Mineral composition of *P. edulis* tuber analyzed by AAS and flame photometer

Sample source		Mineral composition of the tuber of *P. edulis* (mg/100g)							
	Cd	Cr	Cu	Ni	Pb	Zn	Ca	K	Na
Wolayata Sodo	BDL	0.030	0.100	0.335	0.016	0.135	22.8±0.1	502.5±0.7	12.8±0.2
Bakko	BDL	0.020	0.191	0.697	0.022	0.130	15.1±1.1	490±1.0	13.5±0.7
Guliso	0.0005	0.008	0.134	1.065	0.023	0.357	13.8±0.1	325±2.0	13±1.0
Values reported from other sources			0.1-0.3[a]			0.23 to 0.27[b]	23.04-29.97[b],1.3 to 27.8[a]	115-203[b]; 239-694[a]	23-28[b]
Recommended in take (in mg/day) for humans	-	0.050-0.200		0.025-0.035	0.015-0.100	3-30	210 to 1300		120-1500

BDL = below detection limit; a = in mg/100g from potatoes; b = in mg/100g from sweet potato; samples for analysis of Na, Ca and K were done in triplicates

The level of Ni in the tuber was from 0.335 mg/100g for WS and 1.065 mg/100g for Guliso. As discussed on Food Program (2015), nickel plays a major role in helping the body absorb the iron it needs. It assists in breaking down glucose, helps in creating energy for daily use and even contributes to the production of certain enzymes that initiate important chemical reactions such as the development of nucleic acids. Hence, the significant amount of Ni observed from the tuber of *P. edulis* has some health implications. Also analyzed in this study was the content of Pb which ranges from 0.016 to 0.023 mg /100g. The level was found to be higher for samples collected from Bakko and Guliso while comparatively lower value is recorded for sample from WS. The Pb content obtained in the present study was found to be in the range of the typical daily dietary intake of lead which is 0.015 to 0.100 mg (Shils et al., 1999). The tuber *P. edulis* had 0.130 to 0.357 mg/100g of zinc. The level was superior for samples collected from Guliso. The values were close to those values reported in the literature for sweet potato (0.23 to 0.27 mg/100g) (Sanoussi et al., 2016). Reports (Shils et al., 1999) showed that zinc can boost the immune system and diminish symptoms associated with common cold or flu more quickly in those individuals who consume regularly, or take supplements to fight off these infections and viruses. Zinc works with about 200 different

types of enzymes in the body in an effort to maintain normal growth and development patterns.

Flame photometer was employed to determine the level of Ca, K and Na. Results showed that the level of Ca were from 13.8 to 22.8 mg/100g (Table 1). The value was inferior for samples collected from Guliso. The calcium content obtained in the present study is therefore comparable with the values reported for sweet potato and potato (Sanoussi et al., 1016; Mouille et al., 2009). According to Shils et al. (1999), the recommended daily intake of calcium is 210 to 1300 mg/day. Therefore, the tuber under study can be used as food that can be used as source of calcium. Furthermore the presence of Ca in the tuber of *P. edulis* helps to support bone structure of human beings. Potassium content (325 to 502.5mg/100g) in the tuber of *P. edulis* was relatively high in all samples analyzed in the present study. It was also found that the level of K obtained in the present study is greater than the value reported for sweet potato (308.67 to 328.67 mg/100g) and potato (Sanoussi et al., 2016; Mouille et al., 2009)

Sodium is an important mineral that assist in the regulation of body fluid and in the maintenance of electric potential in the body tissue (Alinnor et al., 2010). Compared to other major elements evaluated in this study, Na was found in low amounts with values ranging from 12.8 to 13.5 mg/100g. The values were inferior to those reported for sweet potato (Ukom et al., 2009). According to Food Program (2015), the recommended intake of sodium with diet ranges from 120 to 1500 mg/day. Na/K ratio of the tubers of *P. edulis* studied varies from 0.025 to 0.04. Various report showed that (Sanoussi et al., 1016), a food source having Na/K ratio of less than 1 has impact on lowering blood pressure since Na/K ratio is known in controlling high blood pressure. Thus, it can be concluded that all the three samples of the tuber of *P. edulis* are good food that have impact on lowering blood pressure. *P. edulis* consumption could be recommended as useful nutraceutical therapy for hypertensive individuals. The result obtained from the analysis revealed that the tuber can be used as food.

The flame photometric method was validated by assessing its accuracy which was done using recovery method. The recovery of the flame photometric method was on average found to be 101% which indicates excellent accuracy of the results. The atomic absorption spectrometric method was validated by using its linearity. The calibration plot obtained from this result exhibited a correlation coefficient of 0.999

indicating a high degree of correlation and a good linearity of the method.

3.2. Fatty Acid Profile of the Tuber of *P. edulis*

The fatty acid compositions of the oil of tuber of *P. edulis* were determined using gas chromatography-mass spectrometry (GC-MS), with the chromatogram depicted in Figure 1.

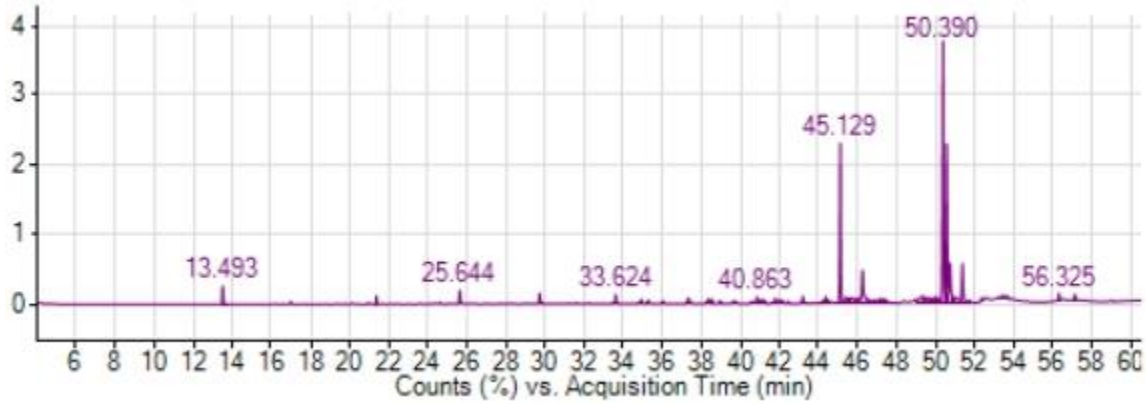

Figure 1: GCchromatogram of fatty acids of the oil of the tuber of *P. edulis*

The results obtained from GC-MS showed that *P. edulis* oil contains a large proportion of double bond containing fatty acids. The dominant unsaturated fatty acid, obtained at retention time of 50.39 min, was found to be linoleic acid which accounts for the total of 42% of the fatty acids. The spectrum also showed other fatty acids at retention time of 45.12, 50.56 and 50.74 min which were due to palmitic (31%), oleic (20%) and stearic (7%) acid, respectively (Figure 2). These fatty acids are typical fatty acids found in various vegetable oils. The low values of the saturated fatty acids recorded in the present study shows that the oil can be used by people with hypertension.

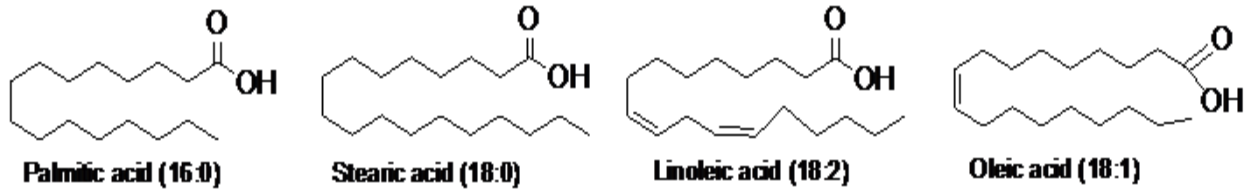

Figure 2: Fatty acids obtained from the tuber of *P. edulis*.

The fatty acid methyl esters identifications were made by comparing the spectra of the components with the database of the spectrum of known components stored in the GC-MS library. The mass spectrum of the peak observed at retention time of 50.39 min, belonging to linoleic acid, is as depicted in Figure 3. The mass spectrum (Figure 3) clearly showed the molecular ion of the fatty acid methyl ester was observed at m/z 294.3.

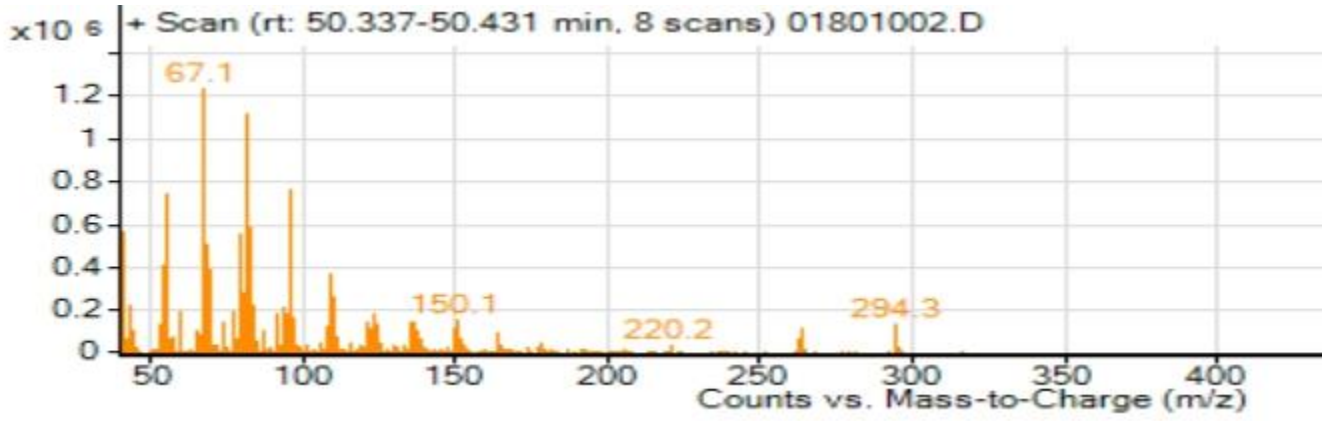

Figure 3: Mass spectrum of linoleic acid (Peak at 50.39 ppm)

4. CONCLUSION

In conclusion the present study has shown that the tuber of *P. edulis* had significant amounts of macro and micronutrients that can be used for various physiological actions. The presence of such high levels of macro and micronutrients can also play a major role in the maintenance of individuals' health. The ratio of Na/K in the samples of *P. edulis* analyzed in the present study in conjunction with the high levels of unsaturated fatty acids in the tuber are suitable as good food in the management of various diseases such as hypertension and diabetes. The tuber was also found to have oil with diverse fatty acids profile. The predominant fatty acid was linoleic acids. Both the mineral composition and the fatty acid profile investigated in the present study showed that the tuber of *P. edulis* can be used as a natural food that can combat malnutrition and diseases.

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5. REFERENCES

Alinnor, I. J., and Akalezi, C. O. (2010): Proximate and Mineral Compositions of *Dioscorea rotundata* (White Yam) and *Colocasia esculenta* (White Cocoyam), Pakistan Journal of Nutrition, 9(10): 998-1001.

Berhanu Andualem &Amare Gessesse (2014): Proximate composition, mineral content and ant nutritional factors of Brebra (*Millettia ferruginea*) seed flour as well as physicochemical characterization of its seed oil. Springer Plus, 3:298.

Food program (2015): Dietary Minerals. Retrieved from http://www.foodpyramid.com/dietary-minerals/ on September 6, 2016.

Fifield, F. W., and Haines, P. J. (Ed.). (1997): Environmental analyticalchemistry. Blackie Academic and Professional, London, 323-349.

Makonnen, M. G. (2015): A possible cultivation system towards genetic improvement of *Plectranthus edulis* (Vatke) Agnew from shoot tip and nodal explants, Afr. J. Agric, **2**(4): 85-91.

Manahan, S. (2000): Environmental chemistry (seven editions). CRS Press LLC, London, England, 204.

Mouille, B., Charrondiere, U. R., Burlingame, B., and Lutaladio, N. (2009): Nutrient composition of the potato. Retrieved from http://www.fao.org/fileadmin/templates/food_composition/upload/potato_nutrient_comp.September , 6, 2016.

Sanoussi, A. F., Adjatin, A., Dansi, A., Adebowale, A., Sanni, L. O., & Sanni, A. (2016): Mineral Composition of Ten Elites Sweet Potato (*Ipomoea batatas* [L.]Lam.) Landraces of Benin.Int. J. Curr. Microbiol. App. Sci, 5(1): 103-115.

Minaleshewa Atlabachew (2007). Studies on Commercially available Enset (*Ensete ventricosum* (Welw.), Cheesman) food Products (Kocho and Bulla) for Major, Minor and Trace Elements (Maser Thesis). Addis Ababa, AU.

Shils, M., Olson, J., Shike, M, & Ross, A. C. (Ed.). (1999): Modern nutrition in health and disease (ninth edition). New York, 109-196.

Taye, M., Lommen, W. J. M., & Struik, P. C. (2012): Ontogeny of the tuber crop *Plectranthus edulis* (Lamiaceae), African Journal of Agricultural Research, 7(30): 4236-4249.

Ukom, A. N., Ojimelukwe, P. C., & Okpara, D. A. (2009): Nutrient Composition of Selected Sweet Potato [*Ipomea batatas* (L) Lam] Varieties as Influenced by Different Levels of Nitrogen Fertilizer Application. Pakistan Journal of Nutrition, 8 (11): 1791-1795.

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Raman Spectroscopy for The Description of Surface Electrical Properties of p-type GaSb Thin Films

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Abstract

The effect of doping level at room temperature on the low injection level photo-response of various un-doped and zinc doped p-type GaSb thin films were investigated using Raman spectroscopy measurements. The presence of a near-surface depletion region was determined through the comparison of the longitudinal optical (LO) phonon mode scattering and the phonon-hole plasmon(L^-) coupled mode in samples of different doping concentrations.Taking into account the values of the carrier densities obtained using the Hall measurements and the ratios of the pick intensities of the LO and the L^- modes,some of the near-surface characteristics, such as the band bending and the surface Fermi-level position above the valence band maximum (VBM) could be inferred as function of the doping level.

Key words: *GaSb, Surface, Fermi-level, Raman scattering, transition, layers.*

1. Introduction

Gallium antimonide (GaSb) is anexciting semiconductor material with several attractiveproperties such as high charge carrier mobility and small (direct) band gap of 0.727 eV at room temperature.This enables the fabrication of high frequency optoelectronic devices working in wide range of infrared region[1]. Gallium antimonide (GaSb) have promising potential to resolve the future challenges of IR optoelectronic devices such asthe need for extending the wavelength for optical communication beyond 1.55 μm to minimize absorption losses in optical fibres [2], the need for maximizing the noise-to-signal ratio of high-speed detectors workingat room temperature (un-cooled) [3-5]and the need for fabricating high frequency optoelectronic devices operating with low power consumption [6-9].

To realize these promises, it isessential to understand and describe the factors controlling the photo-responses of GaSb materials. Differentlayers of a given semiconductor have different photo-responses. However, recent studies on GaSb show that the near surface depletion layer is found to be the most crucial and responsible for the various performance of GaSb samples[10-16]. Hence, the core objective of this work was the study of the effects of the surface and the near surface layersof different GaSb samples on the photo-responsesof the sample by the means of Raman spectroscopy.Raman spectroscopy is found to be a usefulmeans of studying the photo-responses of different layers in semiconductors.Several researchersused Raman spectroscopic measurements asa sensitive means of detecting the presence of a near surface depletion layer and the effects of doping on the photo-responses of different layers in extrinsic semiconductors [12-16].This is typically achieved by comparing the pick intensities of the longitudinal optical (LO) phonon mode scattering and the LO phonon-hole plasmon coupled (L^-) mode.The presence of the longitudinal optical (LO) phonon mode is an evidence for the existence of low free carrier concentration (free charge carrier depleted) layer, and that of LO phonon-hole plasmon coupled (L^-) mode scattering is also an evidence for the high carrier concentration (neutral or accumulation) layer in a given semiconductor [12-16]. The reports of several authors show that, upon employing scattering excitation of sufficient optical penetration depth (x_p) to probe the bulk of a sample, LO phonon mode scattering originates from the hole-depleted near-surface region and LO phonon-hole plasmon coupled mode scattering (L^-) originates from the higher hole concentration regions(the neutraland partly from accumulation layers) of the p-type GaSb [12-17].

It is known that, the electrical property of a semiconductor is not altered under low injection level.Low injection level is the case in which the density of the photo-generated carriers are very much less than the thermal equilibrium majority carrier concentrations or the doping densitiesin a semiconductor under illumination with laser (or light).The widths of different layers in a semiconductor can be considered as almost equal to

the corresponding widths at thermal equilibrium. The width of the highly depleted near surface layerfor an illuminated semiconductor can be directly evaluated by the comparisons of the pick intensities of the longitudinal optical (LO) phonon mode scattering and the LO phonon-hole plasmon coupled mode. The width of the transition region also bedescribed in terms of the doping level. Then, the width of the total near surface depletion layer can be determined as the sum of the width of the transition region and the width of the highly depleted near surface layer. Once, the width of the total near surface depletion width is known, then, the band bending at the surface, the surface charge density and the surface Fermi-level position relative to the valence band maximum(VBM) at the surface can be determined as function of the doping level. The doping leveldependence of the surface Fermi-level pinning position also gives us tremendous information about the doping level dependence of the electronic properties of the surface of a given semiconductor. In this work, we describe whether the Fermi-level positionrelative to the VBM is sensitive or insensitive to the doping density.As a result,the electronic properties of the surface and the performance of the under surface layer (highly depleted layer) of GaSb can be investigated as function of doping level at room temperature.

2. Theory

The bulk of most isolated III-V semiconductors have three various regions of different carrier concentrations. This consists of a neutral region (with high thermal equilibrium majority carrier concentration), followed by a transition layer (with decreasing thermal equilibrium majority carrier concentration in moving towards the surface), and a depleted surface region of very lowthermal equilibrium majority carrier concentration [12-22].The band bending in different layers accounts for the variation of the majority carrier concentrations and the concentration of the ionizations in these layers. Figure 1 illustrates (a) the position dependence of energy band structure and (b) variations of majority carrier density, $p(x)$ and net charge density (ionization), $\rho(x)$, as function of energy in different layers of p-type semiconductor at room temperature. The widths of the transition layer, the highly depleted layer and the total depletion layer are denoted by b_δ, b_S and b_1, respectively.The valence band maximum (VBM) in the neutral region (bulk) is represented by E_{BV} and that at the surface is represented by E_{SV}. The respective conduction band minima (CBM) in the neutral region (bulk) and at the surfaceare represented by E_{BC} and E_{SC}, respectively. The total band bending at the surface is represented by E_S. The Fermi-level position relative to the VBM is denoted by E_{BF} in the bulk and by E_{SF} at the surface. The Fermi and the intrinsic energy

levels in the entire sample are also represented by E_F and E_i, respectively. Applying Gauss's law to the surface and the near surface total depletion region of a given semiconductor, the magnitude of the built up energy of a point in the depletion layer can be given by:

$$E(x)=\frac{k_BT}{2L_D^2}(b_1-x)^2, \qquad (1)$$

where x is the location of the point under consideration relative to the surface, k_B is the Boltzmann constant and L_D is the Debye length described by [17-22]:

$$L_D=\sqrt{\frac{\varepsilon k_BT}{e^2N_A}} \qquad (2)$$

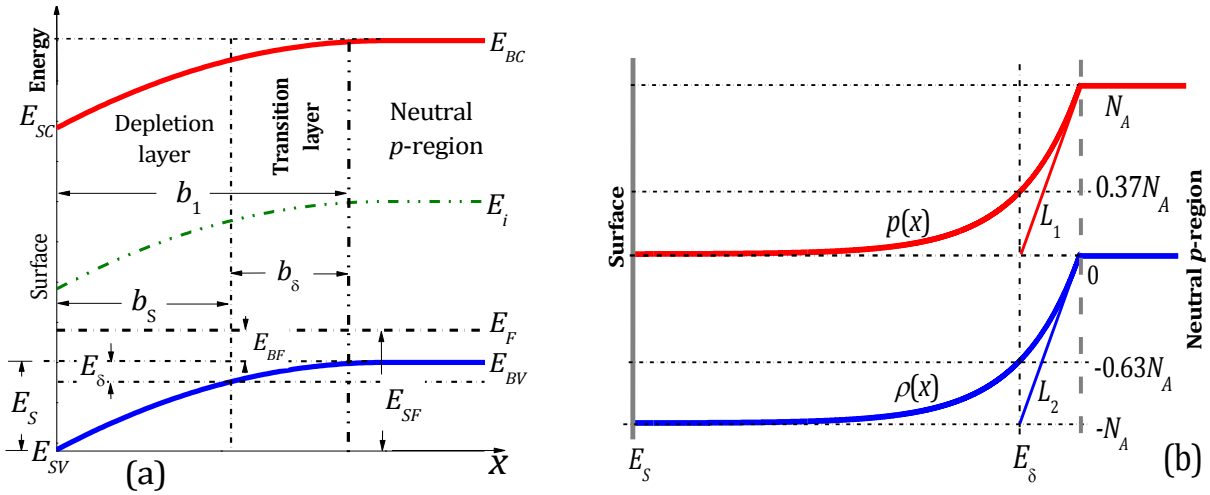


Figure 1: (a) Position dependence of energy band structure and (b) variations of majority carrier density, $p(x)$ and net charge density (Ionization), $\rho(x)$, as function of energy in different layers of p-type semiconductor.

$\varepsilon$is the permittivity of the material and N_A, the doping concentration. Equation (1) is derived assuming very large band bending at the surface and hence the near surface region is highly depleted. At the edge of the quasi-neutral region (x = b_1), the band bending becomes zero and at the surface where x =0 it has value:

$$E_S=\frac{k_BT}{2L_D^2}b_1^2. \qquad (3)$$

Equation that relates the band bending and the Fermi-level position at the surface of p-type semiconductor is given by (see Fig.1):

$$E_{SF}=E_S+E_{BF}. \qquad (4)$$

The description of the band bending at any location x in the depletion region (Eqn. (1)) also enables us to evaluate the thermal equilibrium free carrier's densities at any point x in the depletion region. The majority carrier, $p(x)$ and the net charge (ionization) density, $\rho(x)$at any position x in the depletion layer of a p-type semiconductor can be expressible as:

$$p(x) = N_A \exp\left(-\frac{E(x)}{k_B T}\right) \text{and} \qquad \rho(x) = -N_A\left[1 - \exp\left(-\frac{E(x)}{k_B T}\right)\right], \tag{5}$$

The free hole concentration in Eqn. (5) is in general decreases towards the surface with increasing $E(x)$ while the magnitude of the concentration of the ionization, $\rho(x)$ increases with increasing $E(x)$. The minority carrier concentration at any point in the depletion layer can be described using the law of mass action along with Eqn. (5). The thermal equilibrium majority carrier density, $p_{0S}$and the net volume charge (ionization) density, ρ_{0S}under the surface of a p-type semiconductor at room temperature ($E_S >> k_B T$) hence can be expressed in terms of the energy band bending at the surface, E_S as:

$$p_{0S} = N_A \exp\left(\frac{-E_S}{k_B T}\right) \qquad \text{and} \qquad \rho_{0S} \approx -N_A. \tag{6}$$

Using Eqns. (4) and (6), p_{0S} can be described in terms of the surface Fermi-level position, E_{SF}:

$$p_{0S} = n_i \exp\left(\frac{E_i - E_{SF}}{k_B T}\right). \tag{7}$$

Since n_i and E_i in Eqn. (7) are not the function of N_A, the doping level dependence of p_{0S} can be described only if the doping level dependence of the surface Fermi-level position, E_{SF} is known.

The room temperature surface charge density (σ_{0S}) described in cm^{-2} for p-type semiconductor can also be determined by applying Gauss's law to both the surface and the total near surface depletion region as:

$$\sigma_{0S} = +N_A b_1 . \tag{8}$$

This charge is opposite in sign to the ionization charge discussed in Eqn. (6) above. Upon substituting Eqn. (1) into Eqn. (5), the position dependence of $p(x)$ and $\rho(x)$ in the depletion layer can be described. A closer examination of Figure 1 (b) reveals that the majority carrier concentration decreases rapidly in the initial stages (for energy E close to 0). This is because, the exponential term is changing rapidly or varying linearly with energy, $p(x)$ and $\rho(x)$ also varying linearly with energy for small E as shown by line L_1 and L_2 in Figure 1 (b):

$$p(x) = N_A\left(1 - \frac{E(x)}{k_B T}\right) \text{ and } \quad \rho(x) = -N_A \frac{E(x)}{k_B T}. \tag{9}$$

If this variation keeps its initial value throughout the process, $p(E)$ will fall to its minimum value at the surface and $\rho(E)$ drops to $-N_A$ at energy $E = k_B T$. However, since subsequent slower variation follows with increasing E,the majority carrier concentration, $p(E)$ drops exponentially to $N_A \exp(-1)$, or 37% of N_A and the magnitude of $\rho(E)$ also rises exponentially to $N_A(1-\exp(-1))$, or 63% of N_A at $E = k_B T$ as shown in the solid curve of Figure 1 (b). This range of energy in which the maximum variation of majority carrier concentration takes place is called the *transition region*. Therefore, the transition region in the depletion layer of a semiconductor is defined as the energy range in which the majority carrier concentration decreases to 37% of its maximum value or the ionization rises to 63% of its maximum value. It can also be defined as the energy range in which the magnitude of the majority carrier concentration decreases to zero or the magnitude of the concentration of the ionization rises to 63% of its maximum value, provided the variationsin$p(E)$ and $\rho(E)$ kept at their maximum rate as in Eqn. (9) above.The band bending at the edge of the transition region or between the highly depleted region and the transition region is hence given by:

$$E_\delta = k_B T \tag{10}$$

orcan be derived from Eqn. (1)by substituting $x = b_S$ as:

$$E_\delta = \frac{k_B T}{2L_D^2}(b_1 - b_S)^2 , \tag{11}$$

where b_S is the width of the highly depleted layer or the distance of the edge of the transition layer from the surface (shown in see Figure 1), so that the width of the total depletion layer is the sum of the widths of the highly depleted and the transition layers:

$$b_1 = b_S + b_\delta . \tag{12}$$

Taking into account Eqns. (10) and (11)along with Eqn. (12)yields:

$$b_\delta = \sqrt{2} L_D . \tag{13}$$

Upon illumination of the surface of semiconductors with a light of sufficient penetration depth,an accumulation layer for photo-generated carriers is formed in between the quasi-neutral region and the transition region[12-22].In Raman scattering, the intensity of the LO peak, $I(\text{LO})$ has previously been described in terms of the width ofthe highly depleted near surface region (b_s) and the photon absorption coefficient (α) using the relation[18-22]:

$$I(\mathrm{LO}) = I_0(\mathrm{LO})\left(1 - \exp(-2\alpha b_s)\right), \tag{14}$$

where I_0(LO) is the LO phonon mode intensity observed in a low carrier concentration ($\leq 10^{16}$ cm^{-3}) sample for which the plasmon frequency is too low to affect the LO phonon mode.The factor 2 in Eqn. (14) represents the combined effect of the incident and scattered photons.

The L^-peak, $I(L^-)$ from the higher carrier concentration regions (accumulation and the neutral layers) isalso described similarly as[18-22]:

$$I(L^-) = I_0(L^-)\exp(-2\alpha b_s), \tag{15}$$

where$I_0(L^-)$ is the intensity of the L^-peak.Upon dividingEqn. (14)byEqn.(15),we get:

$$\frac{r}{r_0} = -1 + \exp(2\alpha b_s), \tag{16}$$

where$r$is the ratio of I(LO) to $I(L^-)$, and r_0 the ratio of I_0(LO) to $I_0(L^-)$. The absorption coefficient for a direct band gap semiconductor is expressed by several authors [23-26] as:

$$\alpha(\omega) = \frac{2^{\frac{2}{3}} m_n e^2}{3\hbar^2\sqrt{k_\infty}}\left(\frac{m_n^* m_p^*}{m_n(m_n^* + m_p^*)}\right)^{\frac{3}{2}}\left(1 + \frac{m_n}{m_n^*} + \frac{m_n}{m_p^*}\right)\left(\frac{\hbar\omega - E_g}{m_n c^2}\right)^{\frac{1}{2}}, \tag{17}$$

where $\hbar = h/2\pi$ is the reduced Plank's constant, e the elementary charge, m_n the free electron mass, c the speed of light, ω the angular frequency, E_g the energy band gap between the VBM and the CBM, k_∞ high frequency dielectric constant of GaSb and $m_{n/p}^*$is the effective electron/hole mass.

3. Experimental Details

The samples used in this study were epitaxial p-type GaSb grown in Nelson Mandela Metropolitan University physics laboratory by metal-organic vapour phase epitaxy (MOVPE) on semi-insulating (001) GaAs substrate. The layer thicknessesfor the samples used were varied between 1.4 μm and 15.3 μm. The thicknesses of all the samples used were found to be well exceeded the photon absorption depth in the sample. Hall measurements were used to measure the doping concentrations for all the samples. The typical thermal equilibrium hole concentrationused were 10^{16} cm^{-3} to $10^{17}cm^{-3}$ for un-doped samples and 10^{17} cm^{-3} to $2\times10^{19}cm^{-3}$ for the Zn-doped samples.

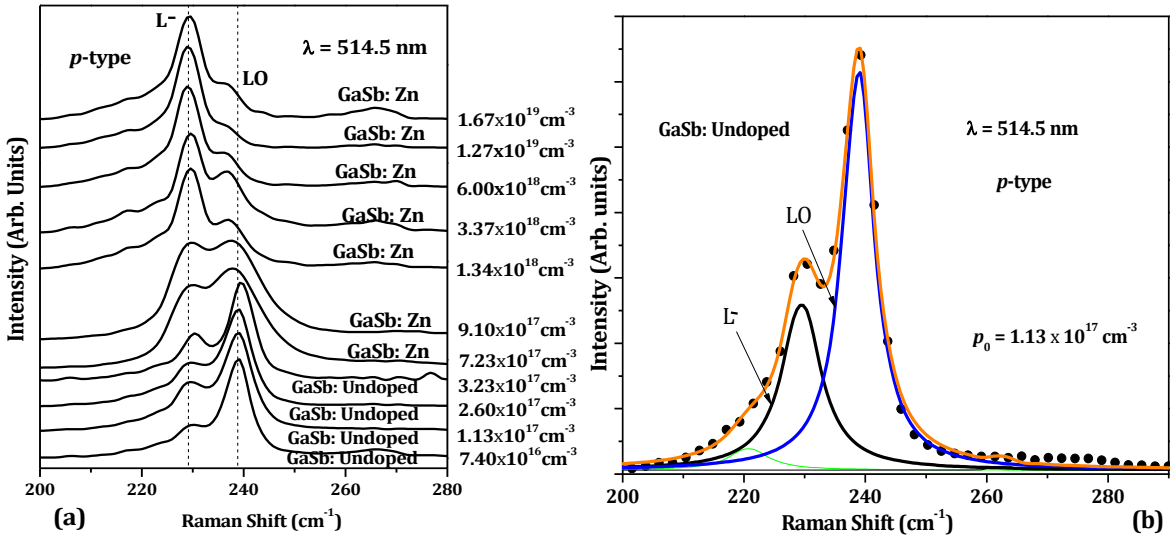
The main components of the apparatus used for the room temperature Raman spectroscopic measurements were a laser source (monochromatic light source), a sample holder (a thick quartz cell transparent to the incident beam), a monochrometer (with diffraction gratings) and a highly light sensitive charged couple device (CCD). A 514.5 nm un-polarized laser line with an incident power of 94 mW/cm^2, was used for probing different depths within the sample. The scattered light from the sample was a mixture of all the Raman lines and the intense Rayleigh line. Part of the scattered light was then focused on a grating monochrometer using lenses and resolved into its components. The light from the monochrometer was converted to electronic signals using the light sensitive charged couple device(CCD). The spectra were collected in a pseudo-backscattering configuration.

4. Results and discussion

Figure 2 shows the Raman spectroscopy results of (a) different *p*-type GaSb epilayers probed using 514.5 nm laser lines, and the contributions of the intensities of L^- and LO as determined by the peak fit method in (b) un-doped (c) slightly doped and (d) highly doped GaSb samples. To

describe the contributions of L^- and LO in the entire intensities of all the samples in Figure 2 (a), pick fit methods were used. Then, the ratio of the pick intensities of the longitudinal optical (LO) phonon mode scattering, *I*(LO) to that of phonon-hole Plasmon coupled (L^-) mode scattering, *I*(L^-) were described for all the samples. The pick fit for Raman spectra of three GaSb epilayers of different doping levels were shown in Figure 2 (b) to (d) below. As can be seen from Figure 2, the peak of the longitudinal optic mode (LO) was prominent at around a Raman shift of 237 cm^{-1} for the un-doped and lightly doped GaSb epilayers. The L^- mode was clearly observed at around a Raman shift of 229 cm^{-1} in at the foot of most the samples might be attributed to the background scattering that can affect the entire intensities in the system, so that their contribution is also included by the pick fit method as it can be seen in Figure 2 (b), (c) and (d).

The 514.5 nm line used to probe the samples in Raman spectroscopy measurements has absorption coefficients (α) to be 4.77×10^5 cm^{-1} in GaSb samples as described by D. E. Aspens*et al.* [26], so that the samples with relatively high carrier concentrations as compared to the LO modes.



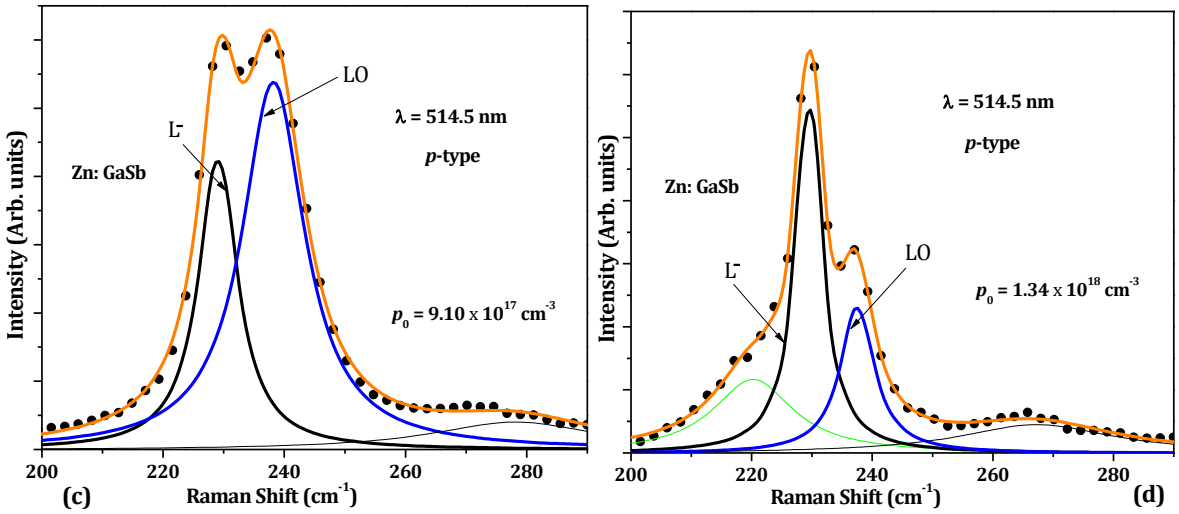


Figure 2: Raman spectroscopy results of (a) different epilayers probed using 514.5 nm laser lines, and the contributions of the intensities of L^- and LO as determined by the peak fit method in (b) un-doped (c) slightly doped and (d) highly doped *p*-type GaSb samples.

The broad band observed at the foot of most the samples might be attributed to the background scattering that can affect the entire intensities in the system, so that their contribution is also included by the pick fit method as it can be seen in Figure 2 (b), (c) and (d).

The 514.5 nm line used to probe the samples in Raman spectroscopy measurements has absorption coefficients (α) to be 4.77×10^5 cm^{-1} in GaSb samples as described by D. E. Aspens*et al.* [26], so that the absorption depth of the line is found to be approximately 21.0 nm. Since the powers of the lights used for illumination were under low injection level, the effects of the photo-generated carrier concentrations were neglected in all the samples when compared to the doping concentrations. Hence, the Hall measurement method was considered as sufficient technique for the determination of the doping densities and the bulk thermal equilibrium majority carrier densities in all doped and un-doped p-type GaSb samples. The calculation of the absorption coefficient $\alpha(\upsilon)$ (Eqn. (17)) in GaSb assumes the high frequency dielectric constant to be k_∞ =14.4, the room temperature band gap energy, E_g = 726 meV, the hole effective masses due to the effect of both the light and heavy holes to be 0.8 and the electron effective mass 0.047

Table 1**:** Parameters related to the surface and the depletion layers in different p-type GaSb samples extracted from the 514.5 nm laser lines Raman spectra shown in Figure 2.

p_0(cm^{-3})	r/r$_o$	Widths (nm)			Energy (meV)			Surface property	
		b_S	b_δ	b_1	E_{BF}	E_S	E_{SF}	p_{0S}(cm^{-3})	σ_{0S}(cm^{-2})
1.00×10^{16}	4.7	18.3	64.1	82.4	193.5	42.7	236.2	1.9×10^{15}	8.2×10^{10}
7.40×10^{16}	4.0	16.7	23.6	40.3	141.8	75.5	217.4	3.9×10^{15}	3.0×10^{11}
1.13×10^{17}	2.6	13.3	19.1	32.4	130.9	74.5	205.4	6.2×10^{15}	3.7×10^{11}
2.60×10^{17}	2.9	13.7	12.6	26.3	109.3	113.0	222.3	2.8×10^{15}	7.0×10^{11}
3.23×10^{17}	2.5	12.6	11.3	23.9	103.7	116.0	219.2	2.9×10^{15}	7.9×10^{11}
4.90×10^{17}	0.9	6.5	9.2	15.7	93.0	75.7	168.7	3.7×10^{15}	1.3×10^{12}
7.23×10^{17}	1.5	9.6	7.5	17.1	82.9	132.7	215.6	5.0×10^{15}	1.4×10^{12}
9.10×10^{17}	1.3	8.5	6.7	15.2	77.0	132.1	209.1	2.6×10^{16}	7.7×10^{11}
1.34×10^{18}	0.9	6.1	9.2	15.3	93.0	71.7	164.7	3.9×10^{16}	1.4×10^{12}
3.37×10^{18}	0.6	4.8	5.5	10.3	67.0	89.8	156.8	2.2×10^{15}	3.2×10^{12}
6.00×10^{18}	0.8	6.0	3.5	9.5	43.1	189.8	232.9	1.6×10^{16}	3.8×10^{12}
1.27×10^{19}	0.4	3.6	2.6	6.2	28.2	145.4	173.6	3.4×10^{16}	5.6×10^{12}
1.67×10^{19}	0.3	2.5	1.8	4.3	8.9	147.8	156.6	4.0×10^{14}	8.6×10^{12}
1.79×10^{19}	0.4	3.6	1.6	5.1	1.8	277.2	279.0	1.3×10^{15}	8.4×10^{12}

Table 1 presents the values of the parameters related to the surface and the depletion layers in different p-type GaSb samples extracted from the 514.5 nm laser lines Raman spectra shown in Figure 2. Parameter r_0 was described from the peak intensity I_0(LO) of the very low concentration (un-doped) and the peak intensity $I_0(L^-)$ of the very high concentration (highly doped) samples before normalization. Then, r was determined from the ratio of I(LO) to $I(L^-)$ for each sample in Raman spectroscopic measurements and the ratio of r to r_0 also described for each sample as function of doping concentration. Using the values of r/r_0 from the Raman spectroscopic measurement data, the width of the highly depleted regions, b_s for all the samples were determined as function of doping level using Eqn. (16). Then, the width of the translation layer, b_δ as function of the doping level is determined using Eqn. (13). The values of the width of the total depletion layer, b_1 for each sample determined as the sum of b_S and b_δ (see Eqn. (12)). Then the maximum energy bending at the surface, E_S and the surface Fermi-level position, E_{SF} can easily calculated using relations (3) and (4). The room temperature value of the energy bending at the edge of the transition layer, E_δ calculated using Eqn. (10) for all the semiconductors is to be 25.86 meV. The Fermi-level position relative to the VBM in the bulk, E_{BF}, the intrinsic Fermi-

level position, E_i and the intrinsic carrier density for GaSb can be calculated using their well-known relations for all semiconductor. The value of E_{BF} is decreasing with increasing doping in the band gap of the semiconductor as we will see later. The typical room temperature values of E_i and n_i calculated using the well-known relations for GaSb are approximately 0.42 eV and 1.71×10^{12} cm^{-3}, respectively. Finally, the thermal equilibrium majority carrier density, p_{0S} under the surface and the surface charge density, σ_{0S} is determined using relations (7) and (8).

The LO mode remains dominant for the range of doping in which the penetration depth of the illumination is less than the total width of the depletion layer ($1/\alpha<b_1$), while the L^- mode dominates in the range of doping for which the penetration depth of the illumination is greater than the total width of the depletion layer ($1/\alpha>b_1$). This shows that LO mode is ascribed to scattering within the low carrier concentration regions and L^- mode to scattering within the high carrier concentration region. Therefore, the presence of the LO in most of the samples shows that the near-surface layer remains depleted across a large range of doping densities. As the doping level increases, the L^- mode also increasing and becomes dominant for highly doped samples, since the width of the depletion layer (b_1) is decreasing and the effect of the highly depleted layer was suppressed as discussed earlier. The systematic increase observed in the FWHM of this peak with increasing carrier concentration was consistent with similar studies on GaSb [9, 27] and GaAs [16].

Figure 3 illustrates the semi-logarithm graphs showing the room temperature doping level dependence of the values of (a) r/r_0 and (b) b_s, b_δ and b_1 drawn using the data tabulated in Table 1. All the solid lines in Figure 3 represent the theoretical results fitted to the experimental results (symbols).

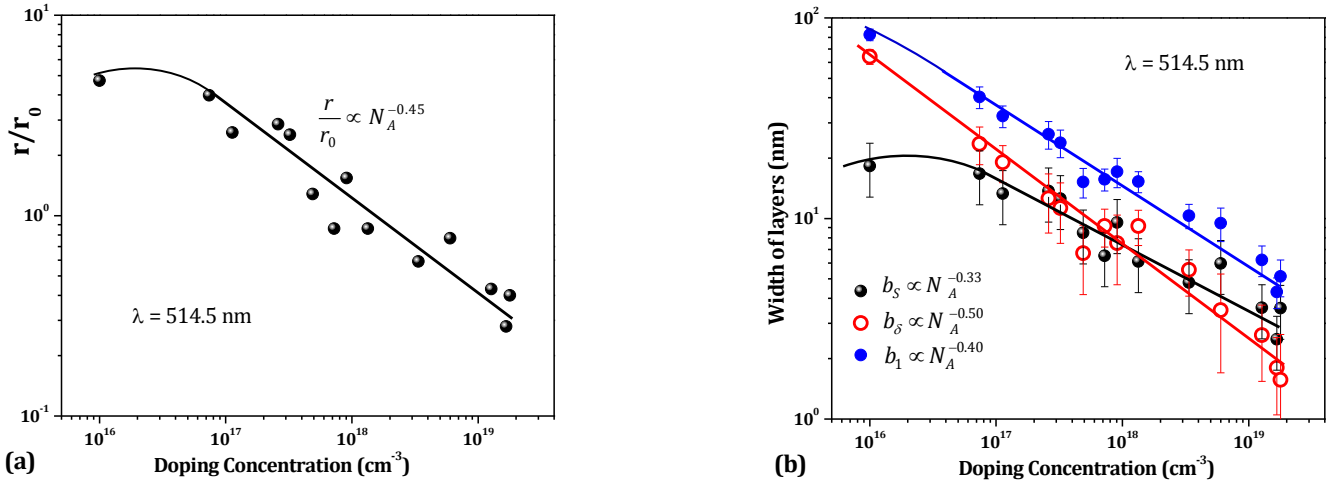


Figure 3: Semi-logarithm graphs showing the room temperature doping level dependence of the values of (a) r/r_0 and (b) b_S, b_δ and b_1 drawn using the data tabulated in Table 1.

Power functions were found to be more reliable for the fitting all the three graphs at higher doping regime. As can be seen from Figure 3, the results obtained for r/r_0 and the widths of the layers in the depletion region in It can also be noticed from the slopes of the curves in Figure 3 that, the width of the transition layer, b_δ drops faster than both widths of the highly depleted layer and the total depletion layers, b_S and b_1 with increasing the doping density. The transition layer dominates most of the depletion region in the low doping regime and this dominance decreases with increasing the doping density and $b_S$becomes the dominance for the high doping regime in the depletion layer.That is, the majority carrier concentration falls abruptly to its lowest value near the surface in highly doped samples within a very thin depletion layer.

For the un-doped and low doping samples, the variation of r/r_0 and b_S with doping is very small while b_δ changes exponentially in the same manner throughout the doping levels. The variation in the width of the total depletion layer, b_1 also shows a slight decrease at the very low doping regime and this variation follows the same exponential manner at the very high doping regime. It is very difficult to generate the relations that can describe the doping level dependents of the above mentioned parameters at this level. This is possible in this case only after describing the doping level dependence of the corresponding energies at the surface and the depletion layer in general decreases with increasing the doping level.

Figure 4 depicts the room temperature doping level dependences of (a) the band bending energies at the surface, E_S and the surface Fermi level position, E_{SF}, (b) The major carrier concentration under the surface and (c) the surface charge density under the surface. The solid lines in Figure 4 also represent the theoretical results fitted to the experimental results (symbols). Description of E_S very necessary to determine the values of the other parameters described in Figure 4. As is shown in Figure 4 (a), logarithmic function is used for the fitting of the graph of E_S, linear function is used to fit for E_{SF}, linear function is used for the fitting of p_{0S} and for the fitting of σ_{0S}, power function is used.

The result obtained in this case shows that, the band bending energy at the surface increases slightly with increasing the samples doping density. Since the increase in the band bending at the surface is completely compensated by the same amount of decrease of the bulk Fermi-level in each interval ($\partial E_S/\partial N_A = -\partial E_{BF}/\partial N_A$), the surface Fermi-level position extracted using Eqn. (4), remains constant approximately at 210 meV above the surface VBM for all the samples (see Figure 4 (a)). The insensitivity of the surface Fermi-level position with a variation in the doping level also confirms the fact that doping appear to have no significant effect on the density of the surface state of GaSb samples. Since E_{SF} is insensitive to the doping level, Eqn. (4)gives the explicit form of the variation of the surface band bending with the doping level in *p*-type materials to be:

$$E_S = C + k_B T \ln\left(\frac{N_A}{n_i}\right), \qquad \textbf{(15)}$$

where $C = E_{SF} - E_i$ is independent of doping. Hence, one can easily notice from this relation that:

$$\frac{\partial E_S}{\partial N_A} = \frac{k_B T}{N_A}. \qquad \textbf{(16)}$$

That is, the rate of change of the energy band bending at the surface is very fast for the low doping regime and *vice versa* as it can be noticed from Figure 4 (a).

Several researchers have reported the position of the surface Fermi-level of GaSb as a function of different surface chemical exposures (Cs, O_2, Rb, Au, *etc*.) using different surface studies (X-ray photoelectron spectroscopy, photoemission and electrical behaviour study of the surface and interface states) [28-31]. The room temperature free surface Fermi-level position obtained by most of these authors lie below mid-gap for p-type GaSb samples. Viljoen*et al*. [32] reported on the cleaved (110) surfaces of GaSb samples using photoemission measurements and showed that the room temperature free surface Fermi-level position relative to the VBM in p-type GaSb roughly below 300 meV. These reported values are hence in consistent with the room temperature surface Fermi-level

positions of p-type GaSb samples obtained in the present work. Viljoen*et al.* [32] have also shown that the surface of GaSb is p-type under all circumstances. It is very easy to identify from these reports that the near surface of p-type GaSb undergoes depletion.

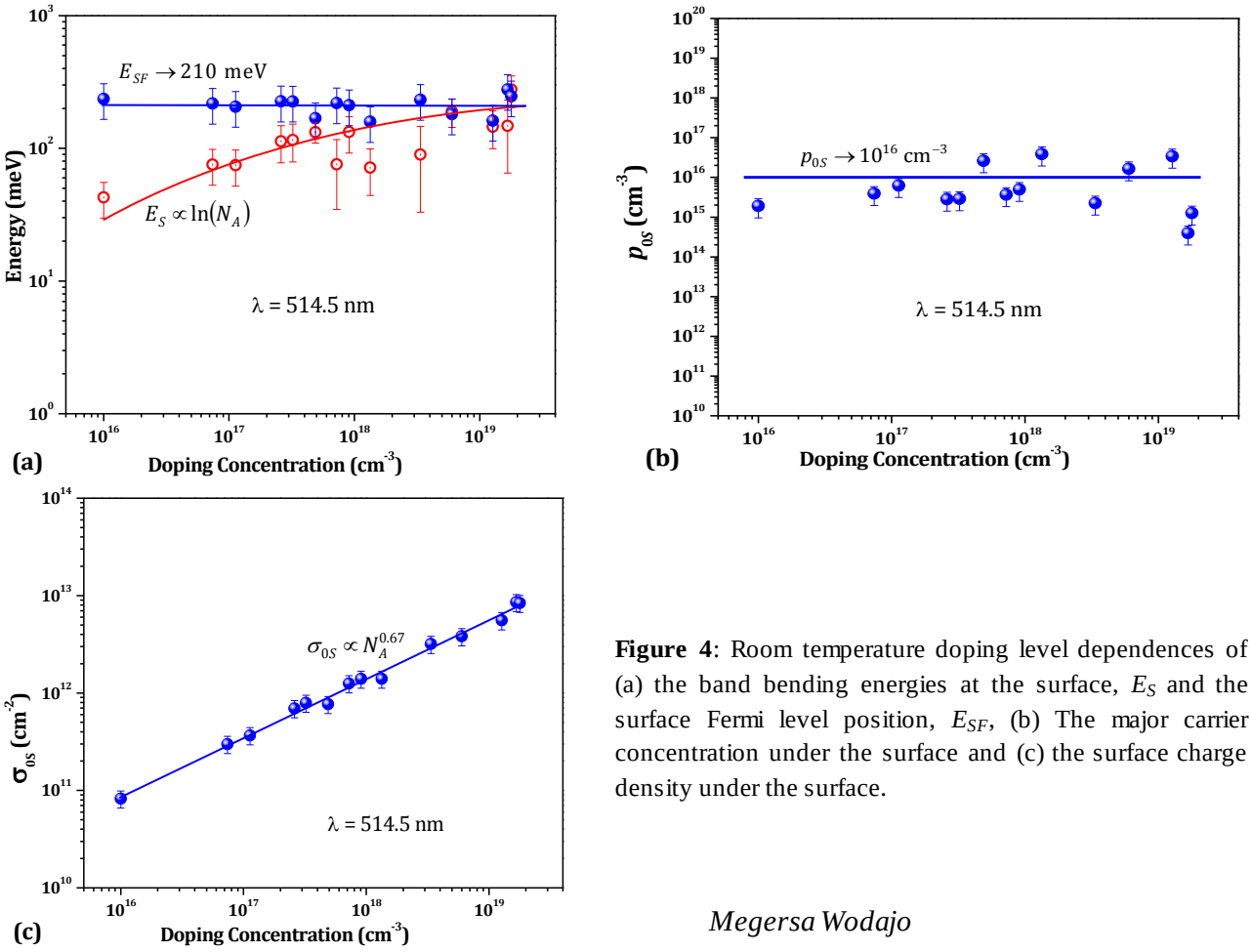


Figure 4: Room temperature doping level dependences of (a) the band bending energies at the surface, E_S and the surface Fermi level position, E_{SF}, (b) The major carrier concentration under the surface and (c) the surface charge density under the surface.

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Figure 4 (b) also shows the majority carrier density, p_{0S} extracted from the measured results of different p-type GaSb samples used in this work. The results for p_{0S} using Eqn. (6) shows that, the doping level and the variation of the band bending do not affect the values of the majority carrier concentration at the surface. The room temeperature values of the under surface free hole concentration (p_{0S}) in this caseis negligibly very small when compared to the free hole concentration in the quasi-neutral region (p_0) for highly doped samples and remains constant roughly at about 10^{15} cm^{-3}in all p-type GaSb samples used in this experiment. A closer examination of Eqn. (7) confirms the insensitivity of p_{0S}, since n_i, E_i and E_{SF} are not function of doping. The room temeperature under surface free electron concentration (n_{0S}) described using the values of p_{0S} and the law of mass action is also found to be approximately 10^9 cm^{-3}. Since n_{0S} is very much less than p_{0S}, this can also be the proof for

the premise that the surface of p-type GaSb undergoes depletion.

Since the Fermi-level position is varying with doping level in the depletion layer except at the surface, the thermal equilibrium majority carrier concentration in the depletion layer also varying with doping level. This variation also increases with incrasing distance from the surface. It can be shown using Eqns. (1) and (5) that, at a fixed distance from the surface in the deletion layer, the majoriy carrier concentration increases with increasing the doping level. This variation also also increases for points far away from the surface. The quantities in transition region show doping level dependence properties that is intermediate to both the surface region and the quasi-neutral region. The increase in the majority carrier concentration in the transition layer with the doping level can have great contibution in the shielding of some parts of the deep bulk region from the effect of the surface charge and tends to narrow the width of the depetion layer with increasing the doping density.

As it is depicted in Figure 4 (c), the surface charge density increases with increasing doping level. This increment is due to the contribution of carriers to the surface states by the additional dopants and increased ionized impurity present in the depletion layer. The variation of the surface charge density has therefore no effect on the surface Fermi-level position and it has direct effect only on the variation of surface band bending in contrary to the effect that the doping level has on the variation of the bulk Fermi-level position.

5. Conclusions

The room temperature photo-responses of different p-type GaSb samples have been measured using Raman spectra. The pick intensities of the longitudinal optic (LO) phonon mode and the phonon-hole plasmon (L^-) coupled mode of various p-type GaSb epilayers were compared using the measured results. The width of the highly depleted near surface layers were calculated directly from the comparisons of the LO and L^- pick intensities for samples with various doping levels. Since the system was under low injection level, the effects of the photo-generated carrier concentrations were neglected in all the samples and the Hall measurement results were used to describe the doping level and the majority carrier concentration in the quasi-neutral region (bulk) of all the samples. The energy gap between the surface and the edge of the quasi-neutral region,b_S was described using the values of b_S obtained from the Raman spectroscopic measurements, the calculated value of the width of the transition layer, b_δ and the doping densities obtained using the Hall measurement results techniques. Using the doping density dependence of the width of the transition layers reported by other researchers for p-type GaSb samples at room temperature, the band bending at the edge of the transition regions were described for all the samples. With the description of these three quantities, the other surface properties like the surface Fermi-level position, the under surface thermal equilibrium carrier concentrations, the surface charge density and other related parameters in the depletion layer could be described. The results of Raman spectroscopic study revealed that both the band bending and the charge density at the surface of p-type GaSb increase with increasing the samples doping density. However, the surface Fermi-level was insensitive to the doping level and pinned roughly at (210±25)meV above the VBM for all of the p-type GaSb samples considered at room temperature. The under surface thermal equilibrium majority and minority carrier concentrations are also found to be remain constant with the variation of doping level in all p-type GaSb samples. This confirms that, doping appears to have no significant effect on the thermal equilibrium electronic properties of the surface of GaSb. The existence of high thermal equilibrium free holes concentration than the corresponding free electrons concentration near the surface confirms that GaSb undergoes depletion (not inversion) at room

temperature. The doping dependence of the electronic properties in p-type semiconductor increases for points far away from the surface in the depletion layer. The transition region shows intermediate electronic properties to both the surface region and the quasi-neutral region. Most properties in the transition region are slightly influenced by the doping density as compared to the near surface region. The effects of doping in general become more influential in the regions closer to the quasi-neutral region and less influential in the regions closer to the surface. This also shows that doping can affect the thermal equilibrium performances of the quasi-neutral (bulk) region of GaSb materials without affecting the electronic properties of the surface region.

References

[1] P. V. Jayaweera, S. G. Matsik, A. G. Perera, Y. Paltiel, A. Sher, Appl. Phys. Lett. 90 (2007) 111109.

[2] R. A. Laudise, J. Cryst. Growth 65 (1983)3.

[3] A. Rogalski, and Z. Orman, Infrared Physics 25 (1985) 551.

[4] A. Joullié, J. Phys. 9 (1999) 2-79.

[5] M. Razeghi, IEEE Journal on selected topics in quantum electronics 6 (2000) 1344.

[6] B. R. Bennett, R. Magno, J. B. Boos, W. Kruppa, M. G. Ancona, Semicond .Sci. Elect. 49 (2005) 1875.

[7] S. G. Choi, S. K. Srivastava, C. J. Palmstrøm, Y. D. Kim, S. L. Cooper, D. E. Aspnes, J. Vac. Sci. Technol. B 23 (2005) 1149.

[8] P. S. Dutta and H. L. Bhat, J. Appl. Phys. 81 (1997) 5823.

[9] H. Kroemer, Physica E 20 (2004) 196.

[10] M. W. Shura, V. Wagener, J. R. Botha and M. C. Wagener, J. Appl. Phys. 111 (2012) 113104.

[11] M. W. Shura, V. Wagener, J. R. Botha and M. C. Wagener, Physica B 407 (2012) 1656.

[12] J. E. Maslar, W. S. Hurst, and C. A. Wang, Appl. Spectrosc. 10 (2007) 1093.

[13] J. E. Maslar, W. S. Hurst, and C. A. Wang, J. Appl. Phys.103 (2008) 013502.

[14]

[15] G. R. Bell and C. F. McConville, Phys. Rev. B 54 (1996-II) 2654.

P. Kozodoy, S. P. Den Baars, and U. K. Mishra, J. Appl. Phys. 87 (2000) 770.

[16] R. Fukasawa and S. Perkowitz, Phys. Rev. B 50 (1994) 14119.

[17] A. Pinczuk, A. A. Ballman, R. E. Nahory, M. A. Pollack and J. M. Worlock, J. Vac. Sci. Technol.16 (1979) 1168.

[18] J. Geurts, Surface Science Reports 18 (1993) 1.

[19] W. Kauschke, N. Mestres, and M. Cardona, Phys. Rev. B 36 (1987-I) 7469.

[20] L. A. Farrow, C. J. Sandroff, and M. C. Tamargo, Appl. Phys. Lett. 51 (1987) 1931.

[21] X. Chen, X. Si and V. Malhotra, J. Electrochem. Soc. 140 (1993) 2085.

[22]

A. Haggag and K.l Hess, IEE Trans. Electron devices 47 (2000) 1624.

[23] P. J. Cousins, D. H. Neuhaus, and J. E. Cotter, J. Appl. Phys. 95 (2004) 1854.

[24] Phys. 95 (2004) 1854.

[25]

A. Subekti, JurnalMatematikaSains, 5 (2000) 1.

[26] D. E. Aspens, and A. A. Studna, Phys. Rev. B 27 (1983) 985.

[27] A. Rakoviska, V. Berger, X. Markadet, B. Vinter, K. Bouzehoune and D. Kaplan, Semicond. Sci. and Technol. 15 (2000) 34.

[28] P. W. Chye, I. A. Babalola, T. Sukegawa and W. E. Spicer, Phys. Rev. Lett. 35 (1975) 1602.

[29] K. M. Schirm and P. Soukiassian, Phys. Rev. B 49 (1994-II) 5490.

[30] P. W. Chye, T. Sukegawa, I. A. Babalola, H. Sunami, P. Gregory and W. E. Spicer, Phys. Rev. B 15 (1977) 2118.

[31] W. E. Spicer, I. Lindau, P. Skeath, C. Y. Su, and Patrick Chye, Phys. Rev. Lett. 44 (1980) 420.

[32] P. E. Viljoen, M. S. Jazzar and T. E. Fischer, Surface Science 32 (1972) 506.

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Success or Failure: Effectiveness of Adama City Master Plan in Managing Urban Growth and Preserving Green Spaces

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Abstract

The fundamental goal of urban master plan is to control urban development scale and limit urban construction scope. However, little empirical research has been conducted to understand the degree to which urban master plan is being implemented after plan adoption and the factors contribute to the variation of its implementation. The research examines the effectiveness of Adama City master plan by measuring the degree to which actual urban expansion over a ten-year period conforms to the plan intention. First, spatial expansion of construction land in planning period is identified. Second, conforming, nonconforming, and unfulfilled areas are identified. Third, two indicators on boundary control were used, through which the effectiveness of boundary containment, and land sufficiency were explored to highlight the effectiveness of the plan. Fourth, the preservation level of proposed land for green spaces is examined. Results of the study reveal that, though, the area encompassed by the master plan is designed large enough to accommodate new developments; it has met more difficulties to control and direct urban growth effectively. Furthermore, proposed land for farmland, informal green, and formal green areas have met more difficulties to follow the plan. The limited effectiveness of the plan mainly attributed to geographic variables, monitoring and evaluation, and political influence. The findings of the research would support sustainable spatial policy and direction of spatial development with respect to sustainable urban environment and creating a balance between ecological and socio-economic needs.

KEY WORDS: *urban growth, master plan, urban planning, green spaces*

1. INTRODUCTION

The fundamental goal of urban master plan is to ensure the sustainable development of urban areas. Urban Growth Boundary (UGB) in the City master plan (CMP) is used to control urban development scale and delimitating urban construction scope (Huang and Tian, 2008). Thus, UGB serves as an effective tool to control the urban sprawling and gives prominence to the guiding role of master plan being widely applied. Among growth management approaches, urban containment policies are widely used to manage urban growth within a planned construction boundary preserving open space, agricultural land, and environmentally sensitive areas that are not currently suitable for urban development (Nelson and Duncan, 1995). Similarly, proposed urban growth boundary in master plan of Ethiopia's urban centers has been implemented as legal boundaries for managing urban growth.

Most of the previous studies tended to hold a positive attitude toward UGBs, and advocated the application of UGBs in different countries to solve the domestic urban problems. At the earliest, Nelson and Moore (1993) evaluated UGB in Portland by using 'residential density" as indicator. Brody & Highfield (2005) have assessed the efficiency of land-use planning and plan implementation in Florida by measuring the degree to which wetland development over a ten-year period conforms to the original design of adopted comprehensive plans of Southern Florida. More recently, Han (2014) analyzed the effectiveness of urban construction boundary (UCB) in Beijing by comparing the morphology of planned UCB with that of the actual urban boundary using GIS technique. Other studies have provided methods of UGB delimitation (Qiwei et al., 2015). Beside these acknowledged studies, however, examination of effectiveness of urban master plan as a tool to rein urban built up expansions within planned growth boundary and related challenges have not been addressed well so far. Moreover, no empirical research is conducted to evaluate Adama City master plan implementation in controlling urban expansion and in preserving proposed lands for green spaces.

Hence, the present study examines the level of implementation of Adama City master plan to direct and control urban growth and to what extent it protected the proposed open spaces at the beginning of planning

period. The plan actually functioned from 2004 to 2014 and it is denoted by CMP04 in this study.

With this aim, the study adopted conformance based approach. Implementation of urban growth management was analyzed from morphological conformity assessment of built up land. The effectiveness was examined using boundary containment ratio (BCR) and boundary sufficiency ratio (BSR). Nonconforming developments were further used to examine conservation of proposed strategic green spaces.

2. MATERIALS and METHODS

2.1 The CMP04

Urban master plan as a tool for urban development has been practiced in the country since 1940s. City master plan (CMP) has traditionally been a crucial type of spatial plan to both envision City development perspective in the future and implement land use control over a specific planning period. It has been revised every 10 years. Accordingly, the latest plan prepared for Adama City was approved in 2004 and actually functioned as a tool to direct and control urban growth from 2004 to 2014. It served as a basic spatial instrument to locate urban infrastructures and to contain urban growth. Structural plan map of CMP04 indicates the distribution and extent of major land use categories; shows magnitude and direction of growth of the City in planning period; and contains the general mandatory provisions for the development of the City.

2.2 Data Acquisition Techniques

Data used in this study were from different sources. UGB and land use plan map were extracted from Structural plan map. Existing built up boundaries of the City of both periods (2004 and 2014) were extracted from land use land cover map as of 2004 and digital orthophoto of the study as of 2014.

2.3 Delimitation of Urban Growth Boundary (UGB) from CMP04

Structural plan map of CMP04 encompasses 13 principal land use categories. In order to delineate proposed growth boundary, proposed land uses are categorized into two classes: Constructible and construction forbidden areas (table-1). This classification was a base for generation of map of "two areas". The delimitation of the boundaries of these areas provide reasonable basis for studying the spatial growth boundary of the City.

Table 1: Reclassification of proposed land use categories in structural plan of CMP04 into "two area"

Land use category in CMP04	New class
Centers &markets, Housing expansion, Mixed land use, Social service, Health service, General service, Manufacturing & Storage, Government office, and Transport	Constructible area
Children play ground, Informal green, farm land, farm and ground water, protection zone, Horticulture	Construction forbidden area

2.4 Conformance Based Evaluation

Planning conformance refers to the conformity between plan and actual development. This theory follows a technocratic view and emphasizes the role of planning as a rational tool to draw a blueprint. Specifically, planning conformance theory assumes that once a plan is adopted, a definite image of the future is confirmed. Thus, the plan evaluation can be undertaken by identifying how closely plan outcomes conform to plan prescriptions (Oliveira &Pinho, 2010). In order to achieve a proper evaluation for different plans, the evaluation theories need to be selected based on the nature of plans. Urban plans can be categorized into two types: project-oriented plans and strategic plans. Projected-oriented plans refer to traditional plans which mostly provide blueprints of the designated end-state of the physical environment. On the other hand, strategic plans deal with the coordination of diverse actors (Faludi& Van, 1994; Faludi& Alexander, 1989).

CMP04 is essentially a material-oriented blueprint plan with a clear envisaged end-state. In other words, the future is closed in the framework of a plan. Hence, with the perception that CMP04 has more features of project-oriented plan, planning conformance theory is chosen as the guiding framework for evaluating implementation of the plan.

2.5 Conformity Assessment

For morphologic conformity assessment, spatial overlay analysis of actual built up as of 2014 and growth boundary of the plan was carried out in GIS framework. Spatial location, extent, and pattern of nonconforming developments were identified.

Quantitative conformity was determined using two basic indicators developed by Han et al. (2009): Boundary Containment Ratio (BCR) and Boundary Sufficiency Ratio (BSR). Figure-1 helps to illustrate these indictors used in the effectiveness assessment.

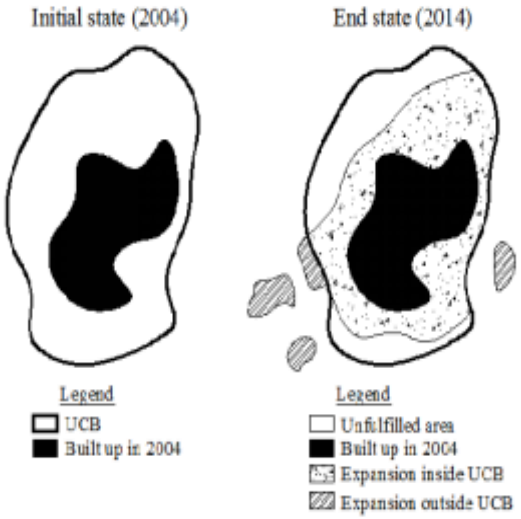

Figure-1: Illustration of the areas and boundaries of analysis

2.5.1 Boundary containment ratio

BCR was used identify that to what extent actual boundary of construction land as of 2014 deviates from planned growth boundary in CMP04. In this regard, less urbanization should occur outside the boundary than inside if the plan is effective to contain urban growth. It is measured by the ratio of "area of increased urbanized land outside the boundary (nonconforming) since its implementation" and "area of increased urbanized land within the boundary (conforming) since its implementation". The higher value of BCR indicates limited effectiveness and vice versa.

$$BCR = \frac{Non-conforming\ area}{Conforming\ area}$$

$$BCR = 0, \quad complete\ effectiveness$$

$$0 < BCR < 1, \quad limited\ effectiveness$$

$$BCR \geq 1, \quad complete\ failure$$

2.5.2 Boundary sufficiency ratio

BSR state that the total possible increase of urbanized land area should be less than or equal to area of proposed land for urban expansion within the planned growth boundary at the beginning of planning period in order to achieve effective urban containment. In this case the area of actual total expansion should be no more than area of proposed expansion. It is measured by the ratio of "area of total increased built-up land since its implementation" and "area of proposed land for urban growth".BSR is inversely proportional to sufficiency of the size of UGB.

$$BSR = \frac{Total\ urban\ expansion}{Proposed\ area\ by\ the\ plan}$$

BSR $\leq$1, planned area size is large enough

BSR>1, planned growth area is insufficient

2.6 Analysis of Green Space Preservation

Green space plays a significant role to prevent urban sprawl, improve urban environment, and store enough space for future development. CMP04 had four kinds of strategic green space land uses: Formal green, Informal green (forest), Farm land, and Ground water protection zones. Evaluating the implementation of green space strongly indicates the control of urban sprawl (He, 2012).

In order to evaluate the level of green space preservation, spatial overlay analysis of nonconforming developments and green spaces proposed in CMP04 was conducted. Then spatial extents of misused land uses were computed. The level of implementation

of the plan was analyzed in terms of preserved areas of each land use class in proposed green spaces class.

3 RESULTS

3.1 Proposed UGB by CMP04

CMP04 targeted at bringing compact development as much as possible and practicable in view of the local climatic conditions (NRSO, 2004). Based on this, urban growth boundary was redefined. By controlling the total amount and regulating the spatial location of urban built-up land, CMP04 is expected to be able to rein the development in proposed urban construction boundary.

Result of aggregated two area classification for UGB delimitation in this study is depicted in figure-2. Area within UGB is the land that reserved to meet the urban growth need in planning period.

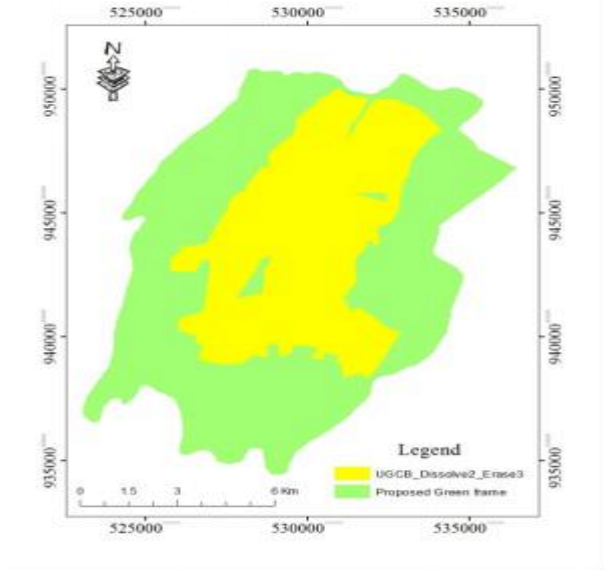

Figure-2: Aggregated proposed constructible and non-constructible areas by CMP04

UGB in CMP04 is predictive type formulated based on the prediction of urban land development required for expected population growth in planning period. Spatial analysis indicates that the plan proposed total 2839.8ha for built up expansion and 7887.9 ha for open spaces using strategic green frame to conserve resources for future development and support smart growth.

2.2 Morphological Conformity

Result of spatial overlay of actual built up and planned urban growth boundary in CMP04 (figure-3) shows that non-conforming developments occurring outside of planned boundary during planning period.

Majority of these open space encroachments are adjacent to UGB at western and eastern parts of the City along the main road from Addis Ababa-Harar. In addition, significant leapfrogging developments away from the dense nodes were also identified in North-West, South-West, and South-East directions, regardless of the UGB set in between. This shows the limitation of the plan in controlling the location of urban construction and preserve open spaces for future development.

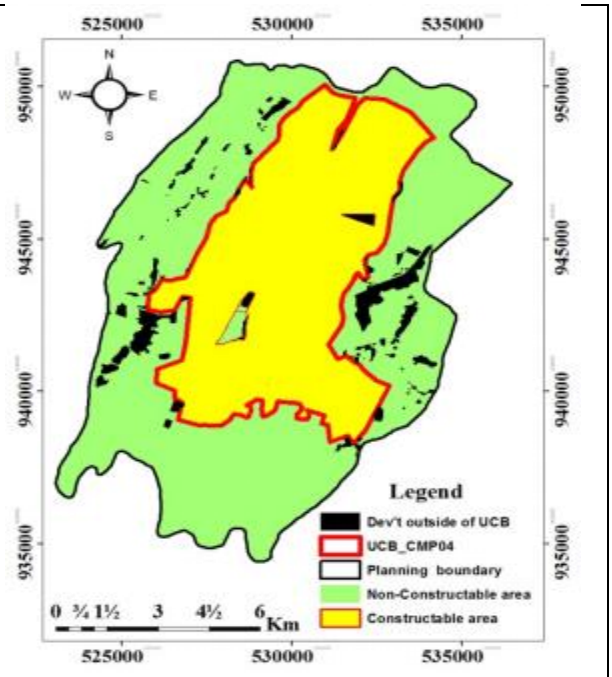

Figure-3: non-conforming developments in Adama City as of 2014

Further spatial analysis of total actual urban growth in planning period reveals that new built up land inside the UGB is 1715.2 ha consisting of 75% of the total built up expansion. At the same time, built up land outside UGB is found 570.4 ha consisting of 25% of the total built up expansion. Most of non-conforming developments are informal developments as of 2004 and not considered during plan preparation. They are supposed to be removed gradually by City administration. However, spatial expansion occurred around them. On the contrary, despite it is reserved for urban growth,

1124.6 ha of land inside UGB located at northern and southern parts of the City is not yet developed indicating poor implementation of the plan in guiding direction of spatial growth.

3.2 Quantitative Conformity

Effectiveness of the plan in controlling urban growth is analyzed using computed value of selected indicators. BCR from area of built up outside and inside UGB; and BSR from area of total built up expansion in planning period and area of proposed land for urban growth in CMP04.

The result shows that value of BCR is 0.33 indicating urban growth outside the UGB has a significant share of the total growth indicating the plan has not effectively controlled the spatial location of new developments. On the other hand, value of BSR was found to be 0.8. It indicates that UGB in CMP04 was planned to encompass area large enough to accommodate all new urbanization if measured by the actual development density. The values of both indicators underline that even the most well intentioned spatial planning designs cannot guarantee conformity or prevent the adverse impacts of sprawling growth patterns.

3.3 Green Space Preservation

The result of spatial overlay of map non-conforming developments and map of proposed land uses in strategic green frame is depicted in (figure-4). It demonstrates that open space encroachments are converted from farmland, formal green, and informal green. Spatial extent of misused land is summarized in table-2 highlights the preservation level of proposed green spaces.

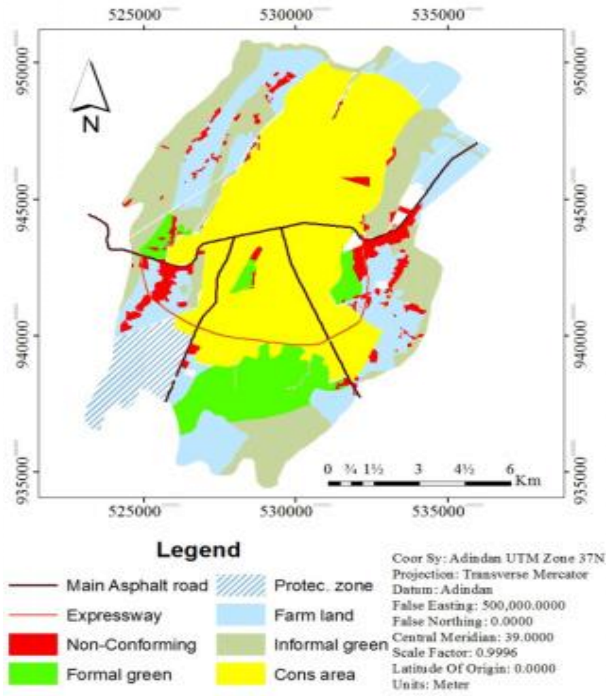

Figure-4: distribution of unplanned developments

Table-2: spatial extents of preserved strategic green spaces proposed by CMP04

Proposed green spaces	**Preserved (ha)**	**Misused**	
		(ha)	**(%)**
Farmland	2737.2	412.35	13.1
Formal green	1217.7	73.68	5.7
Informal green	2673.7	84.42	3.1
Ground water protection	688.9	-	-
Total	**7317.5**	**570.5**	**21.9**

Results depicted in figure-4 and table-2 reveal that proposed ground protection area is well preserved while farmland, informal green, and formal green areas have met more difficulties to follow the plan.

Further analysis indicates that farm land is highly encroached by nonconforming developments. This encroachment is perceived at the outlet to Addis Ababa in front of "Abba Geda". It is strategic site suited close to main road and office of Regional Government and considered potential business site. In addition to this, unplanned developments are identified at the junction point of Adama-Addis Ababa expressway and main road passing through the City at both ends. These sites are relatively perceived suited to ease transportation access. And also most of developments at the outlet to Harar are those of existing developments before CMP04 preparation. According to proposal of the plan, they would be removed gradually. However, in reality they spatially expanded indicating poor implementation. Other leapfrog developments converted from farm land might be due to lack of close supervision. Moreover, non-conforming developments occurred in front of ASTU supplied for expansion has a large share of non-conforming developments converted from formal green and large area occupied by

T/Haiyimanot Orthodox church at the eastern part is converted from informal green. These all explain that CMP04 has met difficulties in preserving proposed open spaces.

4 DISCUSSIONS

In summary, the primary function of urban master plan is to guide and control spatial development of urban areas during planning period. Thus, effectiveness of the plan should be measured by the level of conformity between actual land use outcome and proposed land use in a master plan from both morphological and quantitative perspective.

In this study, effectiveness of the plan is measured by the level of conformity between plan intention and actual outcomes. The findings reveal that the level of conformity is acceptable when measured by the size or quantity. The total area of increased built up land in planning period remains in the limit of the land use quota proposed by the plan.

In contrary, level of conformity between the plan intention and actual land use outcome is low when measured in terms of the morphology. There are significant new developments occurring outside UGB indicating limitation of CMP04 in controlling spatial location of new developments. Such developments are spatial indicators of urban sprawl (Brody and Highfield, 2005). On the other hand, the plan has met difficulties to preserve strategic green frame characterized by encroachment of farm land, informal green, and formal green.

Based on these evidences, it is enough to conclude that CMP04 has met difficulties to play its role in guiding and controlling spatial growth of Adama City. In spite of the morphological deviation, the total area of new developments occurring during 2004-2014 has not exceeded the area allowed by CMP04, which at least shows that the size of reserved land is reasonable. The non conforming developments might result from the following four potential factors.

i. Geographic variables

Proximity to likely public infrastructures and major transportation corridors significantly affects the degree of plan conformity. The spatial variables support the visual results of the study and indicate that most of non-conforming developments occurring outside of UGB are close to major road and expressway passing in the planning area due to better transportation access. It is also perceived that other infrastructure

developments in these areas are relatively good. By contrast, lack of these variables at northern and southern parts of the City is retarded the proposed developments.

ii. Monitoring and evaluation

Non-conforming developments identified in this study might be occurred due to a lack of supervision and monitoring in a timely manner. Technically, through regular monitoring and evaluation, land use changes using geospatial technologies i.e. geographic information system and remote-sensing, it would be possible to identify unplanned developments and take measures to stop the construction in a timely manner.

In addition to this, despite the developments outreach the plan intention, proposed area has not been fully urbanized. Apparently, 11.25km^2 of land within UGB remains undeveloped. It is larger than the area of non-conforming developments identified indicating despite the possibility to develop within reserved area, a large proportion of construction activities happened outside. This explains limitation in monitoring.

iii. Lack of commitment

Illegal and informal developments in 2004 were not considered during CMP04 preparation and they would be removed gradually in planning period. However, in practices, the City administration has not removed many of these developments. Instead, spatial expansion occurred around them. Even the City administration recognized some developments that outreached UGB. It explains that why the majority of illegal developments as of 2004 existed in 2014.

iv. Political factor

Of all the reasons, unsupported political leadership is perhaps the most essential reason that led to the deviation between plan and outcome. Because CMP04 is mainly a 'government-led' plan, the extent of support from regional government will thus largely decide the extent of implementation success of the plan. In Adama, socio-political acceptance and economic development is given the first priority. Hence, in most cases City administration chose to secure political acceptance and support development rather than control. With this aim, political leaders in the City administration, Mayor and its advisory team (cabinet) would place their

primary focus on economic development and political security, since both are the principal criterion when regional government assesses their political achievements. Hence, political leaders in the City provided little support in the implementation of the plan. Instead, the success of investments in Adama made the City administration believe that attracting developers through land supply was an effective way to maintain a rapid economic growth. Moreover, regional government could obtain a considerable sum of land-transferring fees when lending lands to investors, which largely helped the government to maintain its fiscal balance.

Therefore, when development projects come to Adama, the City administration and regional government would satisfy the site selection proposed by developers as much as possible even including areas out of UGB. Especially ones with large economic added-value showed their interests in the City, investors were almost free to select any sites they needed regardless of the limit of UGB. For investors were completely market-oriented, the decisions they made for the locations were mostly based on cost-benefit analysis. Thus, they seldom took the implementation of UGB into account. If the sites out of UGB were economic and appropriate in their opinions, they would definitely apply for that land than within UGB. In order to retain the investment, City administration ultimately accepts their applications. This explains why developments occurred out of UGB at the outlet to Addis Ababa in front of "Aba Geda" are high standard Hotels. Hence, political context in Adama has not created a supporting implementation environment for CMP04.

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

By mapping the spatial expansion of construction land under CMP04 control and measuring the degree of plan conformance, this research evaluated the effectiveness of the plan. The value of the study can be explained in different ways. First, morphological conformity assessment using geospatial technologies provide spatial extent for keeping a plan on track and ensuring effective implementation over the planning period. This method can help planners recognize where there is

nonconformity or significant deviation from original plan design that may adversely influence urban environments. It serves as a monitoring tool with which to guide the direction of plan implementation, to adjust course to updated information, or to plan a new heading before negative outcomes become irreversible. Second, quantitative conformity assessment using BCR and BSR is highlighted the effectiveness of CMP04.This provides insight into master plan implementation as sufficient plan design only by itself will not insure plan implementation. Third, qualitative analysis provides a better understanding of the major factors contributing to nonconforming development and sprawling growth at urban fringes. Identification of why development occurs in unintended areas can help planners reduce such an occurrence in the future. Moreover, it helps the government to design spatial policies to the context to improve plan implementation, to mitigate sprawling development patterns, and to conserve environment. Most importantly, the techniques and findings of this study could facilitate an adaptive approach to other urban centers in the country. An adaptive approach to long-term planning can more effectively reduce undesirable outcomes such as sprawl or prevent development patterns from taking major detours from the originally intended path.

5.2 Recommendations

Although this study provides important information on the effectiveness of Adama City master plan and influencing factors, the results should be considered only an initial step towards understanding the links between urban land use plan and its implementation. Further researches are needed on several fronts. First, only one approach is outlined to examine the effectiveness of urban plans, which by itself is not sufficient. Other evaluation techniques must be developed, and plan implementation should be evaluated with use of multiple approaches of analysis, both quantitative and qualitative. Second, the study has examined Adama City master plan of single planning period. Future research should analyze plans in different planning periods to identify the trend of effectiveness of Adama City master plans. It is recommended that level of implementation urban master plans in more urban centers in Ethiopia should be examined. Comparative analyses would

provide an increased understanding of the effectiveness of spatial planning and plan conformity in general. Moreover, more researches are needed on the factors influencing plan conformity and the degree of urban plan implementation. Finally, regional and National land-use policies should be considered more effectively in order to isolate the effects of growth-management tools on land use plan implementation and sprawling growth patterns.

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7 REFERENCES

Alexander, E. R.,&Faludi, A., (1989).Planning and plan implementation: notes on evaluation criteria.*Environment and Planning B: Planning and Design*, 16, 127-140.

Bengston, D.N., Fletcher, J.O., Nelson, K.C., (2004). Public policies for managing urban growth and protecting open space: policy instruments and lessons learned in the United States. *Landscape and Urban Planning*, 69(2-3), 271-286.

Brody, S. D., &Highfield, W. E., (2005). Does planning work? Testing the implementation of local environmental planning in Florida. *Journal of the American Planning Association*, 71, 159-175.

Brody,S. D., Highfield, W. E., Sara Thornton, (2005). "Planning at the urban fringe: an examination of the factors influencing nonconforming development patterns in southern Florida." *Environment and Planning B: Planning and Design 2006*, 33, 75-96.

Faludi, A., & van der Valk, A. J. (1994). Rule and order: Dutch planning doctrine in the twentieth century. Kluwer Academic Publishers.

GuoQiwei, Chen Xiaojian, and Zhu Yucong., (2015). A Study on Urban Growth Boundary Delimitation: The Case of Baoji, Weinan and Ankang Urban Master Plan.*The Open Cybernetics &Systemics Journal*. 9, 1710-1715.

Han, H. Y., (2014). Theories and Applications of Urban Growth Boundary. Beijing: China Architecture & Building Press.

HAN Hao-ying, LAI Shih-Kung, DANG An-rong, TAN Zong-bo, Ci-fang WU., (2009). Effectiveness of urban construction boundaries in Beijing: an assessment. *Journal of Zhejiang University Science A*. 9, 1285-1295.

He, J. (2012). Implementation of the Shanghai Master Plan. AESOP 26t h Annual Congress. METU, Ankara, 1-26

Huang, M., and X. Tian, X., (2008). Reflection on urban growth boundary in the new urban planning formulation means. *Planner*, 6, 13-15.

National Regional State of Oromia (NRSO), (2004). Synthesized Structural plan. Adama

Nelson, A.C., Duncan, J.B., (1995). Growth Management Principles and Practices. Planners Press, Chicago, IL.

Nelson, A.C., Moore, T., (1993). Assessing urban growth management: The case of Portland, Oregon, the USA's largest urban growth boundary. *Land Use Policy*, 10(4), 293-302.

Oliveira, V., &Pinho, P., (2009). Evaluating plans, processes and results. *Planning Theory & Practice*, 10(1), 35-63.

Oliveira, V., &Pinho, P., (2010). Evaluation in urban planning: Advances and prospects. *Journal of Planning Literature*, 24(4), 343-361.

Pendall, R., Martin, J., Fulton, W., (2002). Holding the Line: Urban Containment in the United States. The Brookings Institution Center on Urban and Metropolitan Policy, Washington, D.C.

Zhang, Z., and Zhang, S. (2013). The ideas and methods of spatial structure-oriented urban growth boundary delimitation. *City Planning Forum,4, 33-41.*

Zhou, C., and YE, C., (2013). Features and causes of urban spatial growth in Chinese metropolises. *Journal of Geographical Sciences*. 6, 728-738.

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Analysis of Physicochemical Properties of Lake Beska; "The Ever Growing Lake of Ethiopia's Great Rift Valley"

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Abstract

In this work we reported the status of one of Ethiopia's Great Rift Valley Lakes; "The ever expanding Lake known as Beseka" in respect to water quality parameters. A composite sample was prepared by combining equal volumes of water samples taken from five Sampling sites. Five physical parameters (pH, DO, EC, T° and Turbidity) were determined for all samples at the spot of sampling while other physical parameters such as TSS and TDS were determined in the laboratory. AAS was used for the determination of heavy metals Pb, As, Cd, Cr, Fe, and Pb while spectrophotometer was used to determine water hardness, total chlorine, NO_3^-, PO_4^{3-}, NH_3, SO_4^2 Alkali metals Na and K are determined by Flame Photometer. The findings indicated that the lake was found to be alkaline with pH above nine and brakish with TDS value of 2569.70 mg/L. The measured higher values of EC and turbidity resulted from higher values of TDS and TSS. Also these values are much higher than the acceptable values for surface water such as lakes. Similarly Pb, Cd, As, F^- and total Cl are above the permissible values while other Physical and chemical parameter are within the acceptable limit of both WHO and FAO Guidelines for drinking and irrigation water.

Keywords: *LakeBeseka, Great Rift Valley, , Physicochemical, Water quality parameters*

1. INTRODUCTION

Ethiopia is naturally endowed with abundant water resources that help to fulfill domestic requirements, irrigation and hydropower (Minstry of Water Resources, 2000). With its current per-capita fresh water resources estimated at 1924m^3, the country is one sub-Saharan African countries endowed with the largest surface fresh water resource. However, only 2% of potential is annually utilized (MoWR, 1999).

The main Ethiopian rift (MER) valley is a part of east African rift system, which extends from the Kenya border up to Red sea. The seismically and volcanically active northern main Ethiopian rift (MER) and Afar rifts are virtually the only places worldwide where the transition between continental and oceanic rifting is exposed on the land (Keir D, 2006). The complex geological processes associated with the rift valley are responsible for creation of east African's largest lakes as well as much of its topography (UNEP, 2008). The main Ethiopian (Woldemichael, 2014) rift valley system occupies very wide plain areas and is constituted by number of surface water bodies mainly lakes of different hydrological and morphometric characteristics (Turdua, 2006).The lakes in the Ethiopian rift valley are situated within three basins: Awash basin (lake Koka, Beseka, Abe), which is located in the northern main Ethiopian rift, the lakes region (HaroDambal, Langano, Abijata, and Shalla), occupying central part of the MER and southern basin (lakes Awassa, Abaya, Chemo and Chew bahir) in the southern section of the main Ethiopian rift (Wikipedia)https://en.wikipedia.org/wiki/Great_Rift_Valley,_Ethiopia Being one of the Rift valley lakes, Lake Beseka is subjected mostly to the impact of natural geologic activities related to the rift valley formation and also to anthropogenic activities that could affect the water quality of the lake and enhance its pollution (Tamiru, 2005). Lake Beseka is one of the highly mineralized lake waters (Bedilu Demissie, 2014). The beds of the lake are volcanic rock and sediments of volcanic ash. Hence the Lake is volcanically dammed, endothermic and saturated with dissolved solids. Lake Beseka has been expanding at an astounding rate since the late 1960's and early 1970's. According to the study carried out by Sir William Hal crow and partners in 1978, in 1962 the lake covered only 3 km^2 and by the year of 1972, the area coverage had reached to 11km^2 (Ministry of Water Resource, 1990). In 1998 its coverage was about 40 km^2 with maximum depth of 11m (MoWR, 1999). In 2005 the lake coverage was about 41.8km^2 corresponding to depth of 15.2m (Tenalem, 2005). Tenalem has evidently showed that change in volume has been found to be related to shift of water balance caused by ground water inflow through open rift faults from the surrounding over irrigated fields and regulated Awash River. Moreover, it has been ever expanding in volume as a result of which serious social, economic environmental factors have been under threat (Tenalem, 2005), (Amare, 2005)(Tamiru, 2005); (MoWR, 1999). The expansion of Lake Beseka is alarming and has detrimental effect on the surrounding biological, physical, hydrological and infra-structural environment. However, trace metal hydrochemistry of the lake which can

potentially be affected by presence of hot springs and the on-going physical dynamism of the lake that involves interaction of the water of the lake with its surrounding geology needs to be studied since the lake is allowed to flow to Awash River, on which thousands of lives are dependent (Ministry of Water Resource, 1990) (Minstry of Water Resources, 2000). Lake Beseka is by the surrounding population for sanitation, drinking water for cattle, home for different aquatic, animals, birds and a number of wild animals. In addition to natural geological factors Lake Beseka is vulnerable to huge anthropogenic activities by the nearby Metehara municipal; Metehara Sugar Estate and Abadir Farm. The color of the lake Beseka is yellowish-brown (Amare, 2005) and this also visually observable. There are different factors such as presence of natural metallic ion (Fe and Mn), humus and peat materials, plankton, weeds and industrial wastes which can impart color to natural water (APHA, 2005); the reason why the color of water of the Beseka is yellowish-brown has not been analyzed. Since, change in color can affect water quality in terms of changing transparency of the water of the lake and hence its biological productivity potential (Wetzel, 1999). MoWR is trying to control the expansion of the lake by discharging about $10m^3/s$ of water to Awash River. However, the adverse effect of the above fact has not studied yet .To these end, the result of the investigation will play a crucial role for further understanding of the chemistry of the lake water and thus contribution to the future water resources management, utilization and environmental protection. So the study involves investigations of the effects of geological and anthropogenic activities on the physical and chemical water quality parameters as well as the impact of the lake on the surrounding ecosystem especially on the downstream of Awash River.

2. MATERIALS AND METHODS

2.1. Study Area

Lake Beseka (latitude $39^o51'$- $31^o53'$N and longitude $8^o52'$- $8^o54'$E) is located in the northern half of the Ethiopian Rift Valley close to Metehara Town at the junction of the Main Ethiopian Rift (MER) and the Afar Triangle about 190 km to East of Addis Ababa. Fringed either side of the main highway and railway line, the lake has been threatening Ethiopia's only access to the Port of Djibouti. It covers an area of more than 40 km^2 with a mean depth of 6 m and maximum depth of 11 m. Moreover, the surface area of the lake has been increasing continuously and its size has changed from 3 km^2 in 1964 to more than 42 km^2(Tenalem, 2005).

Figure 2.1:- Boundaries of Lake Beseka in 2015 and its watershed and sampling sites (Source: Google Earth open source)

Table 2.1: Surface sampling points and the corresponding locations.

Surface sampling sites/ points	Altitude	GPS coordinates	
		North	East
Lake Beseka Point1 (LBP1)	3179	8°54'22.10"	39°53'01.25"
Lake Beseka Point2 (LBP2)	3158	8°53'31.62"	39°51'27.98"
Lake Beseka Point3 (LBP3)	3139	8°52'21.14"	39°52'25.05"
Lake Beseka Point4 (LBP4)	3554	8°53'24.62"	39°54'30.70"
Lake Beseka Point5 (LBP5)	3139	8°49'46.15"	39°50'35.66"

2.2. Instrumentation

A number of instruments and apparatus are used in sampling, sample holding, transportation, preparation, preservation and testing. PET bottles were used as sample holder and ice box for preservation of water sample during transportation. Turbid metric 2100A, EC meter (JENWAY, 4200), pH meter (JENWAY, 430), to measure turbidity, electrical conductivity and pH at the spot of sampling. For this study, a number of instruments were used to determine the concentration of selected Chemical parameters. The Determination of Pb, Cd, Cr, Mn, As, and Fe done out by FAAS whereas the determination of, NO_3^-, SO_4^{2-}, NH_3, F^-, PO_4^{3-}, total hardness and Total Cl was done with Spectrophotometer. The calibration of the instruments was carried out based on (APHA, 2005) protocol.

2.3. Water sampling, transportation, preparation and preservation

Sample collection protocol is the most important step to be followed in any analysis of environmental samples such as water, air or soil. In this experiment we followed (UNEPA, 2010), Guidelines for regulatory monitoring and testing water and waste water protocol. Accordingly, new plastic bottles were labeled and transported to the sampling site. The bottles were rinsed twice with sample water before they are filled with water sample. All the samples were grab samples taken from the surface at one point in the cross-section of the flow. Following the protocol, the samples are then acidified with ultrapure HNO_3, to pH of 2 ± 0.2 (1mL of 65% HNO_3 per liter of the sample), packed and transported to the laboratory for further preparation. The water samples were filtered with a 0.45 μm pore size cellulose acetate membrane filter inserted in a Millipore filtration glass assembly. Samples for metal analysis are transferred to UV-transparent new polyethene bags and, then, 100 μmol/L of ultrapure H_2O_2 was added to initiate radical generation during Solar-UV irradiation. This sample was irradiated with solar-UV of intensity 560 mW/cm^2 for 24 hours (Gelaneh W.M, 2011).

2.3. Method Validation, quality assurance and Sample Analysis.

Method Validation quality assurance and Sample Analysis was done according to (UNEPA, 2010) guidelines for regulatory monitoring and testing water and waste water 2003. Accordingly MDL, percentage recovery were determined for method validation while mean, standard deviation and One way ANOVA are used for quality assurance.

3. RESULTS AND DISCUSION

3.1. Recovery test results

The percentage recovery lied in between 98.32 to 100.12% for AAS as described in table 7 and 99.55 to 100.1% for spectrophotometer (Table 3.1). These imply that, the measured results are within the acceptable range of 75-110%. Thus the digestion of water samples procedure for chemical analysis in the water sample was validated.

Table 3.1:-Recovery test results for metals analyzed by FAAS and spectrophotometer

Parameters	Pb	Cd	Cr	As	Fe	Mn
% recovery	98.32	99.60	100.12	99.90	100.01	101.01

3.2. The results of physicochemical parameters

According to (Chapman, 1996), (WHO, 2004) the pH of most natural waters are within the ranges of 6.5-8.5 implying that lake Beseka is considered as alkaline(table 3.2). The alkaline nature of Lake Beseka arises from the presence of bicarbonate ions (Bedilu Demissie, 2014); (MoWR, 1999) and other alkali and alkaline metals present in the bed rock and volcanic ash. (MoWR, 1999) classified the lake as a sodium bicarbonate type and evidently showed the correlation of its higher pH value with its dominating bicarbonate ions.

The mean temperature of the lake water is 26.6 °C. This phenomenon of temperature has an effect on the physicochemical parameters such as total dissolved solids (TDS), electrical conductivity (EC), pH, dissolved oxygen (DO), and other aquatic life and limnological factors of natural waters. This increased temperature is partially responsible to low amount of DO in in the lake water.

The electrical conductivity of Lake Beseka is measured to be 2709.98µs/cm (table 3.2) which was above the allowable standard for drinking (WHO, 2004). The reason for the observed value of EC arises from the presence of high amounts of dissolved inorganic substances.

The turbidity value of the lake Beseka was 6.34 NTU (table 3.2) and this is slightly higher than the limits allowed for drinking water quality, according to the WHO (2008) standard which is 5 NTU. The presence of high TSS (630 mg/L) is responsible for this value. This increase in turbidity decreases the light attenuation by the

lower portion of the water and this in turn can affects aquaculture.

The total dissolved chemical species (TDS) is 2569.7 mg/L (table 3.2). This implies that Lake Beseka can be classified as a brackish water type since natural waters with TDS values between 1500 mg/L and 5000 mg/L are classified as brackish. In other words, the lake water is between the classes of natural waters known as fresh-waters and saline-waters. The research finding clearly shows that the observed total dissolved solids and suspended solids are above the agreements of (WHO, 2004).

FAO classified water resources with TDS values greater than 2000 mg/Lunder 'severe' degree of restriction for the use of irrigation based agriculture. Lake Beseka's mean TDS value was about 2569.7mg/L which is well above the FAO guideline limit and thus cannot be recommended for irrigation purpose. Since the lake water has been reported to be sodium-bicarbonate type (Bedilu, 2005), (MoWR, 1999) the application of the water for irrigation purpose may cause sodicity problem to agricultural soils. On the other hand, releasing the lake water into Awash River to regulate the ever expanding volume of the lake as it has being practiced by the Ministry of Water Resources may also have possible negative implications on one of the most vital rivers of the country.

Table 3.2:- Mean results of Physical parameters for composite water samples.

Parameters	pH	EC(µs/cm)	DO (mg/L)	Turb.(NTU)	Temp.(^{0}C)	TSS(mg/L)	TDS(mg/L)
Values	9.42±0.02	2709.9± 0.01	6.01 ± 0.03	6.342± 0.01	26.6± 0.50	630 ± 32.01	2569.7±35.43

BOD indicates the amount of biodegradable organics that can deplete DO and it is the measure of the amount of waste or the presence of nutrients which helps the growth of green plants such as algae because the decomposition of these plants increases the concentration of biodegradable organic matter or BOD. In this analysis the amount of BOD and COD is found to be 0.50 and 23.40 mgO/L (table 4.3) the lake water is in the acceptable range (WHO, 2004)

Ammonia is extremely toxic to fish and should be present below 0.2 mg/L. Values above 2 m/L are usually an indication of serious organic pollution (Chapman, 1996). Accordingly, the measured value (0.22 mg/L) is in the acceptable range. This implies that, the lake is safe for aquatic life in respect to ammonia.

In fresh waters, the concentration of nitrate does not exceed 0.001 mg/L and are rarely higher than 1mg/L (Chapman, 1996). Under the influence of human activities, natural waters may contain up to 5 mg/L and this indicates pollution by human or animal waste or fertilizer-run off. The Measured value of nitrate ions was found to be 4.42 mg/L (table 3.3) indicates that the lake is getting polluted by anthropogenic activities.

Arsenic was measure to be 0.059 mg/L (table 3.3) confirming that it is in the range to be present in natural waters (1–2 mg/Land0.01 mg/L) in drinking water (WHO, 2003)(WHO, 2011). The research finding indicated that, the mean values of arsenic is within the above acceptable limit for the lake (WHO, 2003) as surface water but it is above thePermissible limit to be used for drinking purpose.

The observed concentration of cadmium is 0.054 mg/L (table 3.3). The maximum allowed concentration for drinking water is0.003 mg/L (WHO, 2004). This indicated that the lake water is not recommended for drinking. Therefore, releasing the lake water to Awash River might pollute the river itself and can increase health risk of the people living downstream and drinking Awash River water. High concentration of cadmium is also toxic to beans, beets, and turnips at concentrations of 0.1 mg/Lin nutrient solution.

The fluoride content is 2.404 mg/L (table 3.3) which is above WHO's standard (1.5 mg/L) in drinking water (WHO, 2011). The observed high value of fluoride ion confirmed a typical characteristic of ground water of the rift system it is the main cause for the observed tooth decay in the area.

The total amount of iron species over the surface of lake water averaged 0.19 mg/L (table 3.3). This is far less than the concentration of iron expected in natural waters which is 0.50 - 50 mg/L (WHO, 2003). However, the research findings indicated that, iron concentration of the lake increased from previous studies (MoWR, 1990) which were reported to be in the range of 0.01- 0.16 mg/L.

The high temperature of the Ethiopian Grate Rift system is believed to increase the rock-water interaction which could be the main driving force for increasing iron concentration of the lake (Tamiru, 2005).

Lead concentration is 0.631 mg/L (table 3.3) and this revealed that lead concentration is above the maximum allowable international standards. According to WHO, concentration of lead greater than 0.01 mg/L is toxic for humans especially for infants and pregnant. Lead is toxic to both central and peripheral nervous systems including subencephalopatic neurological and behavioral effects (WHO, Guidelines for Drinking-water Quality, 2004). Blood lead level of 30 µg/L causes intelligent quotient deficit of about four points in children. Thus the amount observed in analysis revealed that, the water from the lake is unsafe for both humans and animals.

Manganese concentration was found to be 0.075 mg/L (table 3.3). This concentration is much less than WHO guideline value (0.4 mg/L) for manganese implying the lake water is safe in respect to manganese.

The concentration of sodium in the lake water was found to be 1415.1 mg/L (table 3.3) (table 4.2). The highest concentration of sodium is one of the reasons for the highest TDS of the lake. According to WHO, no firm conclusion can be drawn concerning the possible association between sodium in natural waters and the occurrence of hypertension (WHO, Guidelines for drinking water quality, 2011). Therefore no health based guideline is proposed.

The average concentration of potassium value of the lake water was 45.8 mg/L (table 3.3). Although potassium may cause some health effects in susceptible individuals, potassium intake from drinking-water is well below the level at which adverse health effects may occur (WHO, Guidelines for Drinking-water Quality, 2004).

The measured concentration of sulfate (SO_4^{2-}) is 187.22 mg/L (table 3.3). No health-based

guideline is proposed for sulfate. However, because of the gastrointestinal effects resulting from ingestion of drinking-water containing high sulfate levels, it is recommended that health authorities be notified of sources of drinking water that contain sulfate concentrations in excess of 500 mg/l. The presence of sulfate in drinking-water may also cause noticeable taste and may contribute to the corrosion of distribution systems.

The concentration of phosphate obtained from the laboratory analysis is 21.68 mg/L (table 3.3). Thus the lake water has less contribution to the plant nutrient and hence to the increase concentration of BOD. In other words effect of Phosphate to the depletion of DO is insignificant.

Results obtained for $CaCO_3$ was 80.7 mg/L (table 3.3). Thus the analyzed sample meets WHO and Ethiopian drinking water quality guideline standards of 500 mg/L $CaCO_3$ respectively (WHO, 2004). This also indicates that, the concentration of divalent ions Ca^{2+} and Mg^{2+} ions at Lake Beseka was very low and the water is soft water.

Table 3.3:- Mean results of Chemical parameters for composite water samples

Parameters	Conc. (mg/L)	WHO limit (mg/L)	Pollution status
BOD	0.50± 0.21	*	Acceptable for the lake
COD	23.40 ±1.21	*	Acceptable for the lake
Total Hardness	80.70±3.60	*	Can cause scaling pipe lines/boilers
Ca-Hardness	58.00±2.10	*	Can enhance scaling
Total Alkalinity	8.60±0.31	*	Induce scaling of pipe lines/boilers
Pb	0.63± 0.01	0.01	High; can induce subencephalopathic neurological and behavioral effects.
Cd	0.05 ± 0.004	0.003	Can affect kidney
Cr	ND	0.05	Safe
As	0.06 ± 0.07	0.01	Polluted
Fe	0.19± 0.01	*	Safe
Mn	0.08 ± 0.06	0.4	Safe
NH_3	0.215 ± 0.02	*	Can cause taste and odor problems
Na	1415.10± 8.02	*	May give rise to unacceptable taste
K	45.80 ± 1.00	*	Safe
F^-	2.40 ± 0.12	1.50	Higher, may cause Skeletal/tooth fluorosis
NO_3^-	4.42± 0.01	50	safe
Tot. Cl	339.8± 0.02	5	Very high, cause sterilization of the lake
PO_4^{3-}	21.68 ± 0.08	*	Safe
SO_4^{2-}	187.22 ± 0.06	*	Safe; but may cause noticeable taste

*No health-based guideline value is proposed.

4. CONCLUSION

Lake Beseka is expanding from time to time as indicated in part one of this article and the base rock is basically of volcanic ash and is contributing to the alkaline nature of the lake water. Thus the release of the lake water to the river Awash needs careful attention since it can corrupt the river itself by increasing the pH of the water, salinity and less suitable for river biota by reducing DO and increasing chlorine toxicity. The high concentration of some toxic heavy metals such as lead can also contaminate the river and can endanger human health downstream.

5. ACKNOWLEDGEMENT

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6. REFERENCES

Amare, B. (2005). *Assessment of water quality changes in awash river.* School of Graduate Studies, Chemistry. Addis Ababa: Addis Ababa University.

APHA. (2005). S*tandard methods for the examination of water and waste water 20th.* Washington DC, USA: APHA.

Bedilu Demissie, H. H. (2014). Factors affecting camel and cow milk marketed surplus: the case of eastern Ethiopia. *African Journal of Agricultural Science and Technology (AJAST), 2* (Vol. 2, Issue), 54-58.

Bedilu, A. (2005). *Assessment of water quality changes in Awash River thesis , AAU.* Addis Ababa: AAU,schoo of graduate studies, Environmental science program.

Chapman, D. (1996). *Water Quality Assessment; a guide to the use of biotic, sediments and water in environmental monitoring* (2nd ed.). London: Chapman and Hall.

Gelaneh W.M, T. T.-U. (2011). Solar UV Photooxidation as Pretreatment forStripping Voltammetric TraceMetal Analysis in RiverWater. *International Journal of Electrochemistry, 2011,* 7 pages.

Keir D, E. C. (2006). Strain accommodation by magmatism and faulting as rifting proceeds to breakup. *Ehiopian rift journal of Geophys., 2006.*

Ministry of Water Resource, M. (1990). *Study of Lake Beseka.* Draft final report, MoWR, Addis Ababa.

Minstry of Water Resources, M. (2000). *Status of surface and ground waters for irrigation.* Ministry of Water Resource. Addis Ababa: Ministry of Water Resource.

Tamiru. (2005). Hydro geochemical and lake level changes in Ethiopia Rift. *Journal of Hydrology, 2005*, 1-11.

Tenalem, A. (2005). Change in the hydro geological setting of lake Beseka. Addis Ababa: Addis Ababa University.

Turdua, L. (2006). Infulence of volcanism, tectonics and climate forcing on basin formation and sedimentation. In *The Ziway- Shala lake basin system main Ethiopian rift* (pp. 135-177). Addis Ababa: Artistic Printing Press.

UNEP. (2008). *Africa Atlas of our changing enviroment. Nairobi, Kenya*. Nairobi, Kenya: UNEP.

UNEPA. (2010). Guidelines for regulatory monitoring and testing water and waste water. *UNEPA*. New York, USA: USEPA.

Wetzel, R. a. (1999). *Limnology in Developing countries. Vol.2. New Delhi*. New Delhi, India: international scientific puplication.

WHO. (2003). *Arsenic in drinkin water: Backround document in preparation of WHO guideline* (Vol. WHO/SDE/WSH/03.05/7). Geneva, Switherland: World health Organiation .

WHO. (2004). *Guidelines for Drinking-water Quality* (3rd ed., Vol. 1). Geneva, Switzerland: WHO Press.

WHO. (2011). Guidelines for drinking water quality. Geneva, Switzerland: WHO Press.

Wikipedia. (n.d.). https://en.wikipedia.org/wiki/Great_Rift_Valley,_Ethiopia.

Woldemichael, a. G.-U. (2014). Solar UV-Assisted Pretreatment of River Water Samples forthe Voltammetric Monitoring of Nickel and Cobalt Ultratraces. *Advances in Chemistry, 2014*, 7.

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Performance of Engineering Students in Applied Mathematics

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Abstract

Mathematics has been globally approved as an essential component of engineering and science fields. Thus, studying the performance of applied mathematics is a crucial input for a program aiming at promoting and controlling quality of education in higher learning institutions training students in engineering. The purpose of this paper is to investigate the performance in applied mathematics among engineering students of Adama Science and Technology University, Addis Ababa Science and Technology University, Addis Ababa University and Bishoftu Defense Engineering College. Stratified random sampling technique is used and cross-sectional data are collected from 886 eligible students through structured questionnaire and standardized performance/achievement test. The chi-square test and the logistic regression model analysis revealed that there was no statistically significant difference in students' performance between the science and technology universities and the other universities. The paper also identified topics where students performed poorly in applied mathematics. Moreover, performance of students in applied mathematics was influenced by gender, parents' socio-economic status, pre-university information, high-school mathematics background, class size, absenteeism, class schedule time, student-lecturer interaction and participation in cooperative learning. Finally, the paper calls Ministry of Science and Technology, Universities under study, applied mathematics lecturers and other stake holders to overcome the prevailing problems.

Key words*: performance, engineering students, applied mathematics, statistically significant*

1. INTRODUCTION

1.1. Background of the Study

Mathematics is a fundamental field of study that plays a pivotal role in the development of science, technology, business, and computer science (Barton, 2000).Mathematical techniques are consistently being developed to meet the changing requirements in Physics, Chemistry, Biology, and Behavioral science, Engineering and Computer science (Adleke, 1998). Thus, no other subject forms a strong binding force among other branches of sciences as mathematics. Fields such as Social Studies, Medical science, Psychology, Geology and Business Administration requires Mathematics and use it (Ozer, 1986). Mathematics lessons are more likely to be taught in schools and colleges throughout the world than any other subject (Orton A. and Frobisher J., 2004) and it profoundly influences the socio-economic development of a society and civilization.

Mathematics as a field of knowledge is concerned with conscious examination and study of processes than with particular answers to particular problems, and by the essential dissociation of many of its parts from institution and concrete experience (Hassana O., 2013). In relation, the experiences involving shape or spatial forms lead towards the concept of shape and hence to practical work in real problems (Lee, 1962).

Mathematics is a subject significantly supporting a large number of engineering courses and consequently, it is important for engineering students to hold a strong and fundamental knowledge that can keep their motivation for equitable progress of their engineering fields. Engineering as aprofession requires a clear understanding of mathematics, sciences and technology, hence engineering graduate acquires not only a practical but also abstract understanding of mathematics (Pyle, 2001). Therefore, itis crucial that in university level, most of programs of study require mathematics, at which the ability to mastermathematical skills are important indicator of potential for students in all levels of academics endeavors (Tang, etal. 2009). Mathematics is therefore a subject that supports all the sciences and hence it is the mother of all sciences (Felder M., et al. 1994). It is an inconvertible fact from historical evidence that much advancement in science and technology have their roots in mathematics. Consequently, no nation can hope to advance higher in science and technology without the proper foundation in mathematics. Therefore, the importance of mathematics to humanity cannot be over-emphasized.

The government of Ethiopia is trying to give special attention to Mathematics and Natural Science fields so that the country will be transformed into industrializations. Despite the attention given by the government and the aforementioned significances and applications of mathematics in sciences and engineering, I have observed a significant discrepancy in performance of applied mathematics among engineering students in my discourse of teaching experiences. Therefore, the investigator found that it is crucial to investigate performance of students in applied mathematics and background factors associated with it among engineering students.

1.2. Objectives of the Study

The objectives of this study are to: 1) examine if there is a significant difference in performance of applied mathematics between the Science and Technology University and other Universities, 2) identify some specific areas of difficulty encountered by most of students while learning applied mathematics, 3) investigate if there is a significant difference between male and female students' performance (achievement) in applied mathematics and 4) explore some factors that influence students' performance in applied mathematics.

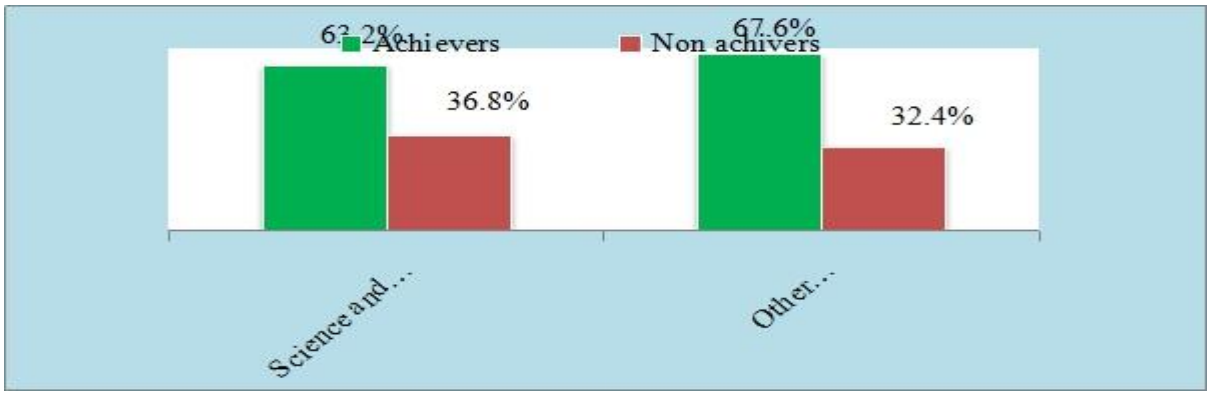
2. RESEARCH METHODS

This is a quantitative study which explores performance of engineering students in applied mathematics. A sample size of 886 students was determined under the assumption of 95% confidence level and 5% margin of error. Stratified random sampling technique was employed to select the eligible students and cross-sectional data were obtained through structured questionnaire and the standardized achievement/performance test. The first stratum consisted Adama Science and Technology University (ASTU) and Addis Ababa Science and Technology University (AASTU) which were categorized as science and technology universities while the second stratum consisted Addis Ababa University (AAU) and Bishoftu Defense Engineering College (BDEC) which were under the category of other universities. The data were analyzed by using the Statistical Package for Social Science (SPSS 7.0). The analytical tools employed in this study were logistic regression model and a chi-square test. A logistic regression model was used to measure the overall effect of independent variables performance and a chi-square test was used to test the existence of the association between performance and independent variables.

3. RESULTS AND DISCUSSION

3.1. Performance in Applied Mathematics and Specific Areas of Difficulty

Figure.1: Performance in science and technology universities and other universities ()

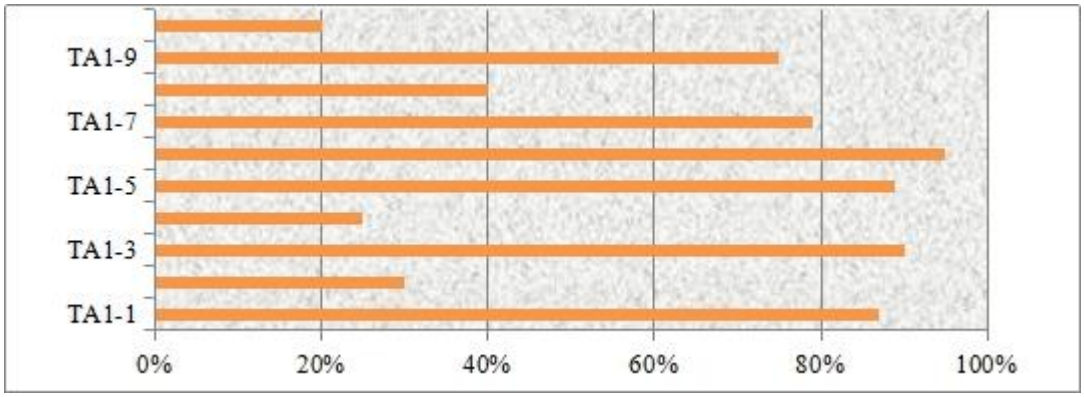


As indicated in Fig.1, the proportion of achievers was 63.2% in Science and Technology Universities where as proportion of achievers was 67.6% in other Universities.

Moreover, the analysis in the chi-square test indicated that there was no statistically significant difference between science and technology universities and other universities in the performance of applied mathematics of engineering students (c2 = 1937,) as given in table 3.

In the standardized test of applied mathematics I areas of difficulty were application of integration, definition of limit and vectors spaces and subspaces as depicted in Fig.2.

Figure.2: Distribution (%) of students' performance in topics of applied mathematics I (n=296)



Keys: TA1-1 Vectors

TA1-2 Vector spaces and sub-spaces

TA1-3 Matrices and system of linear equations

TA1-4 definition of limit

TA1-5 Continuity

TA1-6 Basic differentiation rules

TA1-7 Derivative tests

TA1-8 Max-min value problems

TA1-9 Techniques of Integration

TA1-10 Application of integration

Similarly, in the standardized test of applied mathematics II the areas of difficulty were multiple integrals and its applications as presented in table1.

Table 1: Distribution (%) of students' performance in applied mathematics II topics (n=295)

Topic/subtopic	Percentage(%) of correctly answered questions from a given topic/subtopic
Sequences and series	79.7
Convergence tests for series	63
Power series	71.2
Directional derivatives and the gradient	86
Limit & continuity of funs of several variables	72.1

Extreme values of funs several variables	57
The Lagrange Multiplier	44
Multiple integrals	32.3
Application of multiple integrations	19.9

In the standardized test of applied mathematics III, the areas of difficulty were Stockes' theorem and divergence theorem,surface integral and Green's theorem as indicated in table 2.

Table 2: Distribution (%) of students' performance in applied mathematics III topics (n=295)

Topic/subtopic	Percentage (%) of correctly answered questions from a given topic/subtopic
First-order ODEs	83.4
Bernoulli equation	79.3
Application of 1st order ODEs	42.1
Second-order ODEs	76.4
Euler equations	79.8
Application of 2nd order ODEs	36.5
Fourier series-funs of period	67.8
Fourier series-funs of period	51.2
Half range expansion	31.1
Laplace transform: s-shifting	71.4
Convolution	33.2
Laplace transform: t-shifting	32.1
Line integrals	45.3
Green's theorem	27.2
Surface integrals	25.4
Stockes' theorem and Divergence theorem	23.7

3.2. Factors Affecting Performance of Students in Applied Mathematics

The result of the study as indicated in table 3 the probability of being an achiever in applied mathematics for female students were lower than that of male students (). This might be perhaps due to the fact that most of the families do not encouraged their female children academically during high school due to some socio-cultural factors and these might in turn influence their performance in university.

The probability of being an achiever for students from illiterate parents was lower than that of students from parents with diploma and above level of education and the difference was strongly significant as indicated in table 3. Furthermore, the probability of being an achiever for students whose parents have completed primary and secondary level of education were and respectively lower than that of students from parents with diploma and

above level of education. Thus, College diploma and University degree of parents had guaranteed for the performance of their children in applied mathematics in universities under study. This means students from families who are closest to the academic culture had greatest success in applied mathematics. This might be obviously due to the fact that educated parents provide their children both the necessary information and materials that support their education while bringing up them. These parents also provide higher levels of psychological support for their children through environments that encourage the development of skills necessary for academic success since the higher the educational attainment for parents, the greater their aspirations for their children.

The results in the chi-square statistic and the logistic regression depicted that the chance of being an achiever in applied mathematics was strongly associated with their high school mathematics background and information before joining university about engineering fields as shown in table 3. This suggested that conventional measures of academic achievement are the best determinants of future performance at university. However, the performance of students in applied mathematics was not significantly different between students from government and private high schools with value.

As it was expected, students' class attendance influenced their achievement in this study because regularity shows the effort and seriousness of student about his or her education.

Table3: Results of logistic regression model on performance of applied mathematics (n=886)

Variables	Regression coefficients (β)	S.E	P-value	Relative odds: Exp(β)
Sex(reference = Male)				
Female	-1 .273	0.54	0.018*	0.280
Parent education(reference = Diploma and above)				
Illiterate	-3.48	0.832	0.000***	0.031
Primary	-2.394	0.624	0.000***	0.091
Secondary	-2.011	0.591	0.001**	0.134
Parent occupation(reference = Employed)				
Unemployed	-1.992	0.468	0.000***	0.136
Parent monthly income(reference = 6000-10,000)				
0-1000	-3.150	0.746	0.000***	0.043
1001-2500	-2.909	0.748	0.000***	0.055
2501-5999	0.736	0.714	0.303	0.479
10,000	-1.329	0.653	0.042*	1.265
Type of high school completed (reference = Private)				
Government	-0.196	0.745	0.792	0.822
High school math background(reference = High)				
Moderate	-2.062	0.592	0.000***	0.127

Fair/poor	-3.355	0.570	0.000***	0.035
Pre-university information(reference = Yes)				
No	-4.745	0.595	0.000***	0.009
Class size(reference = 31-60)				
≤30	-0.909	0.685	0.000***	1.404
≥60	-4.013	0.586	0.000***	0.018
Class attendance/non-absenteeism(reference = High)				
Moderate	0.281	0.479	0.557	0.325
Fair/poor	- 1.707	0.618	0.006*	0.181
Class schedule time(reference = Always/mostly morning)				
Sometimes morning	-0.656	0.567	0.247	0.519
Always/most of the time afternoon	-2.460	0.540	0.000***	0.085
Lecturer-student interaction(reference =High)				
Moderate	-1.110	0.549	0.043*	0.330
Fair/poor	-2.663	0.717	0.000***	0.070
Co-operative learning(reference = Yes)				
No	-1.292	0.463	0.005*	0.275
Extra-curricular activities(reference = Yes)				
No	0.658	0.498	0.187	1.930
Type of university (reference = Other universities)				
Science and technology universities	-0.325	0.524	0.534	0.722

Table 3: Results of logistic regression model on performance of applied mathematics

-2Loglikelihood	**1144.654**
Model $\chi 2$	979.688

Note: Statistically significant at: * P < 0.05; **P < 0.01; ***P < 0.001

In the analysis of this study as presented in table 3, it was found that students' performance was associated with class size during applied mathematics lesson. That is, the results in this study showed that students performed better in applied mathematics in smaller class size. This is the case because in a large class size students lack concentration and the teacher also fail to manage the whole class. As a result, some students prefer to sit at the back and may be connected to some social media like face-book through their phone cells. Some students may also discuss about issues that are not related to the subject being taught in the class. Students must be given a fair chance to demonstrate their capacities in learning.

Time of class schedule had shown an effect on students' performance in applied mathematics according to the results in table 3. Thus, the performance of students in applied mathematics

was better when class schedule arranged most of the time morning. This result may be justified as, students might be absent most of the time from class or might get depressed and felt sleep when the class scheduled in the afternoon. Learning mathematics requires drilling, digging and following its steps attentively. So, mathematics class should be shifted from hot afternoons to morning to reduce tension and anxiety among the students.

According to this study, lecturer-student supportive interaction andperformance in applied mathematics was strongly associated as presented in table. This might be because most mathematics instructors encourage and give attentions to few students who are brilliant. Some of them are inaccessible to students that they are teaching and only few are happy to support, encourage and ready to mentor students with low capacity in mathematics and hence such students afraid to knock at their instructors' doors to seek for clearance of teachings done in the class as well as during study time which they could not understand. It is high time that mathematical sciences lecturers shift from theory to practical application of those theories. As its name "applied mathematics" indicates instead of just teaching the theoretical aspect of mathematical sciences, showing its applicability in real life and everyday life situation may enhance interest and better performance of students. In support of the recent drive of the Ethiopian government for technology transformation and sustainable development, the generic skills in mathematic can be explored. Time has come; lecturers in mathematical sciences should enhance their teaching with practical applicability of the proofs and computations to real life situation and help students in developing interest by answering the question "computation for what?"

The results in table 3 indicated that participating in co-operative learning and thus, studying together assisted students in their performance of applied mathematics. This might be the case because students organized in cooperative learning (five-in-one) got the intended support from those outstanding students in the group through doing work sheets and solving different problems together. But the performance of students in applied mathematics was not significantly influenced by participating in different extracurricular activities.

4. CONCLUSION

According to the results of this study, there was no significant difference in performance of applied mathematics between science and technology universities and other universities. Besides, there was strong association between the dependent variable performance in applied mathematics and a number of predictor variables such as sex, parent educational level, parent occupation, parent monthly income, pre-university information, high school mathematics background, class size, class schedule time, class attendance/absenteeism, participation in co-operative learning and lecturer-student supportive relationship. But performance had no significant relationship with type of high school completed, participating in extracurricular activities and type of university.

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6. REFERENCES

Adleke, A. (1998): Teacher's attitudinal variable in the implementation of the further mathematics curriculum as correlates of students' learning out comes. *Zimbabwe Journal of Educational Research, 52, 369-377*.

Barton, A. C. (2000): Crafting multicultural science education with pre- service teachers through

Service-learning. Journal of Curriculum Studies, Volume 32(6), 797-820.

Felder, M. R, Mohr, H. P, Dietz, J.E and Ward, B.L. (1994): A longitudinal study of engineering student performance and retention: Journal of Engineering Education, 83(3) 209-217.

Hassana Oseiwu Ali(2013). Factors affecting students' academic performance in mathematical sciences department in tertiary institutions in Nigeria. US-China education review A, Vol. 3, No. 12, 905-913.

Kumar, S. and Ratnalikar, D.N. (2003): Teaching of mathematics. New Delhi: Anmol publications Pvt. Ltd.

Lee, D. M. (1962): A background to mathematical development. London: Old Bourne B.Co. Ltd.

Orton, A., Orton, D., & Frobisher, L. J. (2004): Insights into teaching mathematics. Continuum

International Publishing Group.

Ozer, Ahmed Hamdi (1986): *Discovering mathematics one*. Ankara: Ardic publications.

Pyle, I. (2001): Mathematics in school. Engineering Science and Education Journal, 170-171.

Tang, H.E.,Voon, L.L., & Julaihi, N.H. (2009): A case study of 'High-Failure Rate' mathematics courses and its' contributing factors on UiTM Sarawak diploma students. *Paper presented at the Conference on Scientific & Social Research,* 14-15.

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Effectiveness of Competency - Based TVET Curriculum in TVET Institutions of Oromia Regional State

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Abstract

A considerable number of TVET trainees are characterized by incompetence, as revealed by COC assessment which resulted in failure to be self employed and employed in different public and private sectors. Using this situation as a rationale, this study aimed to assess the reasons behind incompetence of trainees of competency based program in TVET institutions of Oromia Regional State. Percentages, mean values, standard deviation, Mann-Whitney U test and binary logistic regression were employed to analyze the data. The study revealed the ineffectiveness of TVET program with 74.6% incompetence and 25.4% competence of trainees in COC assessment. The study found out that weak preparation of teaching learning materials, poor implementation of principles of competency based training, poor TVET teachers training and poor TVET institutions and industry linkage. The study also investigated the factors that have strong predicting power of competence of trainees in COC assessment. Integrating knowledge, skill and attitude during training, making competencies to be achieved public in advance, actual demonstration of competencies during training, engaging trainees in applying skills similar to the real world of work, using progress record chart during training and providing practical skills to trainees by industries during cooperative training were found to be the major predictors of competence of trainees in COC assessment

Key Terms: *TVET, COC, Competency-based Curriculum, Industry TVET Linkage, Binary logistic regression*

1.1. Background of the Study

TVET plays a crucial role in human resource development of the country by creating skilled human resource, enhancing industrial productivity and improving quality of life. Strengthening the importance TVET Sharma (2008), indicated education is considered as a key to development whereas TVET is a master key because it has the ability to open all doors of the lifelong learning, reduce unemployment and improve the quality of living. These roles can be realized when competency based TVET program is applied.

To implement competency based curriculum, curriculum reform has been undertaken in the TVET system of the country. In the reformed new competency based Ethiopian TVET system, the role and the character of curricula significantly differ from the role and character of the curricula in the past. While in the past the responsibility for curricula and curriculum development was on the federal Ministry of Education (MOE), it is now transferred to the regions and individual training providers. In the new competency based TVET system, the Ethiopian Occupational Standard (EOS) serves the function of the national Ethiopian standard which defines the occupational requirements and expected outcomes related to the specific occupation. Regarding curricula and curriculum development, the EOS is the basic and relevant reference (MOE, 2007). Therefore, since competency based TVET curriculum design and implementation is a complex, challenging and demanding task, it becomes necessary to investigate how it is designed and implemented and its overall effectiveness.

1.2. Statement of the Problem

According to studies made in Indonesia (Suartini, et al. 2010) and Ghana, (Dasmani, 2011) most graduates from competency based TVET schools lacked adaptability toward the change or development of technology and faced difficulty to cope with it. As a result, the industries were hesitant with competence of the graduates. Competency based TVET program was not effectively implemented in those countries to fulfill the needs of industry.

The studies so far made have focused on the competence of graduates, and the number employed graduates. However, they have not assessed the reasons behind incompetence of trainees in COC assessment. Thus, from this point of view, it becomes very crucial to assess the reasons behind incompetence of graduates of competency based TVET program in TVET institutions of Oromia regional state with particular emphasis on TVET curriculum. To assess these problems the following basic questions were set.

1. What is the current competence status of TVET trainees as assessed by Oromia Center of Competence?
2. How do TVET institutions design competencies based teaching learning materials?
3. How do TVET institutions implement the basic principles of competency based curriculum?

4. To what extent does teachers' training support teachers' in implementing competency-based TVET curriculum?
5. To what extent are TVET institutions attached to industries and other sectors?
6. What are the major determinants of competence of trainees in COC assessment?

2. RESEARCH METHODOLOGY

2.1. Research Design

Research designs are plans and procedures used for research spandecisions from broad assumptions to detailed methods of data collection and analysis. There are three types of research designs, namely qualitative, quantitative and mixed methods. From these research designs mixed research method was employed in this study. There are different types of mixed research methods or strategies. From these different strategies, this study employed the concurrent nested (embedded) mixed research method or strategy. More emphasis was given for quantitative approach, and the qualitative method was embedded in it. This strategy will be employed when a researcher chooses to utilize different methods to study different groups or levels (Creswell, 2009). In this study, different target groups (trainees, trainers, deans, coordinating teams) were involved and studied quantitatively and qualitatively and, hence, this will be the reason for selecting this strategy or method.

Instruments of Data Gathering

The primary instruments for collecting data was self developed questionnaires and interview questions that help to gather evidence based quantitative and qualitative data on the views, opinions and perceptions of the informants regarding TVET curriculum material preparation and implementation, teachers' training, TVET industry linkage and, in general the effectiveness of competency based TVET program in Oromia Regional State. Content analysis of competency based teaching learning material was done using Technical Education Curriculum Assessment rubric, (TECA). Validity and reliability were established using a panel of academicians and a pilot test.

Ethical Consideration

Ethical approval was obtained from Oromia Center of Competency. The research permit and approval was obtained from the Department of Curriculum Studies and Teachers Professional Development Studies of Addis Ababa University. Institutional consent was communicated to the deans of TVET institutions before conducting the study. Informed consent was obtained from the participants before they filled in the questionnaires. Specifically, the participants were informed about the objectives of the study and were informed that their participation was purely voluntary and they were free to withdraw at any time in the course of the study.

3. DATA ANALYSIS AND INTERPRETATIONS

The data presentation and analysis part is divided in six major parts that includes the current status of competence of trainees, how competency based curriculum material is prepared, how basic principles of competency based curriculum is implemented, TVET-industry linkage, teachers training and analysis of main predictors of competence of trainees in COC assessment.

3.1 Competence of Trainees in COC Assessment

Trainees' COC assessment result is highly important for this study because the competence of trainees is determined based on COC assessment result. The COC result obtained from OCOC is depicted in Table 1 below.

Table 1: **COC Result N= 299**

Results	Frequency	Percent
Not competent	223	74.6
Competent	76	25.4
Total	299	100.0

As shown in the table above, three-fourth of the respondents were not competent in COC assessment, whereas only one-fourth were labelled competent. Trainees are employed based on their COC assessment result. Those who succeed in COC assessment will have the opportunity to be employed, whereas those who are not successful will not have the opportunity to be employed. Thus, the effectiveness of competency based TVET program is determined by trainees COC result. As a result the data obtained in the present study revealed the ineffectiveness of competency based TVET program.

3.1. Assessment of Competency-based TVET Teaching Learning Materials

To assess the quality of the designed competency based TVET curriculum teaching learning materials, Technical Education Curriculum Assessment rubric was used. Accordingly, competency based TVET curriculum material assessment criteria was designed to guide the judgment of the quality of curriculum materials. (See Table 2).

Table.2. Assessment of Competency based TVET curriculum Material

Criteria	Automotive	Electrical electronics	Manufacturing	Construction	ICT
Learning outcomes (competencies)	1	3.37	1	1.87	2.13
Instructional strategies	1	3.2	1	2.86	1.6
Problem solving	**1**	**3.33**	**1**	**1.33**	**1**
Assessment	**1**	**3.2**	**1**	**2**	**1.8**
Personal Qualities					
Grand mean	**1**	**3.33**	**1**	**1.91**	**1.79**

As can be seen from the table above, no curriculum material was rated as 'excellent' in meeting the criteria set. Only Electrical Electronics teaching learning material was rated as 'good' in meeting the criteria set for the assessment, with grand mean value of 3.33. The remaining teaching learning materials of Automotive, Manufacturing, ICT and Construction Departments were rated as 'weak' in meeting the criteria set, with grand mean value of 1, 1, 1.79, and 1.91 respectively.

Thus, the reviewed teaching learning materials were not designed according to the principles of competency based TVET curriculum except the Electric Electronics material. According to Goncizi (1990), competency based TVET curriculum material design should pass through different development processes such as DACUM and Functional Analysis. Experts from industry should be involved in content determination processes. Participants who have profound knowledge of the occupation should be selected from various levels of relevant occupation and it is important that different interested educators, practitioners, and unions should be involved in the preparation of curriculum material.

3.3 **Implementation of Competency- based Curriculum**

Mean and standard deviations were used for the analysis of opinion of trainers' and trainees regarding implementation of competency-base curriculum. Standard deviation is a measure of spread or dispersion in a set of score. When the standard deviation is greater than the mean, it is believed that the mean would be inappropriate

as a representative measure of central tendency (Kean University, 2013).

Implementation of competency based TVET curriculum. N = 439

Table : 3

Items	Mean	Std. dev
Identification of competencies	2.92	1.22
Teaching learning (presentation)	2.86	1.44
Learning Materials	2.21	1.17
Entrepreneurship instruction in the classroom	2.76	1.80
Assessment	2.98	1.20
Record keeping	3.17	1.23
Grand mean	2.80	

The grand mean for the implementation of competency based curriculum in the classroom is 2.80. This indicates that, competency based curriculum is not well implemented according to the principles of implementation of competency based TVET curriculum. Unfortunately, this can have an adverse effect on the competence of trainees. Competencies to be achieved by the trainees need to be publicized in advancefor effective implementation of competency-based curriculum. This idea is consistentwith NCTVET (2006), which has indicated that, in competency-based instruction,trainees are informed about the criteria and attitudes that are important to the occupation.Furthermore, competencies to be achieved need to be specific, precise and stated inwritten form. Again, this idea corresponds with the work of Brown (1994), whichindicates that, one of the characteristics of competency based instruction is that whateverstudents learn is based on specific, precisely stated outcomes that have been recentlyidentified as being essential for successful employment in occupation for which the trainee is being trained. These competencies are made available to all concerned exactlywith what the students will be able to do upon completion of their training. According tothe responses obtained from the participants, in spite of their importance, the abovementioned items for effective implementation of competency-based curriculum were notfully utilized during the implementation of the program, a situation which can adverselyaffect the competence of the trainees.

3.3.1 Comparison of Responses on Implementation of Competency-based Curriculum

Mann-Whitney U Test was employed to see whether there are statistically significant differences in opinion between trainees and trainers of TVET institutions regarding the implementation of competency based TVET curriculum. Mann-Whitney U test was used to test the differences of responses between two independent groups on a continuous measure. This test is the non-parametric alternative to the t-test for the independent samples. The main values that are needed to look at in the Mann-Whitney U test are the Z value and the significance level (Pallant, 2007).

Table 4: Comparison of participants response on implementation (N= 439)

Status of responders	N	Mann-Whitney Test	Z	Asymp. Sig. (2-tailed
Trainees	299	1.878E4	-1.741	082
Trainers	140		.	
Total	439			

As can be seen from Table 8, the z value of the test indicates – 1.74 with a p= .08. The probability value (p) is not less than or equal to .05, consequently, the result is not statistically significant. This implies that there is no significant difference in the responses between trainers and trainees regarding the implementation of competency based TVET curriculum.

3.4 Support of Teachers' Training in Implementing Competency- based Curriculum

To assess the support of teachers' training in realizing the implementation of competency based TVET curriculum, questionnaires with three categories each with different sub items were prepared and presented to the trainers. These categories are 'pre-service teachers training', 'in-service training' and 'continuous professional development' (CPD). As indicated in Table 5, the values of standard deviation for all items is less than the mean values of all items and, hence' there would be no problem of using mean for the analysis of the role of teachers training in implementing competency-based TVET curriculum.

Table 5. Response of trainers on the roles of teachers training

N =140

Items	mean	St.dev
Pre-service training	2.50	1.04
In-service training	2.73	1.06
Continuous professional Development	2.61	1.04
Grand mean	2.64	

The mean value for the pre-service training is 2.5, which is less than the average. This implies that pre-service TVET teachers' training is not based on competency based approach. are properly trained in pre-service training that is supported by in-service training.

Similarly in-service training was not properly practiced in TVET institutions. The mean value for this item is 2.73 which is less than the mean. However, without updating their knowledge, skills and competencies acquired during pre-service training, TVET trainers will run the risk of rapidly becoming obsolete in their training capacity. This implies that in-service training for trainers is a very practical solution for increasing their professional level. The last category regarding teachers' training in supporting the implementation of competency based TVET curriculum was concerned with continuous professional development (CPD). This item was rated below the mean, (2.61). However, international experiences as indicated in NICHE (2010), as in general education, CPD also encompasses in-service training, but may go beyond in-service training, and it constitutes fundamental and increasingly important link in TVET trainers learning sequence. Because CPD is very important, international standards on further and in-service education stress that it is a professional obligation for instructors to involve in CPD for quality teaching and to integrate the latest educational research for the success of educational programs.

3.5 Attachment of TVET Institutions to Industries and Other Business Sectors

Table 6 below reveals the responses of the participants about TVET institution attachment to industries and other small enterprises on practical skill development in the real world of work.

Table. 6: **TVET- Industry linkage**

Items	Mean	Standard deviation
There is a collaboration between industries and other business sectors and TVET institutions to determine training needs	2.82	1.20
The link between industries and TVET institution is based on willingness of industry owners	2.94	1.10
TVET institutions make survey of employers to gather labour market information with collaboration of industries	2.82	1.137
There is a supportive government policy that facilitates and encourages collaboration between TVET institutions and industries	2.96	1.16
Industries and TVET institutions jointly draft competency based curricula and courses of study	2.69	1.10
Industries involve in determining occupational standards	2.87	1.11
Industries involve in evaluating the result of the training	2.69	1.06
There is a strategic partnership between industries and TVET institutions	2.79	1.10
TVET institutions make linkage with handcraft villages and in household business to conduct on the job training	2.77	1.19
TVET teachers are allowed to know what goes on in industries and be able to support in guiding trainees	2.58	1.17
Industries support teachers to update their knowledge and skill alongside new technologies in industries	2.49	1.19
Industries play great role in updating and enhancing the skills of trainees.	2.58	1.24
TVET institutions play role in updating and enhancing knowledge and skills of workers	2.77	1.23
cooperative training helped students to acquire further knowledge and skill that help them for their future job	2.85	1.30
TVET institutions conduct tracer study and interact closely with industries they serve	2.57	1.18
Trainees are given opportunity in the industries to practice on the same devices operated at the work	2.46	1.18
The curricula and teaching methods are upgraded with TVET institutions and industries jointly to adapt to rapid changes in production technology	2.67	1.79
Industries involve in planning and administration of competency based TVET program	2.70	1.17
Industries positively invite trainees to their factories to practice on the devices being	2.47	1.17

used		
There is a cooperation and understanding between TVET institutions and industries	2.54	1.16
Industries support trainees to practice and handle new technology during cooperative training	2.52	1.22
Industries and TVET institutions jointly update curriculum to keep it up with technological change	2.51	1.21
Industries support TVET institutions by providing essential equipments, instructional technology and learning materials	2.46	1.27
Grand mean	2.67	

As indicated in the table, all items about TVET industry attachment were rated below the mean, with an aggregate mean of 2.67. Especially, some important items were negatively responded. According to the responses of the participants, TVET instructors were not allowed to know what is going on in industries to support them in guiding their training. According to Kambyat and Shmal (2010), however, the complexities at a work placewhich are brought about by the rapid technological changes lead to a paradigm shift ineducation and training and the growing demand for skills training call for harmonizedefforts to reverse the acute skill shortage. Trainers should work in close collaborationwith industries to explore the endless possibilities and derive new focus to addresssocioeconomic and technology-driven challenges. This implies that industries shouldsupport trainers to acquire the new technologies that exist in industries.As indicated earlier, industries do not appear to support teachers to update their knowledge and skill alongside the new technologies in industries (as revealed on the tablewith mean value of 2.49). However, according to Kambyat and Shmal (2010), one of thechallenges in the present time is the rapid pace of technology which makes skills obsoleteat a greater pace before everyone else could learn from them. The excessive pace oftechnological changes has emphasized the need to integrate technological knowledge andskills in education and training to expand lifelong capabilities of knowledge basedworker. According to Majumdar (2011), the characteristics of the work place as thesupreme learning environment must be coordinated properly to ensure that there is aclose correlation between the types of training that the workforce is being prepared vis-àvisthe work environment, tasks and work systems. Thus, since a weak linkage with localindustries for hands on experience for trainers can lead to an ineffective and inefficienttraining of trainees, industries need to work in collaboration with TVET institutions toupgrade trainees' knowledge and skill, which were overlooked, according to the responseof the respondents.

3.6 Determinants of Competence of Trainees

Binary logistic regression was used to determine the factors that have strong impact on competence of trainees in COC assessment. Logistic regression is used in a situation where the dependent variable is not continuous, but when it is rather categorical or dichotomous.

3.6.1 Implementation of Competency-based TVET Curriculum as a Determinant of Trainees' Competence in COC Assessment

Binary logistic regression was conducted to determine which independent variables under implementation of competency based TVET curriculum are major predictors of competence of trainees in COC assessment.

Accordingly, the major factors influencing whether trainees are competent or not yet competent in COC assessment are integration of knowledge, skill and attitude during training (odd ratio .55, 95% C.I .378-. 810, p = .002), making competencies public in advance (odd ratio 1.58, 95% C.I 1.551- 2.190, p = .005), assessment based on actual demonstration of competency (odd ratio .66, 95% C.I .446- .982, p =.04), engaging trainees in applying skill similar to the real world of work (odd ratio1.48, 95% C.I 1.004- 2.186, p =.048), making competencies to be achieved specific and precise (odd ratio 1.41, 95% C.I 1.042- 1.924, p = .026), and using record chart during training (odd ratio .72, 95% C.I .519- .995, p = .040) .

3.6.2 TVET- Industry Linkage as a Determinant of Competence of Trainees in COC Assessment

Enter binary logistic regression was computed to determine which variable under the category of TVET industry linkage has a determining factor on competence of trainees, (competent and not yet competent)

only one variable, that is, 'industries play role in updating and enhancing the skills of trainees during cooperative training' has a strong determining effect on competence of trainees in COC assessment with odd ratio of 1.53, 95% C.I 1.031- 2.262, and P value of .035. The value of odds for this variable indicates that, when industries play role in updating and enhancing the skill of trainees during cooperative training, the odds of being competent of trainees in COC assessment increase by a factor of 1.53 than those who were not supported by industries in updating and enhancing skills during cooperative training. Therefore, to improve the competence of trainees in COC assessment, industries should play an active role in updating and enhancing the skills of trainees during cooperative training.

4 Conclusion

Competency based TVET curriculum was used as a tool to achieve the competences needed by the labour market and create competent, motivated and adaptable workforce capable of deriving economic growth and development in the country. However, the present study

concluded the ineffectiveness of competency based TVET curriculum in TVET institutions under investigation. According to the findings of the study, among the factors that have influenced the effectiveness of competency based TVET curriculum, is the failure to design competency based TVET curriculum materials according to the principles of designing competency based curriculum.

TVET institutions and industry linkage is among the important factors that influence the competence of trainees. From the study it can be concluded that TVET institutions and industry linkage did not play their joint role in producing competent, skilled and educated workforce that is relevant to the real world of work. The study has also revealed that industries do not provide practical practices on their machines. Certainly, this lack of practical opportunity negatively affects the competence of trainees in COC assessment.

5 Future Research Direction

Much of the study has focused on teaching-learning process, emphasizing on how competency based TVET curriculum materials were designed, principles used during training, trainers' and trainees' perceptions of competency based TVET curriculum, teachers' training, and TVET-industry linkage. Furthermore, the delivery of quality of competency based TVET is closely linked to the building of strong management and leadership capacity to derive the entire system. Unfortunately, this aspect was not included in this study. Therefore, further investigation of the impacts of management system including views of curriculum experts and industry experts on effectiveness of competency based TVET curriculum is highly required.

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Reference

Awgbenle, C., and Iwuamadi, K., (2010). Youth unemployment: Entrepreneurship development programs as an integration mechanism. Journal of Business Management. 4(6), 831 – 837.

Ota: Institute for Development Studies, University of Nigeria.

Allan J. (2001**),** Training needs analysis**.** Colombo: Colombo plan Staff College for Technical Education.

Brown, M., (1994). A Collection of Readings Related to Competency Based Training.

Victoria: Deakam University.

Damson, A. (2011). Challenges facing technical institutes graduates in practical skills acquisition in Upper East Region of Ghana. Ghana **:** Ghana education service

Finch,, C. and Crunkilton, J. , (1999). Curriculum development in vocational and technical education: Planning, content, and implementation. Boston: Allyn and Bacon.

Fraenkel, J. R. and Wallen, N. E. (2008). How to design and evaluate research in education (7th edition), New York: McGraw–Hill.

Goncizi, A. (1996**).** Re-conceptualizing competency based education and training. Sydney: University of Technology.

Khembayat, R. and Shaymal, M. (2010). **P**reparing teachers of today for the learners of tomorrow. Journal of Engineering, Science and management Education/ Vol.2, 2010)

Leonard, E. (2008). Facilitating acquisition of life skills for employability with reference of TVET. Manila: UNISCO

Majumdar, S. (2011). The emerging TVET Landscape in the Asian Pacific Region**.** Philippines: Sense Publisher**.**

MOE. (2007),Ethiopian TVET- System, Guideline (recommendations) on Curriculum development**.** Addis Ababa: MOE.

_____(2008). National Technical and Vocational Education and Training (TVET). Addis Ababa: MOE.

NCHE, (2010). NICHE Strategy on Technical and Vocational Education and Training (TVET).

Nuffic: NICHE.

NCTVET, (2006). A coordinators guide to implementing competency based education. Jamaica: NCTVET.

OEB (2003), Regional Technical and Vocational education and Training (TVET) policy. Addis Ababa: OEB.

Oloruntegbe, K., (2010), Reconceptualization of African Vocational and Technical Education for Emergent Globalization, Relevance and Sustainable Economic Development. Nigeria: Department of Science and Technical Education.

Pallant, J., (2007). SPSS Survival Manual. A Step by Step Guide to Data Analysis Using SPSS for Widows. Sydney: Ligare book printer.

Sharma, A. (2008). Technical Vocational Education and Training (TVET) in Africa**.** Addis Ababa: AU.

UNESCO. (2007).Technical education, policy framework, innovative practices and international partnership.China: UNESCO.

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Optimal Control of Illicit Drug Epidemic

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Abstract

Illicit drug use and related crime have imposed significant costs on various source and transshipment countries for a number of years. A variety of control strategies exist including prevention, treatment, and various forms of law enforcement, so a fundamental question of drug policy is how limited resources should be allocated between different drug control programs, such as source country control, interdiction, or different forms of domestic control such as prevention, treatment or domestic enforcement. It is important to stress that the illicit drug in any country or region is a dynamic one and influenced by developments in youth culture. Therefore, the situation requires regular monitoring and timely response to prevent rapid escalation in use and reduce the level of harms associated with abuse. Since drug use and related problems substantially change over time, it seems that drug interventions should vary too. Static interventions applied to a dynamic process may be not productive. Therefore, an optimal control with two control variables prevention and Treatment subjected to a system of nonlinear ordinary differential equations over a period of time is modeled. Parameter values were taken from world standards studied for drugs. Next, the problem was solved numerically using matlab software. The study shows that prevention is the most appropriate control policy when there are relatively few heavy users, i.e. in the beginning of an epidemic. Treatment, however, is most sufficient to support the decline of drug abuse optimally. In addition, these models are able to generate a number of interesting insights, such as costs of interventions as well as social cost associated with the quantity consumed increase with the delays in the starting year of control measures and the effects and results of controls takes about fifteen years to be seen.

Keywords: *Control, Drug, Hamiltonian, Heavy user, Light user, Optimality, Prevention, Treatment, L-H model*

1. INTRODUCTION AND LITERATURE SURVEY.

A fundamental question of drug policy is how limited resources should be allocated between different drug control programs, such as source country control, interdiction, or different forms of domestic control (prevention, treatment or domestic enforcement). Hence there is ongoing interest in understanding how much we can save (in terms of lives, grams of consumption, or cost to the society) per dollar invested in each of these control programs [1]. Prevention comes in different forms, ranging from school programmers, to community based interventions, and mass media and social marketing approaches. Prevention programmers tend to target adolescents by highlighting the dangers of drugs, provision of accurate information, improving self-esteem, and teaching skills to resist peer pressure. Other approaches include broadly based non-drug focused strategies which target the overall development of the child and which seem to have impact on anti-social behavior, drug use, overall health and educational performance. In recent years there has been increasing interest in prevention approaches that target interventions at the developmental and transition stages with attention focused on the risk factors that can have an impact at each of these stages [8]. The gap between drug dependence and the availability of treatment services is significant and growing wider as the rate of drug use disorders increases in different countries. In a recent global survey of treatment resources, the data shows a general lack of resources (facilities, personnel, etc.) for treating people with dependence across the world but much more so in African countries and especially in east Africa [6, 8].

In particular, most people who start using drugs do so through contact with a friend or sibling who is already using. Indeed, the metaphor of a drug "epidemic" is commonly used precisely because of this tendency for current users to "recruit" new users. If that were the only mechanism by which current use affected initiation one might expect initiation to increase monotonically, Musto (1987) has argued that, in addition, knowledge of the possible adverse affects of drug use acts as a deterrent or brake on initiation [2, 4]. He has hypothesized that drug epidemics eventually burn out when a new generation of potential users' becomes aware of the dangers of drug abuse and, as a result, dos not start to use drugs. Whereas many light users work, uphold family responsibilities, and generally do not manifest obvious adverse effects of drug use, a significant fraction of heavy users are visible reminders of the dangers of using addictive substances. Hence, one might expect large numbers of heavy users to suppress rates of initiation into drug use. It seems plausible that any reasonable model of an endogenous initiation might have the following properties. The rate at which

current light users "recruit" initiates is moderated by the "reputation" or image the drug has, and the reputation is governed by the relative number of heavy and light users, not the absolute number of heavy users. Although most new users are "recruited", for others the impetus to use is internal. In the of diffusion models, these individuals are "innovators" who initiate on their own for the sake of curiosity.

2. MODEL OF CONTROLLED DRUG DEMAND

The mathematical model of a system usually leads to a system of equations describing the nature of the interaction of the system. These equations are commonly known as governing laws or model equations of the system. The model equations can be time independent or steady-state model equations but time dependent models are dynamic model equations [9]. The LH model is essentially a continuous time analogue of Everingham and Rydell's (1994) model. In this model, the population is divided into three groups: non-users, light users and heavy users [1]. The number of non-users is assumed to be large enough compared to the number of users to behave like a constant and does not need to be model explicitly [4]. The flow rates from one state to another are assumed to be proportional to the source states and are computed as the time-continuous equivalents of the Everingham-Rydell model. The assumptions to develop the model according [1] are restricting the drug control budget. These assumptions can be described as follows:

i. the budget is constrained to be proportional to the size of the drug problem, and the proportions of that budget going towards treatment and prevention, respectively, are chosen once and fixed for all time;
ii. the budget is chosen as in case (i), but its allocation between treatment and prevention can be varied over time;
iii. the budget is unconstrained in that both treatment and prevention spending can be chosen to be any non-negative number at all times. Theoretically, this case is the most reasonable one, because at some stages of the epidemic, high expenditures may be useful, while at other stages spending less money may be preferable. It should also be noted that this model is more appropriate than one with a constrained budget if treatment and prevention resources are not allocated from a single pot.

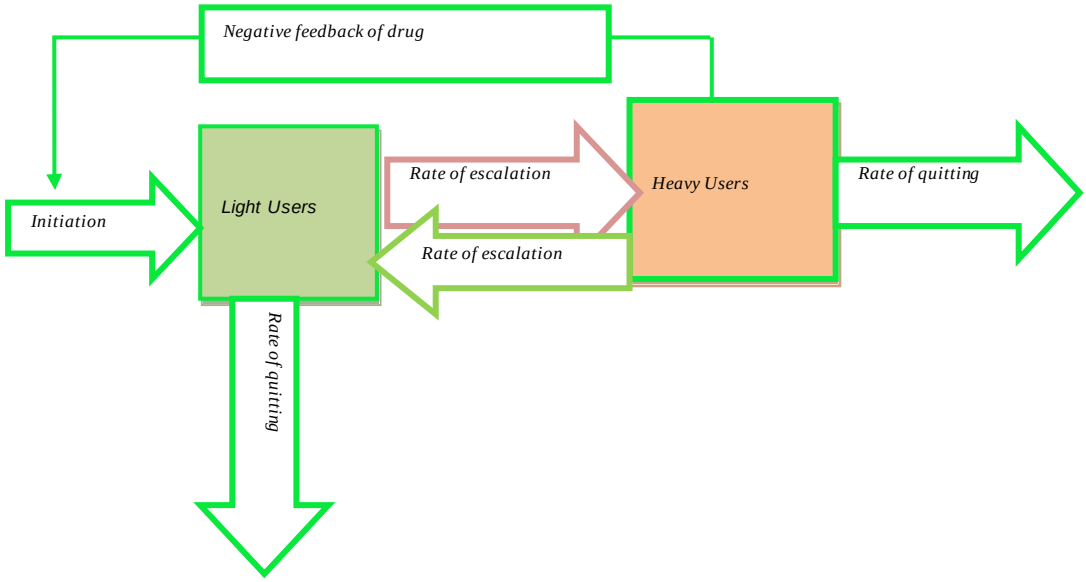

Figure 1: Flow diagram for the LH model

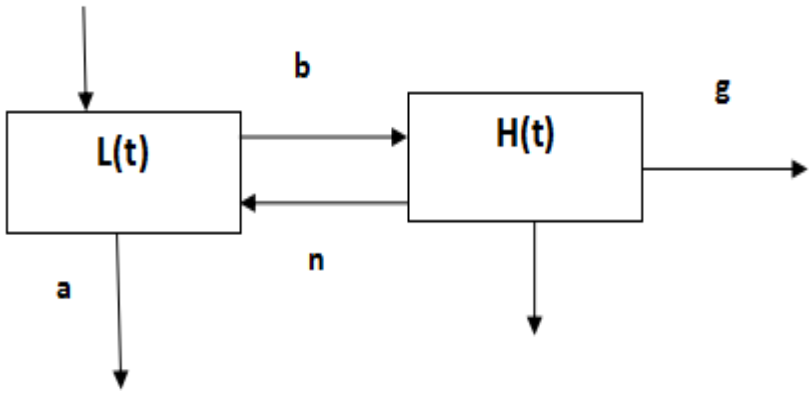

Figure 2: Dynamic model of drug uses

System in Figure 2 is expressed mathematically as system of ordinary differential equations as follows.

$$\dot{L} = I(L,H) + nH - (a + b)L, \qquad L(0) = L_0$$

$$\dot{H} = bL - (n + g)H - \beta(H,u)H, \qquad H(0) = H_0$$

where: a = average rate at which quitting from light user,

b = average rate at which light user escalate to heavy user,

g = average rate at which heavy user quit,

n = average rate at which heavy user escalate to light user

$$I(L,H) = \tau + sLe(\frac{-qH}{L}) \quad (2.1)$$
$$= initiationtolightuser$$

$where$:

L = number of light users,

H = number of heavy users

s = average rate at which light users attract nonusers,

q = constant measuring the deterrent effect of heavy drug abuse,

τ = number of innovators

1. Spending on prevention (denoted by w) such as school-based prevention programs, after school programs, Red Ribbon weeks, etc., is assumed to reduce initiation into drug use, as defined by, down to some fraction ψ of its baseline level,
   If policy targets first the groups at highest risk of initiating drug use, one would expect the first dollars invested in prevention to produce bigger effects than later dollars. That is one would expect ψ to be a smooth convex function of prevention spending *w(t)* that captures such diminishing returns which exponential decay and approaching an asymptotic value h

$$\psi(w) = h + (1 - h)e^{-mw}, \quad (2.2)$$

where:

h = the minimum percentage to which initiation can be cut down by prevention.

$$1 - h = maximumpercentagebywhich$$

$$incidencecanbecutback$$

$$m = isaconstantmeasuringthe$$

$$efficiencyofpreventionspending$$

2. Treatment(denoted by u) is modeled as increasing the outflow from drug use, in this case the outflow from heavy use, H, at a per consumption rate that is a concave function of treatment spending u(t) per (heavy) user. In particular,

$$\beta(H,u) = c(\frac{u}{(H+\varepsilon)})^d \quad (2.3)$$

c = is a constant measuring the efficiency of treatment

d = is a constant measuring the extent to which expansions in treatment spending retain that efficiency as opposed to suffering from diminishing returns

The constant ε =10− 5 is a mathematical convenience that avoids the possibility of dividing by zero and has no effect on the results at all.

In particular, a constant social cost per gram consumed (estimated to be κ dollars per gram) is multiplied by the total quantity consumed, denoted by Q, which is computed as the weighted sum of the number of light and heavy users, with weights equal to the average annual consumption rates of light (k_L) and heavy users (k_H).

$$kQ = k_L L + k_H H \qquad (2.4)$$

So the decision-maker can be modeled as seeking to minimize the entire discounted stream of costs associated with illicit drug use.

$$V\big(u(\cdot), w(\cdot)\big) = \int_0^\infty e^{-rt}(\kappa Q + u + w)dt, \qquad (2.5)$$

where: u(t)and w(t) denote the expenditures on treatment and prevention programs at time t, and Q denotes total annual consumption in grams. Ideally the government would be free to choose whatever controls u(·)and w(·) minimize (2.5), but public budgeting is sometimes reactive, responding to the problem. As a result society allocates drug-control resources in proportion to the current magnitude of the drug problem.

$$u + w = \gamma Q. \qquad (2.6)$$

The optimization problem becomes a nonlinear control problem

$$\text{Maximize } \{-(\kappa + \gamma)\int_0^\infty e^{-rt} Q dt\} \qquad (2.7)$$

Subjected to:

$$\dot{L} = \psi(w)I(L,H) + nH - (a + b)L, \qquad L(0) = L_0 \qquad (2.8)$$

$$\dot{H} = bL - (n + g)H - \beta(H,u)H, \qquad H(0) = H_0 \qquad (2.9)$$

$$u \geq 0, \qquad (2.10)$$

$$w = \gamma Q - u \geq 0\ , \qquad (2.11)$$

3. DERIVING THE CANONICAL SYSTEM

Since we have to consider mixed path constraints as defined by (2.10) and (2.11), we analyze the form of the canonical system for control values lying in the interior and at the boundary of the control set separately.

3.1 CONTROL VALUES IN THE INTERIOR

The analysis proceeds, where $\mathcal{H}$ denotes the Hamiltonian and λ_1 and λ_2 denote the co state variables with respect to L and H, all in current-value

$$\mathcal{H} = \lambda_0 (\kappa + \gamma)(-k_L L - k_H H) + \lambda 1 \dot{L} + \lambda 2 \dot{H}. \quad (3.1)$$

We restrict our analysis to the normal case, where$\lambda_0 = 1$,

$$-\frac{\partial(\kappa + \gamma)(k_L L + k_H H)}{\partial L} < 0, and -\frac{\partial(\kappa + \gamma)(k_L L + k_H H)}{\partial H} < 0, \quad (3.2)$$

The economic interpretation of the co-states as imputed values or shadow prices of an additional light and heavy user, λ_1 and λ_2 are negatives that shows additional user is always "bad". The Hamiltonian maximizing condition for optimal interior control values, $u^* = u^*(L, H, \lambda_1, \lambda_2)$, is given by

$$\mathcal{H}_u = \lambda_1 I\psi_u - \lambda_2 H\beta_u = 0, \quad (3.4)$$

$\Rightarrow \lambda_2 = \lambda_1(\frac{I\psi u}{H\beta u})$ together with the Legendre Clebsch condition (the Hamiltonian is concave with respect to control *u)*.

$$\mathcal{H}_{uu} = \lambda_1 I\psi_{uu} - \lambda_2 H\beta_{uu} \leq 0. \quad (3.5)$$

Satisfies the strict inequality for all u, and thus a unique interior optimal control value exists for (3.4). The evolution of the co-states λ_1 and λ_2 which can be interpreted as the changes in the values of an additional light and heavy user, respectively, where the notation is simplified by

$$\Xi(L, H, u^*) := I_L\psi + I\psi_L - (a + b), \quad (3.6)$$

$$\Sigma(H, u^*) := n + g + (1 + d)\beta > 0, \quad (3.7)$$

$$\Pi(L, H, u^*) := I_H\psi + I\psi_H < 0, \quad (3.8)$$

$$\dot{\lambda_1} = r\lambda_1 - \mathcal{H}_L = k_L(\kappa + \gamma) + (r - \Xi)\lambda_1 - b\lambda_2 \quad (3.9a)$$

$$\lambda_2 = r\lambda_2 - \mathcal{H}_H = k_H(\kappa + \gamma) - \Pi\lambda_1 + (r + \Sigma)\lambda_2 \qquad (3.9b)$$

The optimal control value u∗ is only implicitly determined by (3.4) and cannot be replaced by a closed-form representation. To avoid this inconvenience it has to transfer the canonical system from the state– co-state space into the state-(co-state-) control space.

$$\text{Let} \quad \Lambda := \frac{I\psi_u}{H\beta_u}. \qquad (3.10)$$

Solving the resulting equation for u yields a differential equation for the control variable, which allows us, together with $\lambda_2 = \Lambda\lambda_1$ to replace (3.9a) and (3.9b) by

$$\dot{\lambda_1} = kL(\kappa + \gamma) + (r - \Xi - b\Lambda)\lambda_1 \qquad (3.11a)$$

$$\dot{u} = \frac{1}{\Lambda_u}\left\{\frac{k_H - k_L\Lambda}{\lambda_1}(\kappa + \gamma) - \Pi + (b\Lambda + \Sigma + \Xi)\Lambda - \Lambda_L\dot{L} - \Lambda_H\dot{H}\right\} \qquad (3.11b)$$

The continuous differentiability of u(·) is assured as long as the strict Legendre - Clebsch condition is satisfied ($\mathcal{H}$ is concave in control variable u) .

3.2. CONTROL VALUES AT THE BOUNDARY:

To determine the form of the canonical system for solutions exhibiting a boundary arc, we have to consider the Lagrangian of the system,

$$\mathcal{L} = \mathcal{H} + \mu_1 u + \mu_2(\gamma(k_L L + k_H H) - u) , \qquad (3.21)$$

Thus we can use Pontryagin's Maximum Principle to derive the necessary conditions. Obviously the control constraints cannot be simultaneously active as long as$L > 0, H > 0$. We can therefore consider both cases separately. The derivative of Lagrangian with respect to control variable u or *optimality condition*,

$$\mathcal{L}_u = 0 , \qquad (3.22)$$

We find explicit representations of the Lagrange multipliers as follows

$$\mu_1 = -\mathcal{H}_U , \mu_2 = \mathcal{H}_U \qquad (3.23)$$

The limiting transversality conditions for the co-states, given by (3.21)

$\lim_{t\to\infty} e^{-rt}\lambda_1(t)L(t) = 0$ and
$\lim_{t\to\infty} e^{-rt}\lambda_2(t)H(t) = 0$

Hence Control at the border of the admissible region for$u^* = 0, w^* > 0$ is

$$\dot{L} = I(L,H) + nH - (a + b)L - \frac{1}{m\lambda_1}, \quad (3.24a)$$

$$\dot{H} = bL - (g+n)H, \quad (3.24b)$$

$$\dot{\lambda_1} = k_L(\kappa + \gamma) + \big(r - \Xi(L,H,0)\big)\lambda_1 - b\lambda_2, \quad (3.24c)$$

$$\dot{\lambda_2} = k_H(\kappa + \gamma) - \Pi(L,H,0)\lambda_1 + (r + \Sigma(H,0))\lambda_2, \quad (3.24d)$$

And for $u^* = \gamma(k_L L + k_H H), w^* = 0$ as

$$\dot{L} = I(L,H) + nH - (a + b)L, \quad (3.25a)$$

$$\dot{H} = bL - (n+g)H + \frac{u^*}{d\lambda_2}, \quad (3.25b)$$

$$\dot{\lambda_1} = k_L(\kappa + \gamma) + (r - \Xi(L,H,u^*))\lambda_1 - b\lambda_2, \quad (3.25c)$$

$$\dot{\lambda_2} = k_H(\kappa + \gamma) - \Pi(L,H,u^*)\lambda_1 + (r + \Sigma(H,u^*))\lambda_2, \quad (3.25d)$$

Remark Note that a transition into the (L,H,λ_1,u) -space is not necessary here, because at the boundary arc u^* is explicitly be given (either $u^* = 0$ or $u^* = \gamma(k_L L + k_H H)$), Additionally, the slackness conditions

$\mu_1 u^* \geq 0$, and $\mu_2(\gamma(k_L L + k_H H)) - u^*) \geq 0$,

and non-negativity conditions $\mu_1 \geq 0$, and $\mu_2 \geq 0$, have to be satisfied

Table3.1 nominal parameter value used in the model is taken from different literatures studied on cocaine consumption [1, 2, 3, 5]

Parameter	a	b	g	τ	s	q	c	d	$\in$
Average value	0.163	0.024	0.062	50000	0.61	7.0	0.0005	0.6	0.00001
Parameter	h	1-h	m	r	n	g	k		
Average value	0.84	0.16	2.37×10^{-9}	0.04	0.04	5.31	113		

Table 3.1 lists of Nominal Parameter value used in calculations

3.3 EQUILIBRIUM CONSUMPTION

One can determine these equilibrium values by solving the nonlinear algebraic equations obtained by setting the differential equations of the canonical system to zero.

Therefore, we proceed with numerically for the given parameter values given in (table 3.1).

$\mathcal{H}_{\lambda_1} = 0, \mathcal{H}_{\lambda_2} = 0,$

$r\lambda - \mathcal{H}_{\mathrm{L}} = 0\,,$ (3.31)

$r\lambda - \mathcal{H}_{\mathrm{H}} = 0$

The Equilibrium was found using Newton Raphson method numerically from state, co-state and control state equations. In this case the system yields the following equilibrium in the positive section of the state control-space:

$$E_0 = \begin{pmatrix} L_0 \\ H_0 \\ \lambda_1 \\ u^* \end{pmatrix} = \begin{pmatrix} 347{,}474 \\ 124{,}354 \\ -36{,}863 \\ 5{,}890{,}747 \end{pmatrix} \quad (3.32)$$

Note that the equilibrium shadow price of an additional heavy use, λ_2, and equilibrium treatment spending w^*, can be computed using (3.10) and (2.6), respectively

$$\lambda_2 = \frac{I(L_0, H_0)\psi_u(\gamma(k_L L_0 + k_H H_0))}{H_0 \beta_u(w^*, H_0)\lambda_1}$$

$$= -11{,}499 \quad (3.33a)$$

$w^* = \gamma(k_L L_0 + k_H H_0) - u^*,$

$$= 102{,}937{,}557 \quad (3.33b)$$

The specific question to answer is, how to solve the optimal control problem for the initial states (L_0, H_0), because "running the optimal control model" differs from "running the uncontrolled model." Whereas in the uncontrolled case we have two differential equations and two initial conditions, in the optimally controlled model we have four differential equations plus information on the two initial states and also the terminal conditions, that the solution converges to the equilibrium [5].

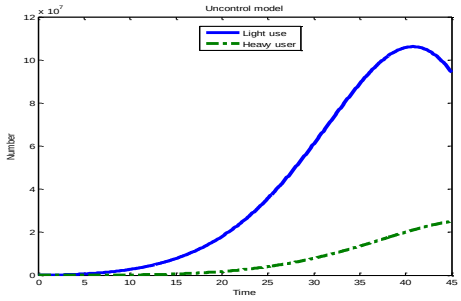

Figure 3 Time paths of light and heavy users for base line parameters (uncontrolled model) it started to decline due to increase in heavy drug users after about

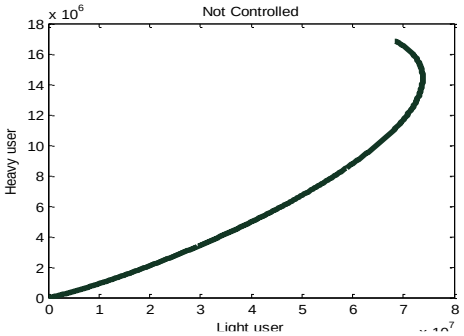

Figure 4: Projections of uncontrolled trajectories into the (L, H)-plane

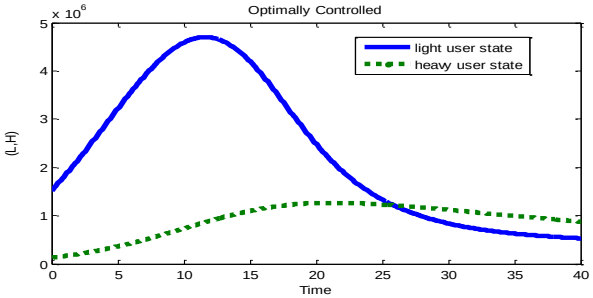

Figure 5:*Prevention and treatment spending for the unrestricted optimal control*

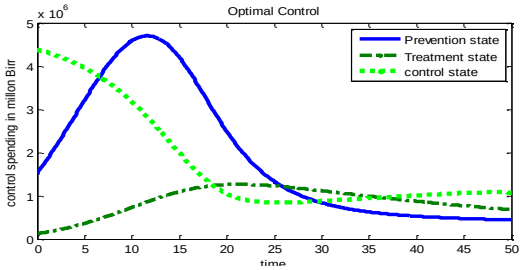

Figure 6: state of the systems and control state with time (controlled model)

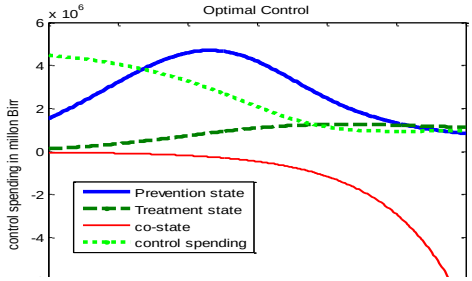

Figure 7: state dynamics including co-state with time

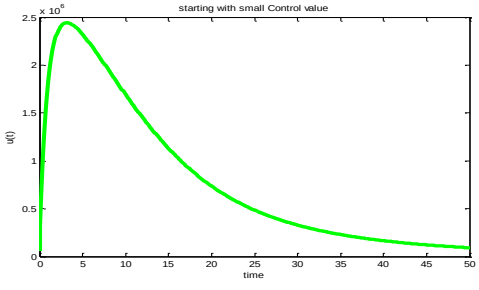

Figure 8: control function started with small control spending over time with both variables

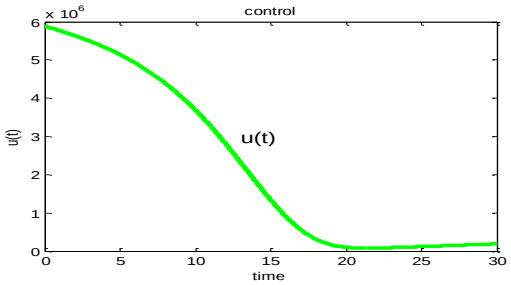

Figure 9: control function started with optimal control spending over time with both variables. It takes about 15 years to bring the dynamics to state of equilibrium.

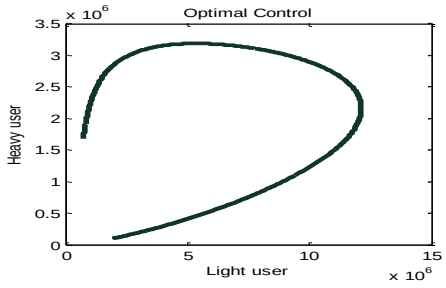

Figure 10: Projections of the controlled trajectories into the (L, H)-plane (controlled but not optimally controlled case)

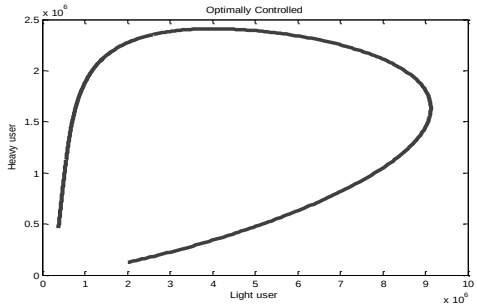

Figure 11: Projections of the controlled trajectories into the (L, H)-plane (optimally controlled case)

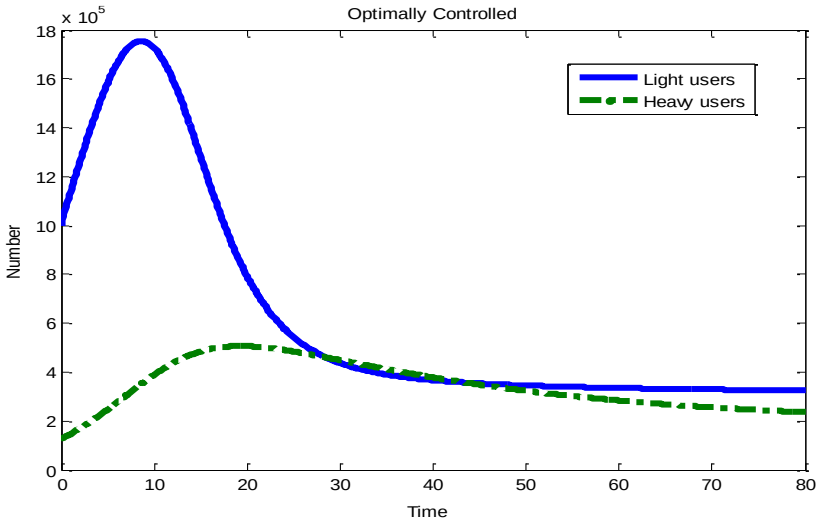

Figure 12: cyclic nature of drug epidemic in addition to the cyclic nature the epidemic started to decline about fifteen years after we started control measures.

RESULTS AND DISCUSSION

The effectiveness of drug prevention and treatment vary over the course of a drug epidemic, so their budget allocations should be similar. Applying static interventions to a dynamic process may be not productive. In particular, prevention does best when there are relatively few heavy users at the beginning of an epidemic and treatment is

relatively more efficient at supporting the decline of drug later in the epidemic.

The transition between when all or most spending should be allocated to prevention than treatment and when it should be allocated to treatment is strikingly brief. Indeed, if one recognizes the time lag between prevention spending and its effect, with the present model it is essentially never optimal and robust to fund prevention programs and treatment simultaneously. Control can reduce total social loss substantially if implemented early in an epidemic even though with or without control the long-run equilibrium is similar; the differences show up during the transition to steady state. The benefits are much smaller if control begins later in the epidemic, suggesting that early detection of epidemics is valuable. High level of spending minimizes the total social loss even though time discounting places a greater emphasis on costs that accrue early in the planning horizon. Later on, as the epidemic recedes toward its steady state, it is optimal to spend very little on both controls.

Historically, there have been cycles of drug use, so the end of one epidemic may also be the beginning of another. Form this study one can understand that, it needs to apply prevention for 15 years before understanding the control effect.

4. ACKNOWLEDGMENTS

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5. REFERENCES

[1]. D. A. Behrens, J. P. Caulkins, G. Tragler and G. Freichtinger, (2000): Optimal control of drug epidemics: Prevention and treatment-but not at the same time, Management Science, 46, 333-347.

[2]. C.P. Rydell, J.P. Caulkins, and S.S. Everingham, (1996): "Enforcement or Treatment: Modeling the Relative Efficacy of Alternatives for Controlling Cocaine". Operations Research, 44(6) 687–695.

[3]. C.P. Rydell and S.S. Everingham, (1994), Controlling Cocaine – Supply versus Demand Programs, MR-331-ONDCP/A/DPRC, RAND: Santa Monica, CA.

[4]. D.F. Musto, (1987): The American Disease, Yale University Press: New Haven, CT.

[5]. J. P. Caulkins, A. Gragnani, G. Feichtinger and G. Trangler, (2006): High and low frequency oscillations in drug epidemics, Int. J. Bifurcat Chaos, 16, 3275 - 3289.

[6]. Fekadu A, Atalay A and Charlotte H. (2007): Alcohol and Drug Abuse in Ethiopia: Past, Present and Future. African Journal of Drug & Alcohol Studies; 6(1):39-53.

[7]. Rowthorn R, Laxminaryan R, and Gilligan C (2009): Optimal control of epidemics in metapopulations, JRSoc Interface 6: 1135–1144.

[8]. Odejide O. (2006): Status of Drug Use/Abuse in Africa: A Review. International Journal of Mental Health and Addiction; 4(2): 87-102.

[9]. G. Tragler, J.P. Caulkins, and G. Feichtinger: (2001): Optimal dynamic allocation of treatment and enforcement in illicit drug control, Operations Research, 49(3): 352–362.

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Dilemmas Between Conservation and Development: The Case of Ethiopia's Forest Coffee Production in A Historical Perspective.

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Abstract

Currently the Ethiopian region which is recognized as coffee forest is confined mostly to the southwest (Welega, Ilubabor, Jimma,Kafa and Bench Maji) and southeast (Bale) administrative zones. In relation to history of coffee production and marketing, south western Ethiopia is very important for two reasons. One Kaffa region, which is located in Southwest and South Ethiopia, is the genetic origin of one of the most important commercial coffee species Coffeaarabica. Second, the region is one of the major contributors of superior quality organic forest coffee to the global market. However, in Ethiopia there is a dilemma in the interest between priority for conservation of genetic resource coffeearabica one the one hand; and to increase the quality and quantity of forest coffee yield for sustainable development. On the basis of empirical evidences and secondary sources, a desk review is carried out to critically investigate the cause and solutions of the dilemmas between conservation of forest organic coffee and increase its quantity and quality for development focusing on South West Ethiopia. A descriptive historical approach is used for discussion of the changes and continuities in forest coffee production and management system. Different theories and frameworks developed by different scholars are applied to for the analysis the current debate between pro-conservation and pro development scholars. And the study concluded that even though they have a significant contribution for protection and contribution of organic coffee to the World market, forest coffee farmers are not getting a rewarding benefit.

Key words:*forest coffee, coffee production, market chain, conservation and development*

1. Introduction

Next to oil coffee is the second most important commodity in global market.Coffee is grown in more than 70 countries. However, over 60 per cent of the world's coffee is produced by four countries namely Brazil, Vietnam, Colombia and Indonesia (Schüβler, 2009:149-150) According to FAO (2014:2) inthe years from 2007 to 2011, forinstance, the world's largest coffee producers and contributors to the global market were respectively Brazil (35%), Vietnam (14%), and Colombia &Indonesia, each contributing (7%) took the third rank.With its 4.5% coffee contribution to the World market, our country Ethiopia stands at the fourth rank and is the first in Africa.

From over 120 species of World coffee, two species, *coffee arabica* and coffee *robusta* are economically very essential. From the literature of coffee sector studies it is obvious that the term coffee derived fromKaffa, the name of the region where coffee or coffee *arabica* first discovered (Mekuria T. &etal, 2004:2; selamta, 2016) Coffee *Arabica, which* covers 66% of the world's coffee produce, is the most widely traded and consumed in the World.*Our country Ethiopia* is not only its birth place but also she is one of its largest producers and contributors to the global market. Ethiopia is the third most important coffee *Arabica* producer next to Brazil and Colombia and stands at the first rank in Africa (Mekuria T. etal, 2004:2; TadesseW/mariam, 2015:5)

In the years 2004 between 2009,from Ethiopia's four quality export standard commercial coffee with brand names of Jimma , Sidama,Yirgacheffe and Hararthat represent around 70% of total coffee exports registered by the Ethiopian Revenue and Customs Authority (FAO, 2014 :3), three of the producing areas are located in south western Ethiopia. It is from this same region that a high quality organic coffee for export is produced in a forest and semi-forest coffee production system.Moreover, the three biosphere reserves, Kafa BR, Yayu BR and Sheka BR, which were nominated in 2010 and 2012, with a mandate of balancing the goal of conserving the last remaining wild coffee forests and safeguarding the livelihoods of the local rural communities located in southwest Ethiopia (Friedrich zurHeide, 2012:17-18).Therefore, south western Ethiopia is the most important region in contributing high quality organic coffee for export and for preservation of coffee *arabica* genetic pool. The south west Ethiopian coffee sector is made to achieve twin goals of augmenting quality and organic coffee and to preserve the genetic pool of *coffee arabica* to the World. However, the issue of increasing quality and quantity of coffee production without using modern input such as fertilizer put the livelihoods of its producers and exporters at dilemma. Using modern inputs to increase the quality and quantity means losing the organic /gene pool/ of *coffee arabica*; through the traditional way of production (without using modern inputs) forest coffee farmers could not increase the quality and quantity of their produce.The purpose of this paper is to examine and investigate causes of the problem/dilemma. To that end the following points are used as leading questions

1. How and why the term *coffee arabica* is coined to Ethiopia's coffee?
2. How the concerned authorities of Ethiopian coffee sector during different regimes strive to enable the country to secure proper benefit from it?
3. Is the issue of increasing quality and quantity in coffee addressed without affecting the interest of organic coffee farmers?

The paper is organized in to three parts. The first part deals with the early history of forest coffee and discuses about how coffee was distributed to other parts of the World from its birth place. The second part of the paper makes a brief historical survey about how forest coffee grew as valuable global commodity up until the early 20th century. The third section provides an overview of south western forest coffee Production &marketing along its marker chain.

2. Methods

This review paper has been done based on intensive reading desk review. In doing so, different theoretical and empirical evidences relating to forest coffee production and its genetic pool conservation are consulted. Moreover, a historical approach is used to examine the issue of how the Ethiopian coffee expanded until it becomes an international commodity. In addition, the works that deal with the experiences of different countries in ecosystem and sustainable natural coffee management were examined. And as a framework crafted by different scholars (such as Méndez, V. E. and Lovell, S, T., *2007;*Gatzweiler, Franz W., 2005) are used for the analysis of the existing dilemma between the issue of conservation of forest coffee and attaining better livelihoods through augmenting the quality and quantity of production.

3. Results & Discussion

3.1 Origin and expansion of organic Coffee to other parts of the World from its birth place

3.1.A. Discovery of coffee and its Early History

The issue of how coffee first discovered is full of uncertainties'. There are various legends about the discovery of coffee in south west Ethiopia. One of the legends attribute the discovery of wild coffee to the legend of Khaldi(who lived in Ethiopia at about 850 AD)and his goat. (selamta, 2016; ICC, 2014) The other legend, which is widely accepted by the Oromo people, relatesorganic coffee's growth to a soil watered by Waqa's tear. What is important and widely accepted fact is that there is a long and widely practiced tradition consuming coffee in various forms. The Oromo people used coffee fruit which they called "buna" cautiously for ritual purposes or as a vigor pill for military expeditions. Even by the 15th the local Oromo people fried in butter and ate it as coffeecake or bread. (Topik, 2013:2; TadesseWoldemariam, 2015:6)

Now Ethiopia is widely accepted as a birth place of coffee. (Daniels, 2009: 10: Topik, 2013:2) There is ample evidence to prove that

coffee arabica is originated in the south western forest region especially in Kaffa. Today it is generally accepted that the center of origin of coffee arabica is Southwestern and Southeastern Ethiopia (BirukGetenet, 2012:3-5)On the other hand, the name of coffee in various languages or tongues like Kaffee (in German), Koffie (in Dutch), café (in French, Portuguese), caffè (in Italian), Καφές (in Greek), Кофеий (in Russian) all indicates that the term coffee is derived from its birth place, kaffa.(Stellmacher, 2007)Moreover, long before the Arabs knew coffee the Oromo people traditionally use coffee as energy food (as bunaqalaa and Qori) (TadesseWoldemariam, 2015:7).In relation to its early history, who and when Ethiopian coffee was introduced to Yemen (formerly known as Arabia)is still obscure. Some writers such as Illy and Illy (2015) as cited in Tadesse Woldemariam(2015:9) made SuniMuslems, who starting from late 7th century onwards used to pilgrimage to Arabian holy places, instrumental for introducing it to Yemen. Some other scholars such as Till Stellmacher(2006:80-82) on their part believe enterprising traderstook its seedlings to South western Arabia at about 1000 A.D. Accordingly, what is clear from the sources is that after its introduction to Arabia the Ethiopian coffee was at least until 15th century used as stimulant crop. (TadesseWoldemariam, 2015:9-10)Unlike the people around its place of origin in and around Kaffa and south west Ethiopia, the Yemeni and the *Suffi*Muslims used to boil the coffee beans and drink it to stay awake at late night Dhikr /remembrance of Allah/. After 15th century however Coffee Arabica began to be produced for commercial use in Arabia Felix, today known as Yemen (Till Stellmacher, 2006:80-83; Topik, 2013:2).

Once after coffee reached them, until 1600 the Yemeni Arabs alone controlled coffee production. Until the 17th century, coffee cultivation was confined in Arabia especially to the highlands of Yemen and the Arabs kept coffee as their monopoly. They strictly prohibited exporting coffee to outsiders and if they had to export it in few exceptional cases, the Arabs roasted coffee beans so that it could not be grown or germinated in an area outside their country (Janzen, 2010:1086) It was only by the *late 16th and 17th centuries that some European and Indian travelers and merchants took coffee beans either by stealing or smuggling it. However, the Europeans saw coffee growing in farms and gardens of Arab countries and Since they first found coffee trees grown in Arabia, Europeans named the Ethiopian* coffee as coffee *arabica*. (Daniels, 2009:10; BirukGetenet, 2012:3)

3.2.Spread of Ethiopia's Coffee from Arabica to different parts of the World

It was in association with Islamic religion and pilgrimages to Mecca that coffee was reached to different parts the Muslim World. By the 15th century coffee reached Mecca and Turkey. From Mecca it was taken by travelers, pilgrims and traders to the different parts of Middle East and eventually it spread to other parts of the Muslim World. For example, from Mecca coffee was taken by Hajj or pilgrims to north & West Africa, to the Far East such as (Java & India), and to Middle East (such as Persia/Iran/ Turkey). In the early17th century, after few sacks of coffee beans sent to Venice from port Mocha of the Yemen, Coffee *arabica* began its

journey as export commodity. Soon the commodity continued to reach Cairo and Alexandria via ships and through the agency of caravan traders; from Cairo and Alexanderia coffee entered to other parts of the Ottoman Empire and to Europe (Janzen, 2010:1087; Topik, 2004:7-8)

Until the 17th century Arabia (Yemen) monopolized coffee production. However, in the 17th the Yemeni lost control coffee raw seeds or seedlings either through smugglers or during wars in (in 1683).Once after they get it from Arabia, the Europeans spread coffee to different parts of the World. Between the 17th and 19th centuries, European colonial powers took coffee to their own country and their respective colonial territories. Three European powers, the Dutch Republic, France, and Great Britain; played significant role in spreading of *coffee arabica*. Firstly, in the 1690s the Dutch explorers and entrepreneurs brought & cultivated coffee in their colony Java and then they spread it to other areas of Southeast Asia like Ceylon, Timor, and Sumatra. Within short period of time, the Dutch East Indies became important region for coffee production. Secondly, at about 1715 and 1718 the French transplanted coffee and began to produce seed beans that could yield a different kind of coffee Arabica at their colony Bourbon/Reunion. Almosta century later the unique coffee Arabica which is different in kind from the one that originated in Ethiopia, taken by the French to their colony in the New World /America/ and soon the French established coffee on the Caribbean island of Martinique. Almost at the same time the Dutch introduced coffee beans to South America. The British had their own special role in spreading Coffee in their Colonies in the "New World" North America (BirukGetnet 2012:6-8; Topika, 2004:7-11; HeranSerkBrhan, 2010:9-10)

Relatively speaking the culture of coffee drinking was introduced to Europe very lately. It was in the 17th century Europeans started coffee drinking and gradually coffee houses expanded, and towards the end of the century demand for coffee as stimulant beverage sprang up. Apart from its stimulant value as beverage, the demand for coffee consumption increased for its social value. This is because in Europe coffee houses gave consumers opportunity to freely chat & discuss social issues beyond the immediate sight/purview/ of state or religious authorities. With this rising demand, coffee continued its rapid spread; it crossed the Atlantic and arrived to the European colonies in the two Americas. As it had been in Europe, in USA coffee had a huge social impact and the coffee house quickly grew as important social gathering places. (Cowan, 2005:18-19; Janzen, 2010:1087-1088)

The French, who planted seed beans that yield a different kind of coffee Arabica has a special place in coffee history for generating the ancestor of Brazil's and Mexico's coffee(BirukGetnet 2012:6-8) And soon Brazil began to grow as a leading coffee exporting country by producing halfof the World's coffee . In 1850 and in 1906 Brazil's coffee production grew in five fold. (Topik, 2004:18-20)

3.3.The Evolution of forest coffee from obscurity to a status of valuable global commodity up until 1941

There is paucity of sources about history of coffee production in the early and medieval period Ethiopia. However, available sources points toward the probability that in its early days coffee production and consumption was strongly associated with Islamic and indigenous religious practices. It was the Sudanese slaves, who were taken to Arabia across Ethiopia, had learned the custom of chewing coffee from the people of southwestern of Ethiopia. In the course of their travel they introduced coffee to south east Ethiopia such as Harar(TadesseWoldemariam, 2015:6)Before the culture of coffee drinking widespread everywhere in Ethiopia after 19th century, it was widely used by the south west and south eastern regions, where the population was predominantly non-Christian (SerkBrhan, 2010:15).However, ittook centuries for south western Ethiopian forest coffee to be recognized as valuable commodity.Even in the 15thand 16th centuries, coffee was not used in Ethiopia as a major cash crop.It was through the Arabs that the Ethiopia coffee entered to World Market. (Topik, 2013:2; Abdusamad H.Ahmad, 1997:543)

3.4.Coffee production and marketing from late 19th century up until 1941

Before the 19th century, market relations in Ethiopia were conducted mostly in a barter system and long distance traders served as agents of trade. Civets, slaves, gold, ginger and coffee were found from south west Ethiopia as items of trade. Throughoutmedieval and early modern period, coffee from south western Ethiopian region was taken by long distance traders across the trade route that stars from saqa /Agaro and run to north west across Gondar and to the north east through Shewa. (BahiruZewde, 2002,22-23)But when compared with other commodities, coffee exported from Ethiopia through various ports like Massawa, and Metemma was very limited (Abdusamad H. Ahmad, 1997:544)

It was by the 19th century that coffee from Ethiopia entered in to international market as valuable commodity. Two historians have different views about why demand for coffee from Ethiopia. According to Abdusamad (1997) it was with the advent neighboring colonial powers such as the British in the Sudan and the Italians in Eritrea that sprang up demand for coffee. However, Steven Topik related the growing demand to coffee to the Arab Muslims. He expounded that it was only after the Muslims across the Red sea domesticated coffee tree and created promising demand in the Muslim World that coffee from Ethiopia began to be widely exported(Topik,2013:2). However, Topik's view is not convincing because coffee from Red Sea area never been a dominant cash crop. And hence it was with the advent of colonial powers such as the British in Sudan and the Italians in Eritrea that demand for Ethiopian coffee grew steadily. In addition to competing, as they did in other matters, to divert the long distance trade routes to their respective colonies, the British and Italians directly appointed colonial agents in strategic areas.(Abdusamad, 1997; Binayew, 2014:298)

Towards the end of the 19th century, Amharas of Shewa kingdom conquered the resourceful

forest coffee region of south west Ethiopia and tried their best to monopolize coffee exploitation and commercialization (Bossolasco L.,2009:3) Though Menilik brought the region under Shewan control, until the opening of the Addis Abeba –Djibuti Rail way in the early 20th century, however long distance caravan traders had used coffee from south west Ethiopia as one of the major trading items. They still were used to sell /export /it either through Metema or Asmara and Massawa. But starting from early 20th century, almost all commodities including the south western coffee began to be exported via port Djibouti (Bahiru, 2002:101-102)

In the late 19th century cash and coffee was highly demanded by Emperor Menilikto purchase modern weapons for the imperial army. As reported by Guluma, a researcher, in a letter he wrote to Aba Jifar of Jimma on 28 August 1893 Menelik told the governor Jimma about the imposition of tribute in coffee on Oromo chiefs. Accordingly, the emperor explained that since the Europeans firearm sellers asked him to pay the cost of the arms in coffee not in cash, he demanded coffee as tribute (GulmaGemeda, 2007:57-60)

Long before Menilik's conquest of the region, coffee in its natural state /condition/ was widely cultivated by the Oromo and Omotic peoples of the Gibe region. During Menilik's war of conquest and even at the time of early administration by conquerors from the north, the natural coffee in some parts of south west Ethiopia was destroyed. Perhaps this indicates the fact that at the early stage of their conquest, Menilik and his soldiers considered coffee as less valuable cash crop. The indigenous people on its part abandoned their coffee farms to engage in producing subsistence crops for their livelihood. Later the abandoned coffee farms were designated by the conquering force as "wild/forest" coffee farms. Emperor Menilik's soldiers, who then were appointed as local governors, took coffee farms as their "exclusive property" and ordered the indigenous farmers to bring the ripe beans to their' coffee storehouses as tribute. The governors' agents sold the stored coffee to local and foreign merchants (Gulma Gemeda, 2007:57-58).

During the last decade of Menilik's reign (1893-1913) there was increase in demand for coffee as export cash crop. In addition to the growing importance of coffee to the country's foreign trade commodity, Menelik's strong desire for more cash to acquire modern firearms had its own contribution for growing demand in coffee. Thus the earlier neglect to coffee production by state leaders reversed. Moreover, in the early decades of the twentieth century, the establishment of orderly administration had its own significant role to transport coffee from farms to market centers and to the port. Though the Ethiopian coffee began to serve as major export commodity, prior to 1920s the largest amount of coffee had been used for local consumption (Topik, 2013:2; *YaredBerhe, 2010*:12)

As Emperor Menilik II (1889-1913) did before, Regent Teferi,the later Haile SelassieI (1916-1974) encouraged coffee as Ethiopia's main export commodity. This motivated the local elite/*balaba*t/ and farmers to cultivate large quantities of coffee to get large revenue. For that reason, in 1920s and 1930s rather than restricting themselves on plots and tributes

from subject farmers or *gebbars*, the appointed governors decided to create their own coffee plantations. To that end, the appointed governors expanded their plots of land through different mechanisms such through land purchase or by snatching land from indigenous peasants. In this plantation system the amount of Ethiopian coffee production in south west Ethiopia increased throughout 1920s and early 1930s. Concurrently, the amount of export through port Djibouti sprang up from 288 metric tons in 1921 to 5,864 metric tons in 1925.In the immediate pre occupation period (1935-1941) the exported coffee continued to grow and in 1935 it reached 9,408 metric tons. During the same years, large quantity of coffee, which is estimated from about 25,000 to 45,000 quintals of coffee , was exported to British Sudan via Gambella dry port from south west Ethiopia.(GulmaGemeda, 2007:57-59; Topik, 2013:2; Yonas Seifu, 2002: 43-44)

Historians attributed the reason to the rapid expansion of coffee cultivation in South west Ethiopia to two major factors. The introduction and expansion of modern transportation infrastructure especially Rail way and water transportation, which enabled transportation of bulky coffee commodity to the ports, was one of the factors. Growing interest of the elite including the local *balabat*& officials to get more revenue by involving in the production and marketing of cash crops was the other major factor. As a result,from 1930s onwards coffee began to play a leading role as the country's major export crop. At the same time many actors other than farmers and traders such as brokers emerged and began active engagement in coffee economy (YonasSeifu, 2002:43-44; YaredBerhe, 2010:12; GulmaGemeda, 2007:60-63)

However, two major challenges disrupted the temporary boom in coffee production in southwest Ethiopia.The economic crisis that hit directly or indirectly all countries of the World from 1929-1933, was one of the challenges that caused for the decline in coffee production and marketing. For example, the cost of one feresula/equivalent to 17 kilo gram/ coffee drastically decreased from 13 Maria Theresa dollars just at the beginning of the crises to about 8 MT dollars during the crises. This in turn discouraged coffee production in a plantation system. The second Ethio- Italian war (1936-1941) was the other major challenge that prohibited large scale coffee production. Like land lords, coffee plantation dislocated and their land confiscated. Moreover, the Italians focused on producing cereal crops for feeding their large army.Consequently, for five years during and after occupation period, coffee production remained very low and stagnant. (YonasSeifu, 2002:44; GulmaGemeda, 2007:63)

For century's traditional coffee production system, have been practiced by smallholder farmers and was dominant in southwestern parts of the country. The forest coffee production system, which confined in south west Ethiopia and Bale mountains, represents the lowest and its yield coverage in the country accounts less than 5%.Moreover, both in terms of contribution to the country's coffee production and in its yield, forest coffee is the lowest. Even though yields vary from year to year depending on different factors such as climatic condition and management during

cultivation, the forest coffee contribution in yields is on average 200-250 kg/ha of green beans per year. Moreover, the south western coffee forest and its ecosystem as cradle of worldwide Arabica coffee are recognized as a biodiversity hotspot. *(TadesseWoldMariam, 2015:14-20; Zekarias Shumeta&etal, 2012:28;* Stellmacher T, 2007:1; Stellmacher T. and Mollinga P., 2009:44)

4. Forest Coffee production and its Market Chain in South Western Ethiopia ,1941- 2008

4.1.Conceptual framework

In south west Ethiopia traditional coffee production systems is still predominant. Even though modern coffee plantation system introduced 100 years before, it is the traditional coffee production system, which composed of forest coffee (FC), semi-managed forest coffee (SFC), garden coffee (GC) that accounts more than 90% of the country's coffee produce. In FC production system, local farmers directly harvest coffee in its natural habitat by picking and collecting coffee fruits with little or no human intervention in a wild forest. The effort and forest management to improve the quality and quantity of in a wild forest coffee production system varies from none intervention to moderate intervention. (BirukGetnet, 2012:8-9; TadesseWoldMariam, 2015:14-20)Hence the management and intervention to improve the quality and quantity of FC cannot be treated in separation its forest ecosystem.

According to Méndez, V. E. and Lovell, S, T., (*2007:2*) the forest ecosystem provides four ecosystem services; production services, regulation services, cultural services and supporting services, are essential for sustainability of human life. In relation to the subject under investigation, in addition to its importance as center of organic coffee Arabica genetic resource conservation, the south western forest ecology is providing production services. In this regard for a forest ecosystem that serves as center of production and conservation, Eco-agriculture is recommended as viable framework. In theory Eco agriculture focus among others on biodiversity conservation, protection of ecosystem services and poverty alleviation. Hence it enables to meet the goals of conservation and sustainable development without jeopardizing the livelihoods of the local community and the generations to come. (Gatzweiler, F.&etal,2005; Méndez, V. E. and Lovell, S, T., *2007:3-4)*

4.2.Conservation Vs Sustainable Development in south west Ethiopia Forest coffee production system

From the literature it is possible to see that forest coffee production system is one of the most debatable issues. To my best understanding the scholarly debate in relation to forest coffee production system in south west Ethiopia revolves around two issues; one emphasis for conservation coffee Arabica genetic /pool/ Resources by protecting its natural forest biodiversity and the other is emphasis for improve the quality of forest coffee production and improve the lives of its producers. The first group of scholars, who in

one way or another contend that the original Coffee*Arabica* genetic resources should be conserved, are referred for this discussion as "conservationists" and the second group, who argue in support improving forest coffee quality and improving the lives of its producers through developmental projects, termed here as "*developmentallists*"

4.2.1. **Essence of the arguments of "Conservationists" and "Developmentallists"**

The Ethiopian wild population of Coffee Arabica is threatened by rapid deforestation. The conservationists believe and contend that the south west Ethiopia forest coffee is one of biodiversity hotspots that contain the world's unique wild *Coffee Arabica,* and should be protected and conserved as a reservoir of genetic diversity. They found that about 60% of the south western Ethiopian original natural forest was destroyed between 1973 and 1997. Due to accelerated deforestation the Forest (FC) and semi forest coffee (SFC) land in 1973 was found to be decreased from 71%in 1970s to 48% in 2005. Within 32 years 23% the original forest in south and south west Ethiopia has converted either to crop lands or small hold commercial coffee plantation (CCP).And between 1990 and 2005, the rate of deforestation was accelerating on an average annual deforestation rate of up to 9 %. Based on such research based evidences, some scholars warn that unless effective measures are taken to stop deforestation and to regulate unplanned expansion of commercial coffee plantations the unique and irreversible natural coffee *arbica gene pool*, may be lost all together with the natural coffee. For scholars in support of conservation, empowering a dedicated institution that can coordinate conservation efforts; enforce forest policies and providing appropriate finance along with technical support for forest coffee farmers is supposed to be best solutions(Gatzweiler, F.&etal,2007:2;Wakjira and etal.2007; Stellmacher T., 2010:1)

Believing that less educated poor forest coffee farmers have a short term planning horizon and less concern to forest conservation for sustainable development, "conservationists" partially reject financial support to farmers and suggest institutional development as a solution to stop coffee forest deforestation. They explained that since these farmers give priority for securing food & subsistence needs, providing financial and technical support may not enable them to carry the entire responsibility of conservation.(Agwanda&etal, 2009:1-2;Stellmacher T and Mollinga Peter, 2009:44) They also recommended that in addition to improving production in forest coffee quality, its farmers should be encouraged to engage in multifaceted non timber forest products like coffee, honey and spices production.(Hein and Gatzweiler 2006; Tadesse W/mariam, 2015:23-24)

Actually some of pro conservation scholars go to the extent of criticizing the government for its failure to establish a strong central institution to manage the forest coffee production. They contend that regardless of its rhetoric to protect forest coffee and its biodiversity by providing land ownership certificate to farmers and through biosphere reserves, conservation capacity in the country is low and the protected area system is little effective in decreasing rate

of deforestation. They also believe that because of the imbalance between the rhetoric and the practice the greatest amount of forest cover in south west Ethiopia is vanished. *In criticism on what is done to the on the country's organic coffee forest, they complained that with in less than 15 years until* 2014, the country's coffee harvested area doubled from 250,000 to 520,000 hectares partly through deforestation with no increase in coffee yields. Some of them went to the extent of warning that if such practice continued it will take only 27 years to totally lose the remaining original forest together with the world's only original wild populations of Coffee *arabica*." Accordingly this threat is happening because the Ethiopian government, instead of authorizing a strong central institution, left the coffee for too many players such as NGOs and Cooperatives in charge of coffee governance. After dismantling the Tea and Coffee Authority set up by the Dergue, the current government practically neglected the coffee governance"(Tarikua Getachew, 2015:1-2; Agwanda&etal, 2009:1-2; Gatzweiler,2005)

Developmentalists" too do not support the idea of increasing coffee harvesting land through deforestation. They rather believe that through deep involvement in forest coffee production and proper management, it is possible to increase FC yield. They also support certification both as strategy to prevent deforestation and to motivate FC farmers to produce quality/specialty coffee/ Accordingly, certification enables forest coffee farmers to intensify their farm management through activities such as withdrawing of over stored trees, removal of ground vegetation. And forest coffee certification system said to have a positive impact on preventing forest degradation in the certified areas and the surrounding forest regions.(BirukGetnet, 2012:8-9; Minten, B. &etal, 2014:9; Takahashi, R. and Todo,Y., 2015)

Conservationists doubted its effectiveness in Ethiopia. Indeed they accept Certification as a viable market strategy and accepted that after the introduction of certification in 1990s, the Ethiopian organic forest coffee or the specialty coffee has been attracting consumers' attention in Europe andUSA. However, they argue that under the existing institutional system, certification as strategy for conservation and sustainable development is not effective. As justification for their argument, conservationists assert that certification is accepted by (FC) farmers as a motivating factor only when their certified specialty coffee enabled them get better price. Even though the Ethiopian specialty&forest coffee has good image and obtaining reasonable price, its farmers are not getting appropriate price. It is rather some other actors/mediators/ who misuse certification for their own benefit that is obtaining good advantage from Ethiopian specialty coffee. Scholars such as Stellmacher, T. (2007:9-10) attributed this problem to absence of a free press/media as a 'watchdog' against personal or organizational abuse of certification. Moreover, unless they use some modern mechanisms such as using fertilizer, even the most intensive management systems could not help forest coffee producers to increase quality and quantity of their yield. For this reason, small hold FC farmers preferred either to use some fertilizer or clear some of the forest which in one way or another affect the forest biodiversity ecology and the organic nature coffee.(Mas

A.H. AND. Dietsch T. V, 2004:648; Gatzweiler, Franz W.,2005).

The certification process itself is not only difficult for the Ethiopian small holder forest coffee farmers but also almost impossible to be feasible in the existing management system and administrative structure. On the side of its farmers getting their coffee produce recognized as specialty and organic coffee requires full filling of different criteria. (Stellmacher,T. 2007:9-10;

For instance, one of the measurement criteria, 'fair trade scheme' requires getting tangible evidence to show that coffee farmers are benefiting fairly, which in the presence large middlemen/brokers/ in the long coffee marketing chains, is difficult to fulfill. In this case with existing imbalance between retail prices and farmers' income from their forest coffee getting certified and incurring high price at international market is less likely. For the last 7 years from 2006 to 2013 for example only 2% exported coffee was able to get certification under fair trade scheme/criterion/ in international transaction system. Moreover, even the certified forest coffee is not necessarily fetch high price (K. Wiersum F. &etal, 2007:3; Oliva,J., 2008:3;Minten,B. &etal,2014:9)

Some other scholars who wrote in support of "developmenalists", believe that in the face of volatile World coffee market, pressurizing forest coffee farmers to give emphasis for conservation is futile effort. In this case it is reported that between *1999 and* 2004 when a great coffee price slump occurred ,most of the farmers in south west Ethiopia, as elsewhere in other coffee producing regions in the country, converted their coffee farms to growing chat and other food cereals. They did so because during that time a certain amount of *chat* , which brought nearly equal price to one kilo gram of coffee at normal time, was sold for as high as $9, while the coffee was only for $0.01.Moreover they argue that since the genetic pool of south western Ethiopian rainforests with wild coffee have already been modified due to conversion of the original forest to agricultural land or to garden and plantation coffee systems; rather than strictly focusing on conservation of forest coffee it is more viable/imperative to work toward increasing the quality and quantity of forest coffee yields. From this point of view what is initiated by farmers to improve their produce and by several development project to developing or breading models [perhaps including in laboratories] of new coffee varieties having international importance is acceptable. They also stated that in addition to conservation coffee genetic resources, great emphasis needs to be given toward improving marketing as a means to increase the incomes of smallholder coffee producers.(SerkBirhan, 2010:9-10; Stellmacher T, 2007:9; Zekarias Shumeta&etal, 2012:28)

Conclusion &Recomendation

The Ethiopian coffee spread from its original homeland to other parts of the World. And it is possible to safely argue that the culture of coffee cultivation and consumption reached at different corners of the World before it became an international commodity in the late 19^{th} and early 20^{th} century. It is possible to see that the history of coffee cultivation and spread with in

Ethiopia and the Horn follows a similar pattern as the outside World**.** At present scholars and the international community almost entirely accept that the South western Ethiopian region is not only the birth place of coffee Arabica but also recognized its forest coffee as important habitat of coffee Arabica genetic pool resource for future use. However, the issue of how to conserve/preserve Ethiopian forest coffee genetic pool altogether with its biodiversity while sustaining development through producing organic forest coffee without jeopardizing the livelihoods its farmers is still a controversial issue. From the literature of coffee sector studies, two groups, who wrote about the dilemmas between Conservation and Development do not dive good emphasis for the burdens of Small hold Forest coffee farmers. One important point they stressed is encouraging organic forest coffee producers through certification. Whether certification both as a market and conservation strategy, could secure the advantage of coffee farmers is debatable; some pro development writers show a tendency of depicting its effectiveness. Pro-conservation writers stress its failure and attributed the reason to lack of appropriate political and institutional ecology in the country. One this point, it is possible to conclude that since the primary motives for establishing organic forest coffee certification programs emphasized the conservation of biodiversity and to and to get better price at a global but with little or no incentive for its farmers, the certification programs is less likely to meet its goals. If it needs to be effective both to attain the goals of conservation and securing sustainable development, a central institution that coordinate and promote Organic forest coffee production and certification management should be established. Local institutions, which fairly represent local forest coffee farmers, needs to be established or reorganized to mobilize to locals towards achieving the goal. And if farmers need to contribute for the effectiveness, they have to get clear idea about the criteria or if needed the criteria should be contextualize to the local situation and as a compensation for those strictly adhere the criteria in production and processing, rewards and incentives should be as a compensation to their low yield. This approach could help guide management decision by both farmers and certification agencies, preferably together.

Reference

Abdussamad H. Ahmad (1997). "Priest Planters and Slaves of Zegie (Ethiopia)" International Journal of African Historical Studies, vol.29, No. 3.

Agwanda(2009). Improving coffee quality in East and Central Africa through enhanced processing practices (Rwanda and Ethiopia) Final Technical Report,CABI Africa, Nairobi

BahiruZewde,*(2002). A History of Modern Ethiopia 1855-1991, (2nd Ed.) Addis Ababa: Addis Ababa University Press.*

BinayewTamrat(2014) "Rivalries over Revenue from Zege Coffee among Local and International Powers from 19th Century to 1935"The International Journal Of Humanities & Social Studies

BirukGetnet, (2012). Genetic Diversity of Wild Coffee (*Coffeaarabica*L.*)* Populations from Southwestern Ethiopia as Revealed by ISSR Markers,M.Sc Thesis in Biology, AAU.

Bossolasco L., (2009) .A study case on Coffee (Coffee arabica L.) LimuCoffee

Cowan, Brain (2005). The Social Life of Coffee: the Emergence of the British Coffee House, Yale University press, new heaven and London.

Daniels,N. (2009).Variations in Coffee Processing and Their Impact on Quality and Consistency. M.Sc. Thesis in forestry, Michigan Technology University

Faire Trade Foundation (2012) Faire Trade and Coffee

Food and Agriculture Organization of United Nations-FAO (2014) Analysis of price incentives for coffee in Ethiopia for the time period 2005–2012

Friedrich zurH.,(2012).Feasibility Study for a Lake Tana Biosphere Reserve, Ethiopia

Gatzweiler, F., (2007) Why financial incentives can destroy economically valuable biodiversity in Ethiopia, ZEF – Discussion Papers On Development Policy No. 115, Center for Development Research, Bonn,Germany.

Gatzweiler, Franz W.(2005) Institutionalizing Biodiversity Conservation – The Case of Ethiopian Coffee Forests University of Bonn, Centre for Development Research (ZEF).

GulmaGemeda(2007). The Rise of Coffee and the Demise of Colonial Autonomy: the Oromo Kingdom of Jimma and Political Centralization in Ethiopia, Michigan State University Press

HeranSereke-Brhan(2010)Coffee, Culture, and Intellectual Property: Lessons for Africa from the Ethiopian Fine Coffee Initiative.The PadrePapers / No. 11 /

Janzen, S. Oestreich- (2010). Chemistry of Coffee, CAFEA GmbH, Hamburg, Germany

Mas A.H. AND. Dietsch T.V.(2004) "Linking shade coffee certification to Biodiversity Conservation: butterflies and birds in Chiapas, Mexico" *Ecological Applications* Ecological Society of America, 14(3),pp. 642–654

Mekuria T., (2004).“The Status of Coffee Production andthe Potential for Organic Conversion in Ethiopia” Conference on International Agricultural Research for Development, Berlin

Méndez,V. E. & Lovell,S. T. (*2007*).“Ecosystem Services Conservation and Farmer Livelihoods in a Shade Coffee Landscape of Western El Salvador”*Paper presented at the Second International Symposium on “Multi-Strata Agro forestry Systems with Perennial Crops: Making ecosystem services count for farmers, consumers and the environment.” September 17 – 21,CATIE, Turrialba, Costa Rica.*

Minten,B. (2014). “Structure and Performance of Ethiopia’s Coffee Export Sector”, Working Paper 66, EDRI&IFPRI

Oliva, J., (2008).“Safeguarding biodiversity in Ethiopia’s coffee forests: Opportunities and challenges related to intellectual property rights” BioResTrade& Environment Review, Issue 4

Saoud, R. (n.d). The Coffee Route from Yemen to London from 10th-17th Centuries www.muslimheritage.com/.../coffee-route-yemen-london-10th-17th-cent.

Schüβler, L.(2009) “Protecting ‘Single-Origin Coffee’ within the Global Coffee Market: The Role of Geographical Indications and Trademarks” The Estes Centre Journal of International Law and Trade Policy, Vol. 10 N. 1. pp. 149-185

Schüβler, L., (2009). “Protecting ‘Single-Origin Coffee’ within the Global Coffee Market: The Role of Geographical Indications and Trademarks” The Estey Centre Journal of International Law and Trade Policy, Vol. 10 No. 1.

Stellmacher T., (2006). Governing the Ethiopian Coffee Forests: A Local Level Institutional Analysis in Kaffa and Bale mountains, Inaugural – Dissertation. InstitutefürLebensmittel- und Ressourcenökonomik (ILR) Bonn, Germany.

Stellmacher T.,(2010). Protection of biodiversity through coffee certification? The case of forest coffee in Bench Maji and Kaffa Zone, Ethiopia

Stellmacher, T.(2006). **“**Governing the Ethiopian Coffee Forests: A Local Level Institutional Analysis in Kaffa and Bale mountains” InstitutfürLebensmittel- und Ressourcenökonomik (ILR), Bonn,Germany.

Stellmacher,T. (2007). Prospects and challenges of forest coffee certification in Ethiopia: the need to effectively link economic benefits and biodiversity conservation

Stellmacher,T.and Peter P. Mollinga. (2009). "The Institutional Sphere of Coffee Forest Management in Ethiopia: Local Level Findings from Koma Forest , Kaffa Zone" International Journal of Social Forestry, Volume 2, Number 1, 43-66

TadesseWoldemariam,(2015).coffee Ethiopia's gift to the World. Environment and Coffee Forest Forum

Takahashi, R. and Todo,Y.(2015) "Coffee certification and forest quality: A case in Ethiopia" International Conference of Agricultural Economists., Milan, Italy.

TarikuaGetachew,(2015) "Analysis: Ethiopian Coffee : A gold mine in its Last Leg" Addis Standard,pp.1-2

Topik, S., (2004) "The World Coffee Market in the Eighteenth and Nineteenth Centuries, from Colonial to National Regimes" Working Paper No. 04/04

Topik, S.,(2013). The Making of a Global Commodity Part 1: Out of Arabia

UNDP (2012) Proposal for Coffee Platform in Ethiopia

WakjiraDereje(2007). Forest Cover Change and Socioeconomic Drivers in Southwest

Wiersum, K.F.(2007)Certification of wild coffee in Ethiopia: Experiences and challenges(Article submitted to Forests, Trees and Livelihoods)

YaredBerhe.(2010). The Legal Regime Regulating Coffee trade in Ethiopia, M.A Thesis in Law, AAU

YonasSeifu(2002) A historical Survey of Jimma Town, 1936-1974, M.A thesis in History, AAU.

ZekariasShumeta.(2012).Analysis of Market Chains of Forest Coffee in Southwest Ethiopia

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Effect of Processing on Anti-Nutritional Factors of Black Climbing (*P.Coccineus.L*) (Hepho) Bean Flour

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Abstract

The study was aimed to determine the effect of processing on anti-nutritional factors of *Hepho (black climbing bean) (Lablab purpureusL.).Two (2) anti-nutrients (the raw, dehulled traditionally cooked (DTC), undehulled, traditionally cooked (UTC), dehulled pressure cooked (DPC) and undehulled pressure cooked (UPC) of hepho bean seeds had respectively contents (mg/100g) of phytic acid 304.80, 196.20, 231.90,118.90, and 103.00; and for tannin contents were 368.04,293.04,269.57,215 and 218.00) were determined in each sample seed. The four processing treatments given to the seed showed a general reduction trend on these two anti-nutrients at different rates and levels. Pressure cooking was the best processing method for phytic acid, and tannin while pressure cooking after (PCD) was the best processing method for tannin. Then it was concluded that hepho (Lablab purpureus L.) is good sources of nutritional profile and all processing methods effectives reduced anti-nutritional factors and this might be important in utilization of hepho and popularizing it; because most of the time the people have no interest to eat hepho due to its bitterness characteristic that related with presence tannin the seed removing tannin through pressure cooking after removal of the hall will avoid this problem and increase the importance of hepho.*

Keywords:*"Hepho" (Lablab purpureus L.), domestic traditional cooking, pressure cooking, ant-nutritional factor, Dehulled and undehulled.*

1. Introduction

Hepho is the Afan Oromo name for Black climbing bean (.*Lablab purpureusL.)* which is a seed pulse crop, belongs to the Phaseolus species and family of *Leguminous.* Therefore, the word Hepho, as used by the Oromo, describes the entire black climbing bean with black seed bean. Hepho bean (*Lablab purpureusL.*) is one of the principal food and cash crops legumes grown in both the lowland and medium altitude areas of Ethiopia ranging from 700-2000m above sea level, particularly, in the North-West parts and Wollega Zones (Western and Easter Wollega and Bennishangul-Gumuz) (Derese, 2012). Black climbing bean "Hepho" is the most important food legume as the source of protein for consumption (Tadese and Bekele, 2003). This crop is known in the country since the 16^{th} century (Shimelis and Rakshit, 2005). Its growth habit of is in determine type-4 (climbing), seeds size is medium spexled /speckled with black color (Zelelem 2002). Intercropping with maize and planted under Fence around household (supportive) (Aboudum et al., 2010). Hepho seed usually reach a harvestable stage within five to six months from planning depending on the environment, the plant dies after the seeds have matured. From the single plant one can harvest a seed only once or can harvested a seed from the plant in next year again. The storage of Hepho is relevant only for seeds. The usual storage method is to keep the seeds in suck or in locally known storage place was similar as that of cereals. Hepho is eaten at its early maturing period and after its maturation period when it is dried in the form of wett with Enjera by adding different types spices those used as spice in the local and in the form of mullu' Nifiro. Though legumes are important sources of dietary proteins for human and animals, their usefulness have been hindered by the presence of some anti–nutritional factors known as toxins (Reedy, N.R. and Pierson, M.D., 1994). Nutritional quality is affected by these factors that interact with the intestinal tract such as phytate, tannins and oxalates which reduce protein digestibility and amino acid absorption (Heng .L, et al., 2006 and Obasi, 1994). Being leguminous species the same things are happening in black climbing "hepho" bean. However, these substances need to be destroyed either by heat or other treatments otherwise concentration of toxins will exert adverse physiological effects when ingested by man and animals (Alonso et al, 2000). Because of this eating of hepho is not popular throughout the country and it is limited only to some parts of the country. Not only this but also those who have the habit of eating hepho also always raise this issue as the problem of eating hepho even though, it is high nutritious bean like other common bean . Therefore, for expanding its proper utilization; it is desirable to study its anti-nutritional factors and to examine effects of processing techniques on reducing these anti-nutritional factors. The purpose of this study was therefore; to determine the effect of DTC), (UTC), (DPC) and (UPC) techniques on anti-nutritional factors of hepho.

1. Materials and Methods

Sources of Materials

The fresh seeds of "hepho" or black climbing bean (*Lablab purpureus L*) for this study were obtained from Leka Dullecha district Oromia State of Ethiopia.

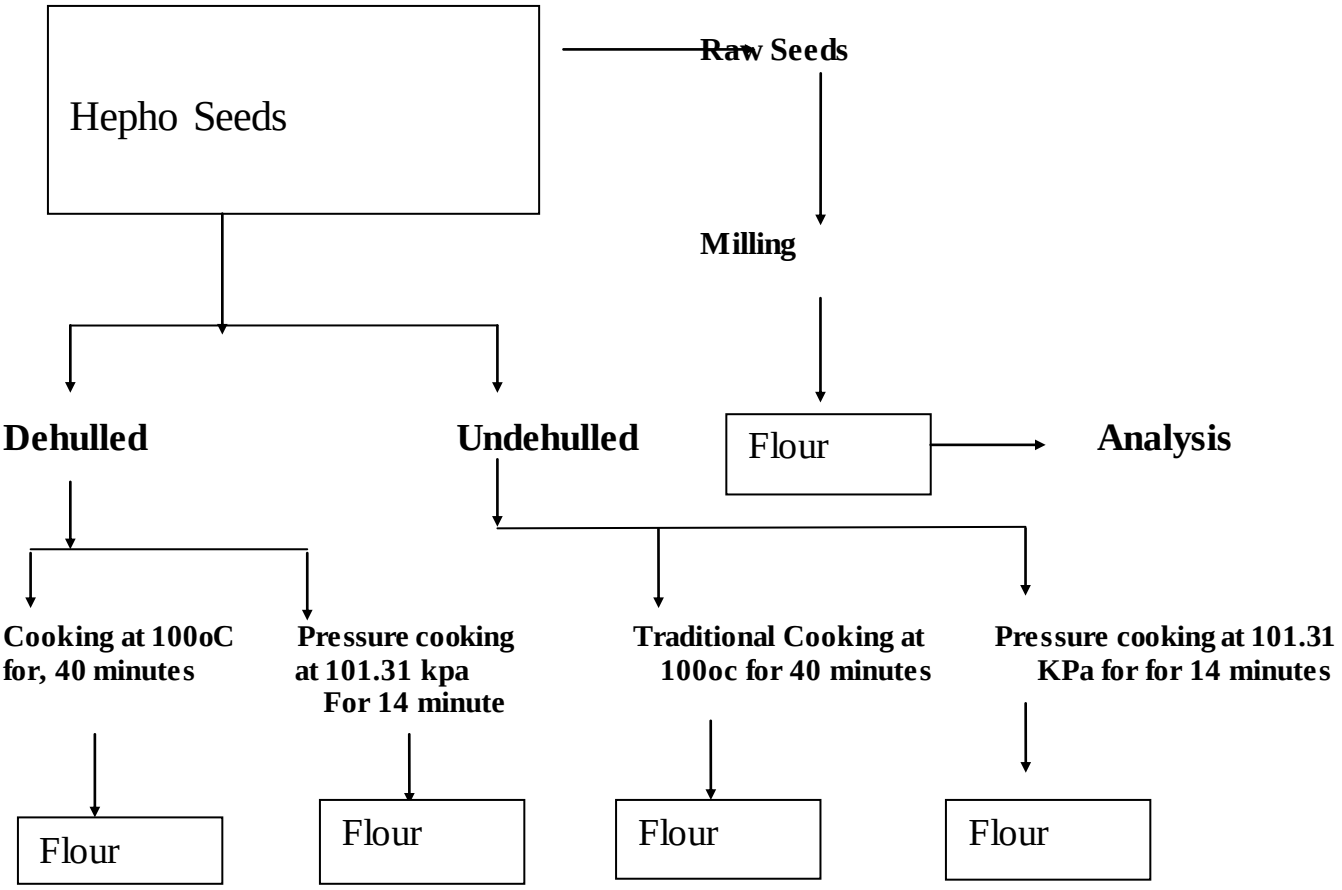
All equipment and chemicals used were available at Adama Science and Technology University Oromia state Adama town (sample preparation part) and Ethiopian Health and Nutrition Research Institute (EHNRI) laboratory services Addis Ababa which is capital of Ethiopia. All the chemicals used were of analytical grade. The experiment was conducted on raw, dehulled and undehulled hepho bean seed for analysis of anti-nutritional factors of the seeds. Anti-nutritional analysis was carried out in triplicate via traditional and pressure cooking methods.

Sample Collection and preparation

A total of 18 kilograms (6kg from each kebele) apparently uninfected Hepho were collected from the randomly selected 18 households (1 kilogram per house hold) of study site (Bandira, Kubena Hambelta and Horo Hambelta kebeles). The samples were packed in polyethylene bags, kept in an ice box (to prevent moisture loss), and transported to Chemical Engineering laboratory of Adama Science and Technology University within the two days of sample collection.

Fig 1. Dehulled (left) and Undehulled (right) of hepho seeds for flour production

Frame work of the Experiment



Determination of phytate

The method described by Nwosu (2011) was used. The phytic acid in the samples was precipitated with excess $FeCl_3$ after extraction of 1g of each sample with 100ml 0.5N HCl. The precipitate was converted to sodium phytate using 2ml of 2% NaOH before digestion with an acid mixture containing equal portions (1ml) of conc. H_2SO_4 and 65% $HClO_4$. The liberated phosphorus was measured calorimetrically (Jenway 6051 Colorimeter) at 520nm after colour development with molybdate solution.

The percentage phytate was thus calculated:

$$\% \text{ Phytate} = \left(\frac{100}{Wt}\right) X \left(\frac{au}{as}\right) X \; C \; X \left(\frac{Vt}{Va}\right)$$

Where W = weight of sample used

au = absorbance of test sample

as = absorbance of standard phytate solution

C = Concentration of standard phytate solution

Vt = Total volume of extract

Va = Volume of extract analyze

Determination of Tannin

The Folin-Denis spectrophotometric method was used. The method was described by Ezegbe (2012). A measured weight of each sample (1.0g) was dispersed in 10ml distilled water and agitated. This was left to stand for 30min at room temperature, being shaken every 5min. At the end of the 30mins, it was centrifuge at 1000rpm for 5minutes and the extract gotten. 2.5ml of the supernatant (extract) was dispersed into a 50ml volumetric flask. Similarly 2.5ml of standard tannic acid solution was dispersed into a separate 50ml flask. A 1.0ml folin-denis reagent was measured into each flask, followed by 2.5ml of saturated Na_2CO_3 solution. The mixture was diluted to mark in the flask (50ml) and incubated for 90min at room temperature. The absorbencies were measured at 250nm in a Genway model 6000i electronic spectrophotometer. Readings were taken with the reagent blank at zero. The tannin content was given as follows;

$$\% \text{ Tannin} = \left(\frac{Au}{AS}\right) \times \frac{100}{W} \times \frac{Vf}{Va}$$

Where; Au = Absorbance of test sample

As = Absorbance of standard tannin solution

C = Concentration of standard tannin solution

W = weight of sample used

Vf = total volume of extractVa = Volume of extract analysed

Va = Volume of extract analysed

Statistical analysis

The results obtained from the various analyses were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 16.0 (SPSS Inc., Chicago IL, USA).

2. Results and Discussions

Phytate and tannin content of raw and processed hepho flour were presented in **Table1**. All the processing methods applied in this study significantly reduced ($P<0.05$) these two anti-nutritional factors.

Phytate content

The phytate content of raw 'hepho' bean seeds was determined to be 304.80mg/100g and among the processing methods employed, pressure cooking was found to be more effective in reducing the phytate content. The highest reduction (66%) was observed in the dehulled PC followed by undehulled PC (61%) reduction (Table1). This report was in agreement with the works of Akinjayeju and Ajayi, 2011). on black beans (*Phaseolus vulgaris*) and Osman (2007) reported pressure cooking of lablab beans caused reduction phytate content by 52.29%. In this study, the traditional cooking also reduced the phytate content where dehulled TC cause reduction by 36% followed undehulled TC by 24% **(Table1).** This finding was well agreed with work of Mubarak (2005) that normal boiling decreased the phytate content of mung bean by 25.36%. The evident reduction in phytate during cooking may be caused by degeneration by heat or the formation of insoluble complexes between phytate in addition to leaching into the cooking medium, and other components, such as phytate-protein and phytate-protein mineral complexes (Abiodun and Adepeju, 2011) and

also the reduction might be due to the hydrolysis and heat destruction of some molecules of isositol hexaphosphate to penta, tetra and triphosphate components (Ejigui *et al.*, 2005). The reduction of phytate during processing of bean seeds can enhance the bioavailability of proteins and dietary minerals (Soetan and Oyewole, 2009).

Tannin Content

The tannin content of raw 'hepho' bean seed was determined to be 368.04 mg/100g and among the processing methods employed, pressure cooking was found to be effective in reducing the tannin content. The reduction caused by dehulled PC was found to be 42% followed by undehulled PC which was 41% **(Table1).** This value was in agreement with the works of past Authors such as Mittal *et al.*, (2012) for chickpea processed by pressure cooking. Osman, (2007) reported the reduction of tannin content of labal beans by pressure cooking was higher than the present finding (60 to 70%). Significant reduction was also observed, 27% reduction by dehulled TC. This agreed with the work of Ekanayake et al., (1999) on chickpea processed by normal cooking. Dehulling and cooking was observed to cause higher reduction in tannin content of hepho bean that had agreed with the work of Abiodun and Adepeju, 2011) for bambara nut. This could be attributed to the predominant presence of tannin in the seed coat and it's also heat labile and degrade upon heat treatment (Rakic et al., 2007). Reduction of tannin content in the hepho bean was expected to improve its nutritional value because tannins form complexes with proteins and reduce their digestibility and palatability Abiodun and Adepeju 2011). Tannin is known to contribute for bitterness of beans (Ajala, 2009) and hepho is much bitter when eaten undehulled.

Table 1. Anti-nutritional composition of raw and processed Hepho bean seeds (mg/100g)

Treatment	Phytate		Tannin
Raw	304.81±0.72 [a]		368.04+2.49[a]
DTC	196.19± 0.04[c] (-36%)		293.04±52.19 [b] (- 20 %)
UTC	231.90±1.41 [b] (- 24%)		269.57± 0.00[c] (- 27%)
DPC	118.95±1.00[d] (- 61%)	(-42%)	215.30± 0.00[d]
UPC	103.72+1.02e (-66%)		217.90± 3.16[d] (- 41%)

"Mean not followed by the same superscript letters in the same column are significantly different (P<0.05).

NB: DTC stands for De-hulled Traditionally Cooked, UTC for Undehulled Traditionally Cooked, and DPC for Dehulled Pressure Cooked and UPC for Undehulled Pressure Cooked." "(+) and(-) indicate increased and decreased from raw mean**"**

3. Conclusion

It is concluded that dehulled traditionally cooked reduce the phytate content of Hepho bean seeds than undehulled traditionally cooked. Hence among traditional cooking methods dehulled traditionally cooked was more preferable to reduce anti-nutrient phytate. Similarly, dehulled pressure cooked reduces phytate content of the seeds than undehulled pressure cooked; from this it can be concluded that the removal of hull affect the content of anti-nutritional factors, because in bothtraditionally and pressure cooking methods anti-nutritional factors were effectively reduced in dehulled case.In case of tannin content even though the dehulled traditionally cooked from traditional treatments decreases it. However, dehulled Pressure cooking was more favorable to reduce tannin content which is more related with bitterness of Hepho. Even though, all processing treatments were effective in reduction of anti-nutritional factors; pressure cooking was found to be best for removal of anti-nutritional factors.

Generally, this study showed that traditional cooking and pressure significantly reduced the anti-nutritional factors under the study (phytate and tannin). Pressure cooking appreciably reduced the anti-nutritional factors as compared to traditional cooking. Dehulling and cooking was found to cause a higher reduction in the anti-nutritional factors present in 'hepho' seeds than the undehulled treatment.

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Reference

Abiodum A.O and Adeoeju A.B.(2011): Effect of processing on the chemical, pasting and Anti- Nurtitiona composition of Banbara Nut (*vigna Subterranea L verdc*) floors. Advanced J of food Sci. **3**: 224-227.

Akinjayeju K.E and Ajayi F.E. (2010): Effects processing Methods on some Anti-nutritional factors in legumes seeds for poultry feeding. Inter. J. of poultry Sci. **9**:996-1001.

Alonso R., Aguirre A., and Marzo F. (2000): Effects of extrusion and traditional processing methodson antinutrients and in vitro digestibility of protein and starch in faba and kidney beans. Food Chem. **68**: 159-165.

Ajala, L. (2009). The Effect of Boiling on the Nutrients and Anti-Nutrients in Two non conventional Vegetables. *Pakistan J. of Nutrition***8 (9):** 1430-1433

Derese Mokonnen. (2012): Caning quality evaluation of Haricot Bean (p. Vulgaris. L) varieties Grown in Ethiopia. Addis Ababa University. Addis Ababa

Doss A, Pugalenthi M, G.V. Vadivel, G. Subhashini and Anitha Subash R(.2011): Effects of processing technique on the nutritional composition and Anti-nutritional content of underutilized food legume. Inter. Food research J. **18**:965-979

Ejigui Jeanne, Lsavoie Laurebt, Marin Johanne and Desrosiers Therese. (2005): Influence of Traditional processing Methods on the nutritiona composition and Anti nutritional factors of Red peanuts (*Arachis hypogea*) and small Red Kidney beans (*Phaseolus vulgaris*). J.of BioSci. **5**: 597-605

Ekanayake, S., Jansz. E.R., Nair B. M. and Abeysekera M. V. (2009**).** A review on an underutilized legume Canavalia gladiate. *J. of Food Sci*. **8**: 1-25.

Ezegbe, C.C. (2012): Nutritional quality and physico- Chemical properties of the seed and oil of Chinese Fan Palm. MSc Thesis, Department of Food Science and Technology, Federal University of Technology Owerri, Nigeria

Garemu Bultosa. (2007): Common grain nutrient composition and Laboratory Methods in grain composition Analysis. Haramaya University., Ethiopia

Heng L., Vincken J-P., van Koningveld G., Legger A., Gruppen H., van Boekel T., Roozen J., and Voragen, F. (2006): Bitterness of saponins and their content in dry peas. J. Sci.Food Agric.**86** *:*1225-1231

Mittal Rajni,Nagi Hps, Sharma Priyanka and Sharma Saceitu. (2012): Effect of processing on chemical composition and Anti-nutritional factors in chickpea flour. .J. of Sci. **2**: 180-186.

Mubarak, A. E. (2005): Nutritional composition and antinutritional factors of mung bean seeds (*Phaseolus aureus*) as affected by some home traditional processes. J of Food Chemistry. **89**:489–495

Mugendi J.B,Njagi, M.N.E,kuria N.E, Mwasaru. M.A,Mureifhi.J.G and Apostolides.Z. (2010**)**: Effect of processing technique on Mucuna bean. Africa J. of food Sci. **4**:156-166

Nergiz , C. and Gokgoz, E. (2007): Effects of traditional cooking methods on some antinutrients and in vitro protein digestibility of dry bean varieties (*Phaseolus vulgaris* L.) grown in Turkey. *Inter. J. of Food Sci.and Technology*.**42**:868- 873.

Nwosu, J.N. (2011): The effects of processing on the anti-nutritional properties of 'Oze' (*Bosqueia angolensis*) Seed. *Journal of American Science* **7**(1): 1-6.

Obasi., O.M. (1994): Effects of processing on Anti-nutritional factors in edible seeds of Kerstings Gruondnut (*Kerstingiella Geocopa Harms)* Ghana J. Sci **36**: 67-71

Onwuka, G.I. (2006): Soaking, boiling and antinutritional factors in pigeon peas (*Cajanu caja* and cowpeas (*Vigna unguiculata*). J. Food Proc. and Preserv., **30**: 616-630.

Osman, M. A.(2007**).** Effect of Different Processing Methods, on Nutrient Composition Antinutrional Factors, and *in vitro* Protein Digestibility of Dolichos Lablab Bean [*Lablab purpuresus (L*) Sweet]. *Pakistan J. of Nutrition* 6 (4): 299-303.

Soetan O.K and. Oyewole E. O. (2009**).** The need for adequate processing to reduce the anti-nutritional factors in plants used as human foods and animal feeds: A review. *African J. of food Sci.* **3**:223-232.

Rakic. S., Petrovic, S., Kukic, J., Jadranin, M., Tesevic, V. and Povrenovic, D. (2007): Influence of thermal treatment on phenolic compounds and antioxidant properties of Oak acorns from Serbia. Food Chemistry. **104**: 830 – 834.

Reedy, N.R. and Pierson, M.D. (1994): Reduction in anti-nutritional and toxic components in plant foods by fermentation. Food Research International **27**: 281 – 290.

Shimelis,E.A and Rakshit, S.K.(2007)**:** Effect of processing on anti nutrients and in vitro protein digestibility of kidney bean (P. vulgaris L.) varieties grown in East Africa. J. of food chemistry, **103**: 161-172

Tadese W.(2003)**:** Variation and association of morphological and biochemical characters in grass pea (*Lathyrus sativus L.*) *Euphytical*, Ethipia. **130**: 315-324

Zelalem, Feleke**.** (2002):Report on informal survey of major beans disease in Metekel Zone, Pawe agricultural research center. **Pp**.14-19 (unpublished), Ethiopia.

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Evaluation of the Antibacterial Activities of the Crude Extract of the Leaves of *Catha Edulis*

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Abstract

The emergence of new infections and increase of bacteria drug-resistance rise up the urgent need for the development of new antibacterial agents from natural sources. This study was designed to evaluate the antibacterial activity of the crude extract of leaves of Catha edulis. The antibacterial activity was determined by the disk diffusion method against one strain of Gram-positive (Staphylococcus aureus) and one strain of Gram-negative bacteria (Pseudomonas aeruginosa). The micro-dilution method was applied for the determination of the minimal inhibitory concentration (MIC) of selected bacteria strains. The antibacterial activity of the samples was more effective inhibiting the growth of Gram-negative bacteria comparing with Gram-positive bacteria. Crude extractof leaves of Catha edulis showed the highest antibacterial activity against antibiotic resistant Pseudomonas aeruginosa; with a MIC value (200mg/mL) lower than the reference antibiotic tetracycline (250mg/ml). Helvaci S, Kökdil G, Kawai M, Duran N, Duran G, et al. (2010). Antimicrobial activity of the extracts and physalin D from Physalis alkekengi and evaluation of antioxidant potential of physalin D. Pharm Biol 48: 142-150.High concentrated values (300 mg/ml to 500mg/ml. These compounds have important biological activities and could be responsible for at least part of the antibacterial activity of the crude extract of leaves Catha edulis. The crude extract from Catha edulis leaves waKalix P (1988) Khat: a plant with amphetamine effects. J Subst Abuse Treat 5:163-169.s the most efficient to inhibit the growth of the bacterial strain antibiotics resistant Pseudomonas aeruginosa, and Staphylococcus aureus, which represents an important step for the search and development of a new antibacterial agent.

Key words: *Antibacterial activity, Staphylococcus aurous, Pseudomonasaeruginosa, antibiotics resistant.*

1. INTRODUCTION

1.1. Background and Justification

Infectious diseases results a greater deaths approximately 17 million worldwide annually. Mostly in children and the elderly (Butler MS, Buss AD, 2006) the morbidity and mortality associated with infectious diseases have remained significant, particularly food-borne illnesses including diarrhea among children and respiratory infections such as tuberculosis, despite the advances in antimicrobial chemotherapy and supportive care. To make matters worse, the haphazard use of antimicrobials in the treatment of many infectious diseases has inevitably led to the emergence of multiple drug resistant microorganisms (Powers JH., (2004)).

For example, in 1990, almost all cholera isolates in New Delhi (India) were sensitive to furazolidone, penicillin, cotrimodal and nalidixic acid. In 2000, these drugs became largely obsolete in the treatment of cholera. The use of natural products, such as medicinal plants as therapy against infectious diseases is a traditional therapeutic measure especially in developing countries as they contain a combination of potential antimicrobial compounds instead of a single purified molecule (Duran N, Duran G, *et al,* (2010). The use of natural products, such as medicinal plants as therapy against infectious diseases is a traditional therapeutic measure especially in developing countries as they contain a combination of potential antimicrobial compound(s) instead of a single purified molecule (Helvaci S, Kökdil, et al. (2010).

Catha edulis, from the family Celastraceae is a natural stimulant that is found as aflowering evergreen tree and is widely cultivated in Africa and southern parts of Arabia (Costea DE, *et al*, (2004)). The chewing of young shoots and leaves of *Catha edulis* is a traditional and social habit in some countries of East Africa, Arab Peninsula and Ethiopia (Kalix P (1988)). The chewing of young shoots and leaves *of C. edulis* is a traditional and social habit in some countries of East Africa and Arab Peninsula (Kalix P (1988)). It contains the alkaloid called cathinone (an amphetamine-like stimulant) and other polyphenolic compound such as tannins and flavonoids, which generally occur as glycosylated derivatives and are known for their antioxidant effects (Kromhout D (1993)).

Although, the stimulating effects of *Catha edulis* are well known, the antimicrobial effects of *Catha edulis* remain little work has been done to test its antimicrobial properties. The present study was designed to investigate the antibacterial properties of *Catha edulis* extract against Gram-positive bacteria, and Gram-negative bacteria. The results revealed that crude extractions *Catha edulis* possess potent antibacterial properties against Gram-positive bacteria tested as well as Gram-negative bacteria activity.

1.2. OBJECTIVES

1.2.1. General objective

To evaluate the antibacterial activities of crude extractions of the leaves of *Cathaedulis* on selected Gram positive and negative bacterial species.

1.2.2. Specific objectives

1. To assess the antibacterial activities of crude extractions of the leaves of *Catha edulis* on *Staphylococcos aureus* and *Pseudomonas aeruginosa*
2. To determine the minimum inhibitory concentration of crude extraction of leaves of *Catha edulis* on *Staphylococcos aureus* and *Pseudomonas aeruginosa*

1.3. Statement of problems

Microbial infections are still now cause great troubles for humanity due to lack of vaccine against some infections, especially pathogenic bacteria, emergence of drug resistance and the resurgence of infection among the others (Barron and Leung, 2015). In view of this, scientific studies have to be conducted on the traditional medicinal plants to overcome the global problem of antimicrobial resistance and for the purpose of developing a new, effective and safe antimicrobial drug. It was necessary to further study its antibacterial activity by using crude extractions, which in turn could simplify the isolation and identification of active principle responsible for the antibacterial activity of the *Catha edulis*.

1.4. Significance of the Study

From this study we can understand and make peoples aware that *Catha edulis* are not only used to as chewing and stimulant, but it has medicinal value.

1.5. Limitation of the study

This study was conducted in Adama Science and Technology University west shoa, special zone of Oromia region. The study was only on the leaves of *Catha edulis* and for our initial study we selected two bacterial strains due to time, materials and budget limitation.

2. LITERATURE REVIEWS

2.1. Overview of infectious diseases

Infectious diseases are among leading causes of death in the world, in the face of major medical advances (WHO, 2012). In addition, infectious diseases are the key agents for aggravating poverty in the world and causes enormous health related burden through life long disability (TDR, 2012). According to the WHO death projection (2013), infectious diseases will remain to be the killer diseases with a level of about 13 million human deaths annually until at least in 2030 G.C. Although infectious diseases can affect people of all ages, they impose a particular burden on children of age below five years (TDR, 2004).

The negative impacts of infectious diseases are highly observed in developing countries (Mulder *et al*, 2014). In high income countries, the deaths from infectious disease are mainly due to respiratory infections and Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS) whereas in sub-Saharan African countries, respiratory infections, diarrheal disease, HIV/AIDS, malaria and tuberculosis account for roughly similar proportions of total infectious disease deaths (TDR, 2004). In addition to the problems of the known or established infections, epidemics of new and old infectious diseases periodically emerge which greatly magnify the global burden of infections (Morens *et al*., 2004).

Emerging infectious diseases can be defined as infections that have newly appeared in a population or have existed but are rapidly increasing in incidence or geographic range. To mention some examples, the emerging infectious disease includes HIV/AIDS, hemolytic uremic syndrome (caused by *Escherichia coli O157:H7*) Ebola (Barron and Leung, 2015). Emerging infectious diseases are part of the infectious disease having a significant burden on global economies and public health (Jones *et al*., 2008).

The contributing factors for emerging infectious diseases include ecological changes (those due to economic development and land use), human demographics behavior, international travel and trade, technology and industry, microbial adaptation and change, and break down in public health measures. These changes can lead to the emergence of new diseases, the reemergence of diseases once controlled, and to the development of antimicrobial resistance (Cohen, 2000).

The majority of emerging infectious events are caused by bacteria which can be associated with evolution of drug resistant microbes (Jones *et al*., 2008). The incidence of bacterial infections can be affected by the occurrence of newly emerging disease. For example, the emergence of infectious disease like HIV/AIDS has caused the increase in the incidence of opportunistic infections in both the developed and developing

countries of the world (Sedona and Bhagani, 2011).

Among the opportunistic infections, bacterial infections are common since they occur when the natural host defenses like neutrophils are overwhelmed by disease causing agents like HIV (Malka *et al.*, 2010). Therefore, it is possible to implicate that researches focusing on the causes of infectious disease and how to effectively treat and prevent them from spreading have to be encouraged to effectively lift people out of infection and to build a better world for future generations.

2.2. Antimicrobial resistance

Antimicrobials are an extremely valuable resource across the spectrum of modern medicine to treat and prevent infectious diseases. Their development has been associated with dramatic reductions in communicable disease mortality and has facilitated technological advances in cancer therapy, transplantation, and surgery (Dixon and Duncan, 2014).

However, after a certain time of antibacterial usage, some bacterial pathogens became unresponsive to many of the first effective drugs. For example, the resistance feature or evolution of *Staphylococcus aureus* had not been stopped to the first effective drug, benzyl penicillin, but continued to be resistant to different antibiotics. For example, this bacterium became resistant to penicillin and aureomycin by developing different mechanism of resistance such as production of a lactamase and increased cell wall production; which in turn decreased the usefulness of such drugs for serious *staphylococcal* infections (Howden *et al.*, 2014; Livermore, 2000).

In addition, antibacterial resource is threatened by the dwindling supply of new antimicrobials and the global increase in antimicrobial resistance (Dixon and Duncan, 2014). Even though the antibiotic resistance is a global threat, its burden is higher in developing countries like Ethiopia because of the high prevalence of bacterial diseases and the presence of risk factors for its emergence and spread (Huynh *et al.*, 2015).

Rates of antimicrobial resistance among hospital and community pathogens have increased considerably. This is especially more common in clinic settings in which resistant strains are frequently found before they spread to the community (Canton *et al.*, 2013). Hence, antibacterial resistant infections would be likely more common in immune- compromising conditions like HIV/AIDS patients due to their frequent encounters with the health care system, need for empiric antimicrobials, and immune dysfunction (McNeil, 2014).

The increasing prevalence of hospital and community-acquired infections caused by multi drug- resistant (MDR) bacterial pathogens is the limiting option for effective antibiotic therapy. Moreover, this alarming spread of antimicrobial resistance has not been paralleled by the development of novel antimicrobials (Cassir *et al.*, 2014).

Therefore, the ongoing explosion of antibiotic-resistant infections continues to be global health care problem with an equally alarming decline in the research and development of new

antibiotics to deal with the threat (Ca I *et al.*, 2011; USAID, 2015).

According to Centers for Disease Control and Prevention (CDC) estimation (2013), antibiotic resistant bacterial infections in United States caused more than two million people to be sickened and resulted in a death of at least 23,000 patients every year.

In addition, antibiotic resistance has contributed to an increase in economic burden to United States, which may be as high as $20 billion in excess direct health care costs and $35 billion due to lost productivity of society.

2.3. Causes of antimicrobial resistance

The emergence and spread of bacterial resistance have been driven by complex socioeconomic and human behavioral factors including misuse of antibiotics, the practice of unskilled practitioners and laypersons, and poor drug quality, particularly in developing countries (Okeke *et al.*, 1999). In addition, the spread of resistant bacteria in hospitals and the community can be enhanced by overcrowding, lapses in hygiene or poor infection control practices (Michael *et al.*, 2014)

The emergence of antibiotic resistance is primarily due to excessive and often unnecessary use of antibiotics in humans and veterinary medicine. The rates of bacterial resistance to the antibiotics have been increased proportionally with the volume of antibiotics used for different purposes; the more these drugs are used the quicker resistant strains emerge and spread (Austin *et al.*, 1999; Wise *et al.*, 1998) as a result of selective resistance pressure induced by antibiotic overuse.

For instance, the prevalence of penicillin resistant *Streptococcus pneumonia* and *Streptococcus pyogenic* has been associated with an increase in the outpatient antibiotic use indifferent countries (Albrich *et al.*, 2004). There are various factors which may influence an increase in irrational antibiotic use and hence antibacterial resistance, but lack of awareness and knowledge of the people to the antibiotics is the main factor which has strong impact on the non-adherence and inappropriate use of most antibacterial (Chan *et al.*, 2012) The use of counterfeit and substandard medications is the other component of irrational drug use aggravating the development of drug resistance as they may have insufficient or suboptimal dose to kill or inactivate microorganisms (Kelesidis *et al.*, 2007).

On top of the contribution of irrational use of antibacterial by humans for bacterial resistance, inappropriate use in animals has shown to play for the prevalence of bacterial resistance. Even though the use of antibiotics in animals has its own medical reasons, its overuse for farm animals, especially for growth promotion and prevention of infection, contribute to the increased prevalence of antibiotic-resistant bacteria of human significance (Khachatourians, 1998; Mathew *et al.*, 2007).

Self-medication is another global practice and potential contributor to human pathogen resistance to antibiotics, with a risk of causing serious health hazards such as adverse reaction and prolonged suffering.

Self-medication of antimicrobials without medical guidance may result in greater probability of inappropriate, incorrect, or undue therapy, delays in appropriate treatment; which in turn can contribute to the emergence of bacterial resistance and increased morbidity (Bennadi, 2014). Self-medication with antimicrobial agents has been associated with low income, lack of drug knowledge, advice from friends, previous experience, long waiting time in health settings and distance to the health facility (Ganesan *et al*., 2014; Ocan et al., 2014). The main sources of self-medication without prescription are the different retail pharmacies (Ganesan *et al*., 2014). The extent of antibacterial resistance is not only attributed by the inappropriate use of antibiotics by patients but prescribers also contribute a lot. For example, bacterial selective pressure due to inappropriate glycol peptide and vancomycin prescribing has increased the prevalence of multidrug resistance in methicillin-resistant *Staphylococcus aureus* (MRSA) strains (Shorr, 2007).

Over prescribing of antibiotics is associated with an increased risk of adverse effects, more frequent re-attendance and increased medicalization of self-limiting conditions. Viral infections are the primary driving forces for over prescribing of antibiotics, particularly in primary health care. Among the different bacterial diseases, respiratory infections are the leading infection for antibiotic prescriptions (Lior and Bjerrum, 2014).

2.4. Treatment approaches for bacterial diseases

2.4.1. Conventional approaches

Treatment of bacterial infections is becoming more difficult to treat as majority of the pathogenic bacteria become resistant at least to one antimicrobial drug which was effective previously for the causative pathogen. In spite of such difficulties, the commercially available antibacterial drugs play great roles for saving the life of patients with bacterial infections caused by susceptible bacteria (Carmeli, 2008).

The common antibacterial agents are often classified according to their principal mechanism of action as cell wall synthesis inhibitors (example, β-lactams and glycopeptide agents), protein synthesis inhibitors (example, aminoglycosides, macrolides and tetracyclines), nucleic acid synthesis inhibitors (example, fluoroquinolones and rifampin), anti-metabolites (example, trimethoprim, sulfonamides) and those that disrupt bacterial membrane structure (example, polymyxins and daptomycin) (Tenover, 2006; Walsh, 2000).

In order to treat the infectious disorders effectively and to reduce the emergence of bacterial resistance, the practice of antimicrobial therapy should consider the following principles of chemotherapy. These includes susceptibility of the bacteria to concentrations of the antimicrobial agent at the site of infection, the dose and route of administration of the drug, the duration of treatment and the immune status of the host for microbial clearance.

In addition, initial empirical therapy to severely diseased patients should be adequately

broad spectrum and adequately dosed by considering safety and the pharmacokinetics of the drug in individual patients (Carmeli, 2008; Levison, 2000).

2.4.2. Traditional approaches of managing bacterial infections using medicinal plants

Herbal medicines have been used for many years dating back as far as 3000 B.C. Despite enormous advances in conventional medicines, traditional medicines have been encouraged by WHO partly because some conventional drugs have failed to prove effective, have serious side effects, or cannot cure certain new illnesses such as AIDS (Kareru *et al.*, 2007). It has been estimated that about 65% of the world's population have incorporated medicinal agents into their primary modality of health care (Fabricant and Farnsworth, 2001). In Africa, 90% of the population relies on traditional healers to meet their primary healthcare needs (Kareru et al., 2007), which indicate the presence of many medicinal plants with a potential source of new drugs.

The antimicrobial value of medicinal plants relies on some chemical substances produced by these plants: these chemicals called "secondary metabolites" and include alkaloids, terpenoids, flavonoids, tannins and phenolic compounds, essential oils, lectins and polypeptides, polyacetylenes etc (Cowan, 1999). Herbal products from medicinal plants are preferred because of less testing time, higher safety, efficiency, cultural acceptability and lesser side effects. On top of these, the chemical compounds present in herbal products are part of the physiological functions of living organisms and hence they are believed to have better compatibility with the human body (Prasad *et al.*, 2012).

However, the use of traditional plants may be associated with the problems of scarcity of valuable medicinal plants, lack of standardization of methods of preparation, poor storage conditions and incertitude in some traditional health practitioners, which affect the efficacy and the practice of traditional medicine (Njume and Goduka, 2012).

The crude extracts of different medicinal plants such as *Rhamnus prinoides* leaf extract (Berhanu, 2014), *Calpurnea aurea* leaf extract (Umer et al., 2013), Peterollobium stellatum root extract (Andualem et al., 2014), *Datura stramonium*, *Croton macrostachyus*, and *Acokanthera schimperi* extracts (Taye et al., 2011), etc have been scientifically evaluated and approved for their antimicrobial activity against the growth of different pathogenic bacteria from which novel bioactive drugs could be obtained or derived by devising an appropriate scientific studies.

2.5. The Experimental plant

2.5.1Catha edulis

Catha edulis, the edible part of *Catha edulis* Forsk, belongs to the score of vegetablematerials that humans ingest not for their nutritive value but to experience their psychoactive effects (Graziani *et al*, 2008). The khat plant is a dense evergreen shrub belonging to the family Celastraceae (Kalix, 1996).

The shrub grows at altitudes between 1500 and 2500 m, requires high rainfall and grows best on acid, well-drained, clay soil. With irrigation and pruning, khat leaves can be harvested up to four times per year. Khat plants grow to a height of 6 m. The leaves are leathery, glossy, brownish green, with serrated edges, arranged in an alternate fashion on the straight branches. The young shoots and leaves are the parts chewed for their psychoactive properties. The khat leaves are most commonly 'preserved' for transportation by being wrapped in banana leaves. A bundle of approximately 100-200 g of plant material makes up a measure of sale sometimes called, confusingly, a 'kilo' (Nezar *et al*, 2005).

2.5.2. Medicinal value of khat *(Catha edulis)*

Traditional *Catha edulis* leaves have been used in traditional medicine for the treatment of depression, fatigue, hunger, obesity, and gastric (Wilder *et al.*, 1994)

Figure 1: Fresh *Catha edulis* leave

3. MATERIALS AND METHODS

3.1. Description of study area

The study was conducted in laboratory of Adama Science and Technology University. Adama is a town in central Ethiopia and forms a special Zone of Oromia region and surrounded by East Shoa Zone. It is located at

8'54"N and 39'27"E at an elevation of 1712m above sea level and has annual rain fall of 7600mm and means annual monthly temperature of 21^0C. Adama City is situated at 99 km South East of Addis Ababa and sits between the base of an escarpment to the West, and the Great Rift Valley (http:/en.wikipedia.org/wiki/Adama).

3.2. Reagents and chemicals

For this study Mmethanol, acetic acid, Nutrient Agar, Peptone water, Penicillin, Crystal Violet Iodine, Alcohol, cotton swab, and Safranin were used for this project paper.

3.2.1. Test organisms

Two human pathogenic bacteria made up of one Gram-positive *(Staphylococcus aureus* and Gram- negative bacteria *(Pseudomonas aroginosa)* were used for the antibacterial assay, these bacteria were cultured in laboratories and identified by gram stain and biochemical test.

3.2.2. Antibacterial Agents

For this study Penicillin, 1mg/ml, as the standard reference drug for antibacterial assays was used.

3.2.3. Media

The bacteria were cultured by using different media such as nutrient agar, Peptone water, and material petri dishes, test tubes, gram-stain kit, were used**.**

3.3. Methodology

3.3.1 Collection of Catha edulis

The leaves of *Catha edulis* were bought from local market of Bole, in Adama East Shoa special zone of, Oromia. The fresh bundles were packed in plastic bags and transported into the laboratory in the month of March 2016.

3.3.2. Crude extraction procedure.

The *Catha edulis* leaves are then dried in open air (under shade) and it were powdered. Approximately, 50g of the *Catha edulis* leaves were ground and soaked in 100 ml of a water bath at 25°C for 24 hours with continuous shaking using Cole Centrifugation shaker at 320 ppm. Finally, the extracts were suspended in 20 ml and stored at 4°C until tested for antibacterial activities.

3.3.3. Preparation of dried filter paper discs

Filter paper was used to prepare discs approximately 6 mm in diameter. Then it were mixed with crude extract of *Catha edulis* leaves and placed in a Petri dish and sterilized in a hot air oven at160°Cfor 180 minutes.

3.3.4. Minimum Inhibitory concentration

Both bacteria are grown in 10 ml of peptone water respectively for various concentrations.

After 12 hours of incubation at 37°C, different concentrations of *Catha edulis* leaves extracts ranges from 0, 50, 100, 200,300,400,500mg were added in various tubes of grown bacteria and again incubated for 10-12 hours at 37°C. After incubation we observed the growth pattern in UV-spectrometer at 320nm wavelength for all concentrations, and further analyzed for the minimum inhibitory concentration and the lethal dose of the khat against bacteria.

3.3.5. Antibacterial activity test

The antibacterial activity test of the crude *Catha edulis* extracts against one Gram-positive (*Staphylococcus aureus* and one Gram-negative bacteria *Pseudomonas aeruginosa* were carried out by Disk Diffusion method. The agar plate was prepared for each organism as follows. 0.2 ml of the standardized inoculation were mixed with 20 ml of sterile agar (maintained at 45-50 ^{0}c in a molten state) using a mixer, and then poured into sterilized petri dishes and set aside. After congealing, well-isolated colonies of the same morphological type are selected from an agar plate cultured at 37 ^{0}c for 18-24 hour. The predetermined lethal doses (350mg and 340mg/ml) of khat discs are dispensed onto the surface of the incubated agar plate.

Each disc was pressed down to ensure complete contact with the agar surface and the discs are placed with a dispensing apparatus, they distributed evenly. Ordinarily, 4 discs were placed on each plate. Each plate are inverted and placed in an incubator set at 37^{0}c for 18 hour after the discs are applied. The antibacterial activity was evaluated by measuring the diameter of the zone of inhibition excluding the whole size by use of an antibiotic zone reader.

3.4. Data analysis method

The data for this study were analyzed by using descriptive form of statistics and also it was represented in the form of diagram, table, and graph.

4. RESULT AND DISCUSSION

4.1. RESULT

4.1.1. Catha edulis extracts exhibited antibacterial properties

The crude extract of *Catha edulis* were tested against Gram positive bacteria and Gram negative bacterial using the disc diffusion assay (Ho PL, Chow KH, Yuen KY, Ng WS, Chau PY (1998)]. The results revealed that *Catha edulis* extract inhibited growth of Staphylococcus *aurous* and Pseodomonas *aeruginosa*. In the presence of extract, the results showed that the zone of inhibition for *Staphylococcus aurous* around *the Catha edulis* extract disc diffusion was 4.5mm and for Pseodomonas *aeruginosa* around the C. edulis extract disc diffusion was 8mm. *Catha edulis* extract had effect against both *Staphylococcus aurous* and *Pseodomonas aeruginosa*. The zone of inhibition for *P. aeruginosa around* the antibiotic disc (positive control) was 11.5 mm, and the zone of inhibition forS. *aurous* around the antibiotic disc (positive control) was 8 mm.

Table 1: Minimum inhibitory concentration (MIC, in 350 mg/ml) of crude extract

No	Tested Bacteria	Zone of inhibition growth bytetracycline	Zone of inhibition growth by crude extract ofleaves of *C. edulis*
1	*P.areoginosa*	11.5mm	*8mm*
2	*S.aurous*	8mm	*4.5mm*

4.1.2. Estimation of MIC and lethal dose

Our spectrometer results implied 350mg/ml for *Staphylococcus aurous* and 340mg/ml for *Pseodomonas aeruginosa* were the lethal dose of khat extracts as shown in fig.2 and 3. Thesefigures shows that as concentrations of crude extracted *Catha edulis* increase, the inhibition effect on the growth of *Pseodomonas aeroginosa* and *Staphylococcus aurous* also increase.

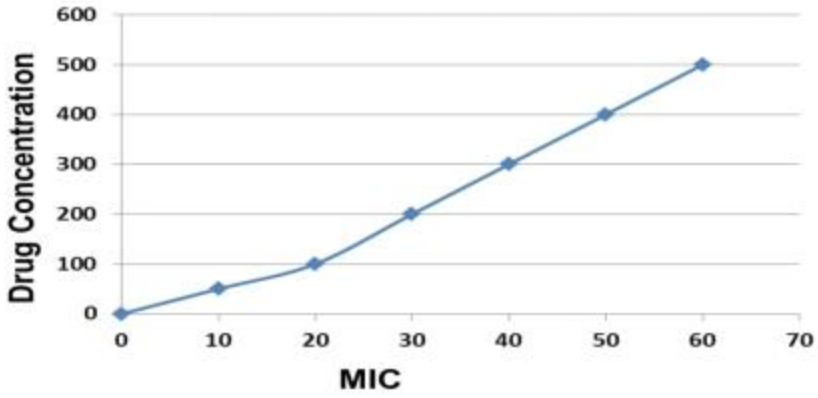

Figure: 2. Antibacterial activity against Pseodomonas aeroginosa at various concentrations of crude extract of leaves of Catha edulis

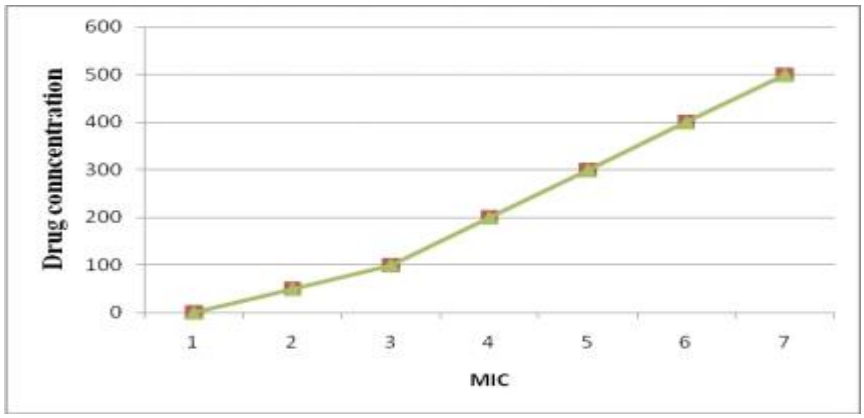

Figure: 3. Antibacterial activity against *Staphylococcusaureus* at various concentrations crude extract of leaves of *Catha edulis*

4.1.3. **Measurement of Zone of Inhibition**

Antimicrobial activity of leaves of *Catha edulis* were evaluated based on the diameters of clear inhibition zone surrounding the paper disks. If there is no inhibition zone, it is assumed that there is no antimicrobial activity. Fig.4 shows that representative disk diffusion plates with initially our selected bacteria after 24 h incubation. The diameter of inhibition zone of *Pseudomonas areoginosa* was larger than that of *Staphylococcus aureus*, indicating that *Pseudomonas areoginosa* is more susceptible to crude extract of leaves of *Catha edulis* than *Staphylococcus aureus*. With regards to diameters of the inhibition zones, crude extract of leaves of *Catha edulis demonstrated* that effective inhibition on the growth of these bacteria. Among two bacteria, *Pseudomonas areoginosa* was significantly more susceptible while *Staphylococcus aureus* was more resistant.

The average size of inhibition zones varied from 5mm to 8.5mm against *Pseudomonas areoginosa*, and 2 to 5 mm against *Staphylococcus aureus* compare to standard drug inhibition by tetracycline 6mm to 25mm showed significant results. However, the figure2 and figure 3 shows as the concentration of crude extraction leaves of *Catha edulis* increase, inhibition effect on the growth of *Pseudomonas areoginosa*, and *Staphylococcus aurous* were also increased. This showed that higher antimicrobial activity at higher concentration had clear inhibition zones. The, inhibition zone sizes increased at a higher crude extractions leaves of *Catha edulis* concentration for most of the bacteria tested, which indicated leaves of *Catha edulis* was more effective at higher concentration against antibacterial.

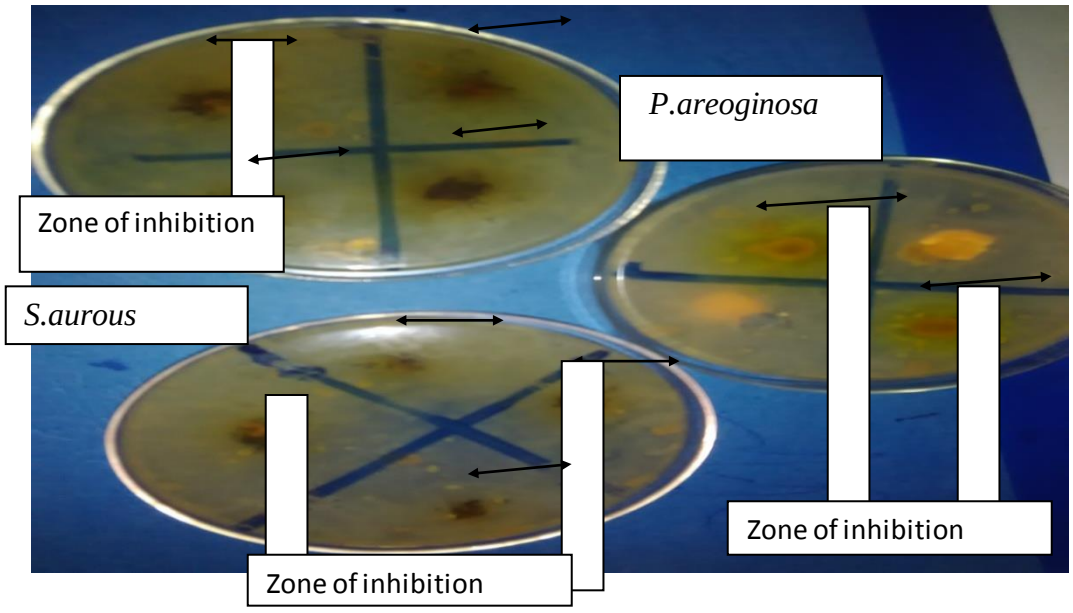

Figure: 4. Effect of *Catha edulis* on the Growth of *Staphylococcus aurous* and *Pseudomonasareoginosa* at different concentration Bacteria by Disk Diffusion

4.2. Discussion

There are numerous studies that have explored the antimicrobial activity of different medicinal plants from various natural resources by employing diverse testing conditions. Although *C. edulis*is widely studied for its psychoactive properties, little work has been done to test its antimicrobial properties.

The results with the previous findings, which demonstrated the antimicrobial properties of C. edulis extract against bacteria (Porphyromonas gingivalis, Tannerella forsythensis, Streptococcus pyogenes with the zone of inhibition in the range of 10 to 14 mm at a concentration of 10 mg per cm 3 but showed no effect against either Staphylococcus aureus), or yeast (Candida albicans) (Al-hebshi N, Al-haroni M, Skaug N (2005)).

Our findings revealed that the crude extract of *Catha edulis* exhibit antibacterial properties against *Pseudomonas aeroginosa,* and *Staphylococcus aureus* and we determined the lethal doses were 350 and 340mg/ml respectively. Our experiments also proved that khat has some significant antibacterial property compare to tetracycline. Our results also implied that khat will be a potential antibacterial agent and can develop as an antibiotic with further research.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The findings of the present study were demonstrated that the potential of crude extract of leaves of *C. edulis* against Gram-positive (S.aureus) and Gram-negative (P. *aeroginosa)* bacteria tested. This activity is the pathway of developing an antibacterial agent able of treating bacterial infections. Chemical activity that found in leaves of *C.edulis* showed promising results against a tetracycline resistant *Staphylococcus aureus* which represents an important step for the search and development of a new antibacterial agent. Further toxicological and pharmacological studies will be useful to confirm of crude extraction leaves of *Catha edulis* against antibacterial activity by the same procedure or in other methods.

5.2. Recommendation

Further studies should be conducted to isolate, purify and identify bioactive principle(s) responsible for the antibacterial activities of the plant.

In vivo antibacterial studies of the crude and active solvent fractions should be conducted to confirm the antibacterial effectiveness of the plant.

At last, the antibacterial activities of the plant should also be done on other bacterial species which were not addressed by this study.

6. REFFERENCES.

1) Abdulwaheb M Muche A (2007) Khat *(Catha edulis)* foresk) an updated review.*Pharmacologyonline***2**: 12-25
2) Al-hebshi N, Al-haroni M, Skaug N (2005) In vitro antimicrobial and resistance modifying activities of aqueous crude khat extracts against oral microorganisms.
3) Arch Oral Biol 51: 183-188.
4) Barron MA, Leung DYM (2015). Lessons from Ebola and readiness for new emerging Infectious threats *J Allergy Clin Immunol***135**: 872-874
5) Berhanu A (2014). Microbial profile of Tella and the role of gesho (*Rhamnus prinoides)* as bittering and antimicrobial agent in traditional Tella (Beer) production. *Int Food Res J***21**: 357-365.
6) Burden of bacterial resistance among neonatal infections in low income countries: how convincing is the epidemiological evidence? *BMC Infect Dis***15**: 127.
7) Butler MS, Buss AD (2006) Natural products--the future scaffolds for novel antibiotics? *BiochemPharmacol* **71**: 919-929.
8) Canton R Horcajadad JP, Oliverb A, Garbajosaa PR, Vilab J (2013). Inappropriate use of antibiotics in hospitals: The complex relationship between antibiotic use and antimicrobial resistance. *EnfermInfecc Microbiol Clin* **31**: 3-11.
9) Carmeli Y (2008). Strategies for managing today's infections. Clin Microbiol Infect 14: 22-31. Shorr AF (2007). Epidemiology of *staphylococcal* resistance *Clin InfectDis***45**: S171- S176.
10) Chan YH, Fan MM, Fok CM, Lok ZL, Ni M, Sin CF et al (2012) Antibiotics nonadherence and knowledge in a community with the world's leading prevalence of antibiotics resistance: implications for public health intervention. *Am J Infect Control***40**: 113-117.
11) Cohen ML (2000). Changing patterns of infectious disease *Nature***406**: 762-767
12) Cowan MM (1999). Plant products as antimicrobial agents Clin *Microbiol Rev***12**:564- 582.
13) Crombie L, Crombie WML, Whiting DA, Szendrei K. 1979. Alkaloids of Catha edulis Part 3.Structures of C*atha edulins* K-1, K-2, K-6 and K-15; new macrolide-bridged polyesters of euonyminol *JChem Soc Perk Trans I*:**2976**±2981.
14) Fabricant DS, Farnsworth NR (2001) The Value of plants used in traditional medicine for drug discovery. *Environ Health Perspect***109**: 69-75.

15) Ganesan N, Subramanian S, Jaikumar, Rawat H, Kumar S (2014). Self-medication and indiscriminate use of antibiotics without prescription in Chennai, India: a major public health problem. *JCPS***1**: 130-141.
16) Geneva [Online] avaialbaleat:http://www.who.int/tdr/publications/global_report/en/ [accessed on October 2, 2015].
17) Graziani M, Michele S, Paolo N. (2008) Khat chewing from the pharmacological point of view: an update. *Subst use misuse***43**: 762–783.
18) Helvaci S, Kökdil G, Kawai M, Duran N, Duran G, et al. (2010) Antimicrobial
19) Activity of the extracts and physalin D from Physalis alkekengi and evaluation
20) of antioxidant potential of physalin D. Pharm Biol 48: 142-150.
21) Howden BP, Peleg AY, Stinear TP (2014) The evolution of vancomycin intermediate *Staphylococcusaureus* (VISA) and heterogenous-VISA. *Infect Genet Evol* **21**: 575:582.
22) Ho PL, Chow KH, Yuen KY, Ng WS, Chau PY (1998) Comparison of a novel, inhibitor-potentiated disc-diffusion test with other methods for the detection of extended-spectrum beta-lactamases in *Escherichia coli* and *Klebsiella pneumoniae*. J Antimicrob Chemother 42: 49-54.
23) Huynh B, Padget M, Garin B, Herindrainy P, Kermorvant-Duchemin E, Watier L et al (2015).
24) Kalix P. (1996) *Catha edulis,* a plant that has amphetamine effects. *Pharm world sc*i **18(2)**: 69-73.
25) Kareru PG, Kenji GM, Gachanja AN, Keriko JM, Mungai G (2007) Traditional
26) Mathew AG, Cissell R, Liamthong S (2007). Antibiotic resistance in bacteria
27) Malka R, Shochat E, Rom-Kedar V (2010). Bistability and bacterial infections *PloS ONE***5**: e10010.
28) Medicines among the Embu and Mbeere peoples of Kenya *Afr J Tradit Complement Altern Med***4**: 75 – 86.
29) McNeil JC (2014). *Staphylococcus aureus* – antimicrobial resistance and the immunocompromised child.
30) *Infect Drug Resis* **7**: 117-127.
31) Michael CA, Dominey-Howes D, Labbate M (2014). The antimicrobial resistance crisis: causes, consequences, and management. *Front Public Health***2**:145.
32) Morens DM,Folkers GK, Fauci AS (2004). The challenge of emerging and re-emerging infectious diseases *Nature***430**: 242-249.
33) Kalix P (1988) Khat: a plant with amphetamine effects. J Subst Abuse Treat 5:
34) 163-169
35) Nezar N Al-Hebshi NS (2005) Khat *(Catha edulis)*—an updated review. *Addiction biol***10**: 299 – 30
36) Njume C, Goduka NI (2012). Treatment of diarrhoea in rural African communities: an overview of measures to maximize the medicinal potentials of indigenous plants. *Int J Environ Res Public Health***9**: 3911-3933.
37) Taye B, Giday M, Animut A, Seid J (2011). Antibacterial activities of selected medicinal plants in traditional treatment of human wounds in Ethiopia *Asian Pac J Trop Biomed***1**: 370-375

38) TDR (2012) Global Report for Research on Infectious Diseases of Poverty WHO, *USAID* (2015)

39) WHO (2012) the evolving threat of antimicrobial resistance, options for action. *WHO Geneva*.

40) Widler P, Mathys K, Brenneisen R, Kalix P, Fisch Hu (1994). Pharmacodynamics and Pharmacokinetics of Khat: A Controlled Study. *Clin PharmacolTher* .;**55**:556-562.

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Attitudes of University Students Towards Corruption: Adama Science and Technology University Graduates in Focus

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Abstract

This study examined the attitudes of Adama Science and Technology University prospective graduates towards corruption. A total of 346 graduates of Adama Science and Technology University in 2014/15 G.C weres selected using stratified, random and systematic sampling techniques. Out of 346 randomly selected respondents, 286(86.1%) males and 46(13.9%) females filled in the self-administered questionnaire adapted from ICAC (1994). The data obtained were analyzed by using descriptive statistics. The finding of this study revealed that there were variations in understanding of corruption. Moreover, the students' mind setup seems to be pre-occupied with tendency toward corruption. Based on findings of the study, it was recommended that, Ministry of Education needs to integrate analysis of fundamental values and concepts related to the phenomenon of corruption in to selected courses that are already taught as to enable students of higher education to thoroughly understand its impacts and struggle corruption. Finally, other recommendations and suggestion were also made for further investigation.

Key terms: *perceptions, attitudes, corruption, University, prospective graduates*

1. INTRODUCTION

1.1. Background of the Problem

Corruption has existed and constituted a serious problem since ancient civilizations. It is experienced by all societies, in both developed and developing countries (Egube, 2006 & Faniel, 2009). In developing countries, however, it is endemic due to the absence of essential checks and balances between the different centers of power (ESCPS (2012). During an extensive period of time, corruption was perceived as a kind of lubricant, or positive incitement, in growing economics (Holmberg et al., 2009). Nevertheless, the last decade of public opinion surveys show that people worldwide are surprisingly in an agreement regarding the fact that corruption is vicious and because of its social, economic, political and psychological implications (Mauro, 1995).

In line with this, ISSP (2004) identified that, corruption perception could have more devastating effects than corruption itself, because it generates a "culture of distrust" towards some institutions and may create a cultural tradition of gift giving and hence, raising corruption. On the other hand, African Development Bank Group (ADBG, 2003) identified that, individuals attitude towards corruption are shaped by the social, legal and economic systems of the countries they live in as well as their everyday experiences of corruption. In Africa corruption, it becomes a major governance challenge that has seriously impeded the continent's development (AIMDG, 2008). It flourishes as luxuriantly as the bush and the weeds which it so much resembles, taking the goodness from the soil and suffocating the growth of plants expensively bred and tended (Wraith and Simpkins, 1963 cited in Faniel, 2009).

Individual perceptions of what is considered to be corrupt are of interest because they can have an impact upon the perpetuation of corrupt practices (ESCPS (2012). According to Hochschild (2005) perceptions of corruption depend on where individuals are where they are located both socially and spatially and who they are. Furthermore, strengthening the above concept, Independent Commission Against corruption (ICAC) (cited in Shimales, 2005.P.2) states;

> *If people do not recognize the activity, which they may be witnessing, or in which they may be participating as "Corrupt" or at least as "harmful" then they are not likely to react to it as such. If they do recognize the behavior as corrupt, but believe that for example, such behavior is appropriate given the circumstances, they are also unlikely to attempt to change the behavior.*

Institute of Educational Research (IER, 2001 cited in ESCPS (2012) also stated that, corruption in Ethiopia become a serious problem over the past few years and at higher end of the scale in terms of the incidence and magnitude. Similarly, The World Bank's 2005 survey showed that 40% of the businesses surveyed cited corruption as one of the three major challenges to running a business in the

small and microenterprises sub-sector. In its 2007-2008 as well as in 2009 annual report, the World Economic Forums (WEF) Global competitiveness Report also identified corruption as the fourth most problematic factor in doing business in Ethiopia (AIMDG, 2008).

Likewise, according to ESCPS (2012 conducted by FEACC, in Ethiopia, corruption in the public sector was ranked the seventh most serious problem next to access to safe drinking water facing the country today. Moreover the survey identified that, fraud, trickery, embezzlement; extortion, nepotism, and theft were the principal features by which corruption manifested in Ethiopia. Thus, these indicate that corruption is still among the major problems in Ethiopia and more importantly, it needs attention both from government and citizens.

In line of this, researchers (e.g., Hallak and Poisson, 2007, Heyneman, 2007) suggested that in higher institutions the presence of corruption is a growing concern for the industry as it influences its effectiveness and efficiency. As a result, it may produce graduates whose skills and professional levels could be a danger to the public sectors and industries. On the other hand, as the purpose of education is to provide a way for society to model good behaviour for children or young adults, allowing an education system to be corrupt may be more costly than allowing corruption in other sectors; it contains both immoral and illegal elements. It undermines that would motivate young people to work hard and damages the ability of education to serve a public good, most notably the selection of future leaders on fair and impartial bases (Rumayntseva, 2005). In this sense, it contradicts one of the major aims of education, which is to transmit civic culture together with values of integrity, equity, fairness and social justice. This has many implications for the political, social and economic of the countries.

Waite and Allen (2003) founded that, although corruption is widespread, the issue has not gained substantial attention by scholars in the field of higher institutions students. In the same way, Engudai (2011) has also disclosed in her findings about unethical behaviour and improprieties reflected by higher education institutions students. Such improprieties and bad practices found in different sectors and higher institutions coupled with what would seem influence students' future behaviour as they are potential entrant of various sectors and industries, where people at large demands fair services based on transparency and accountability. Therefore, identifying students' outlook towards corruption before entering different sectors and industries has substantial advantages for combating corruption in public sectors from the grass root level across the nation. Thus, this and the existing views concerning the attitudes of university students towards corruption are being initiated the researcher to examine the attitudes of Adama Science and Technology University graduates towards corruption.

1.2. Statement of the Problem

Corruption, the worst social evil on earth, has, no doubt, become a major global threat to the stability and security of societies and the flourishing of values of democracy, expansion of ethical values, and enhancing sustainable development (Faniel, 2009). Thus, corruption is a pervasive cancer and a plague that invades all sectors of society both in developed and developing countries, though to varying degrees (Atuobi, 2008).

Accordingly, various sources (e.g., Shimales, 2005; ESCPS (2012) in Ethiopia, though no government institution was reported to be free from improprieties, unethical acts and corruption, situation was identified to be relatively more serious in public institutions such as sectors and agencies which are engaged in the allocation of land(Municipalities) and government housing, the provision of telephone services and electricity, granting of loans, licensing and issuance of permits, collection of taxes and procurement of consumable and fixed assets. Likewise, customs and excise offices, Finance, Judiciary, the police, Banks, Hiv/Aids secretariat, construction sectors, as well as the woreda and kebele administrations were also found to be highly affected by corrupt practices. Worse situations noticed in these institutions may be the reflection of the most sensitive services these offices have been providing to the public (IER, 2001, ESCPS (2012). In line with this, according to Shimales (2005.p.105) states;

> *'One major problem related to corruption in Ethiopia is, the popular misconception about it. To mentioned some as an example; most newly recruited employees of the Custom and Revenue Authority came to the office with the wrong impression and with the expectation to enrich themselves illegally in a short period of time. As a result, some employees come to this office leaving better salary anticipating getting much more through corruption. Such problem is, in general, associate with the perceptions and attitude of the society. Moreover, the attitude has been much more reflected on graduates recently recruited from various colleges and universities'.*

Even if a lot has been done to take the edge off corruption, ESCPS (2012) identified corruption as one of the major challenges facing the country. Likewise, although there has been an effort to include civics and ethical education in the curriculum, over the last recent years, as far as my experience and observation in higher education institution is concerning, this does not guarantee that everyone who earns a degree at a university is immune from choosing a sector that is highly prone to commit corruption instead of their genuine professional choice.

As a result, it is important to have a good understanding of graduates' attitudes as well as of their overall reflection on corruption to tackle. In addition, to the best knowledge of the researcher, no previous studies seem to have been conducted on the mind set up of university students. Moreover, the attitudes of graduates'

towards corruption has not yet been identified and examined. So it is very instrumental to check whether the corrupt act comes from the pre-occupation of potential itinerant to the sectors, and their mind has been built by the corruption in society or not.

Therefore, the main purpose of this study was to examine the attitudes of university students towards corruption with reference to Adama Science and Technology University graduates through investigation of their attitudes. It is with this background of the problem statement that, specifically, this study was entirely focused on answering the following research questions;

- What are the graduates' preference areas in securing their Jobs?
- What are the graduates' attitudes towards corruption?

1.3. Objectives of the Study

The general objective of the study was to assess the attitudes of Adama Science and Technology University graduates' towards Corruption.

1.4. Significances of the Study

It is clear that, today's university students are the potentialitinerant of public and private sector, as well as leaders of tomorrow. Therefore, to fight corruption, examining the attitudes of university students towards corruption is indispensable.

Accordingly, this study will have the following significances:

- Serving as an input for policy makers, curriculum developers, experts, and Ethics and Anti-Corruption commission to know the perceptions and attitudes of university students towards corruption as managers and leaders of tomorrow.
- Serving as a source of reference for others who would like to know more about the attitudes of University students towards corruption and it may also serve as a spring board for further studies in the area.

1.5. Delimitations

This study was delimited to cover Adama Science and Technology University graduates of 2014/2015 G.C from the regular classes. The researchers were quite interested to assess the problem and forwarded its solutions and justifications. Furthermore, this study did not include post graduates and summer students as they have already been engaged in work life. This study was delimited to the attitudes of graduates towards corruption. This University was chosen because of proximity of the researchers to the study site, the experience of researchers in the study area and resource limitations.

2. RESEARCH METHODOLOGY

2.1. Research Design

The purpose of this study was to examine the attitudes of Adama Science and Technology University graduates of 2014/2015 G.C towards corruption. For the purpose of this study, a descriptive survey method was employed. Even though the selection of research design depends on the nature of the study, the research problems being addressed and the resources available for the study, there is an increasing attention of using quantitative method as a research strategy.

2.2. Target Population

The target population of this study was graduates of Adama Science and Technology University of regular program. The respondents were selected from five schools (School of Engineering, School of Agriculture, School of Humanity and law, School of Natural Science, and School of Business and Economics). Schools of Educational Sciences & Technology Teachers and Health Sciences were excluded from sample due to the fact that they have already been engaged in work life and absence of graduates respectively.

2.3. Samples and Sampling Techniques

Determining an appropriate sample size to a certain population under study is a very vital issue in research because large sample sizes may waste more resources, time and money and small sample sizes may lead to inaccurate results. So, determining appropriate sample size depends on the purpose of the study, homogeneity or heterogeneity of the population, resources in terms of time and money, level of precision (sampling error), level of confidence (risk level) and degree of variability (Israel,1992).

2.4. Sampling Procedures

With respect to sampling procedures, to select sample respondents the researcher employed stratified and systematic sampling techniques. First, graduating respondents were identified by all sample schools and departments based on sex proportion. As a result, the sample frame was obtained from the Registrar of the University and the sample size was determined by Israel (1992), to find out the respondents (sample size) from the total population. Then, by using the students list, the respondents were

taken through systematic random sampling from sample departments.

Accordingly, from the total 2502 respondents, 346 were taken as a sample of the study. Next, the numbers of male and female respondents from each department were obtained according to the proportion of the population in each stratum. Based on the gender proportion, the researcher selected 298(86.1%), and 48(13.9%) of male and female respondents respectively. Finally, the sample respondents were selected from each stream using n^{th} value of systematic random sampling techniques. Therefore, the return rate was very high 332(96%) and 14(4%) were rejected due to significant missing values.

2.5. Data Collection Instruments

In the study to investigate the perceptions and attitudes of prospective graduates towards corruption, two instruments were used to gather pertinent information. These were self administeredclosed ended questionnaire prepared in English that reflect the objectives of the study. The questionnaire was adopted from ICAC (1994) by the researcher. The questionnaire has two sections. The first section comprised objectives and back ground of the respondents. The second part consists of items that can measure the variables (attitudes towards corruption) in the study.

For the response format items of the attitudes towards corruption, this part has seven items dealing with different aspects of questions on reflections of students' stances or attitudes towards corruption in line with preference areas of institutions in securing their job and also twelve scales ranging from strongly agree to strongly disagree. Again items were rated on a four point Likert scale (4= Strongly Agree; 3= Agree; 2= Disagree, 1= Strongly Disagree). In the questionnaire, there were positively and negatively stated items that were randomly placed to reduce the effects of response bias.

2.6. Data Collection Procedures

Following the pilot testing, every necessary precaution such as securing permission to enter research area (schools) and sampling subjects of the study were undertaken. The questionnaire was administered to subjects by the researcher together with a research assistant for fivedays before and after classes within sufficient but specified period of time. In addition to what was stated in the instrument, some concepts were orally clarified during the administration of the questionnaire. The respondents were reminded to ask whatever doubt they might have on the meanings of the items (words) and additional explanations of the items were given.

2.7. Pilot Testing

Pilot testing was conducted on a total of 30 participants (20 male and 10 female) students were randomly selected from all schools. In this case students were told how to give response to the questionnaire that provided them and some vague questions, which forwarded by the students, had been made clear during the pilot distribution.

The instruments were piloted to check the clarity of the items and the internal consistency of the instruments. To check the internal consistency of the items of the questionnaire, Cronbach-Alpha was calculated. Accordingly

the alpha coefficient for perceptions and attitudes towards corruption items were found to be 0.912 and 0.861 respectively.

Each item of these scales was validated by experts in the area of psychology from Adama Science and Technology University and Addis Ababa University. Three of them have unanimously agreed on the relevance of the items for the desired target information. Therefore, three, five and four items from demographic variables, attitudes which lacked clarity were discarded respectively. The clarity of the items was further checked by the civics and ethical education experts regarding appropriateness of the items for the students. In instruments, relevant descriptions were given for the words or expression which was suspected to be difficult for the respondents. One language expert checked the appropriateness of the descriptions.

2.8. Method of Data Analysis and Procedures

Data collected through questionnaire was coded and entered to computer by editing to avoid some errors in the data collection. A computer software known as Statistical Package for Social Sciences/ SPSS/V.16 was used for analysis. Before further analyses were carried out, the general characteristics of the data were tested. This was followed by an analysis of the relationship of variables. For the data analysis, both the quantitative and the qualitative methods were used. The response obtained was analyzed and presented using of simple descriptive statistics such as percentages, frequencies, means and standard deviation.

2.9. Ethical Consideration of the Research

Before starting to conduct the study, permission were assured from the selected study area management bodies. Ethical consideration was taken into account so that the concern integrity consents were protected. Essentially, respondents were enlightened to know the purpose of the study prior to responding to the question. The selected study participants were requested kindly permission whether they agree or not. Any information regarding this research were confidentially protected and not to exposed to anyone.

3. RESULTS AND DISCUSSION OF THE STUDY

3.1. Graduates' Attitudes towards corruption

3.1.1. Students' preference areas in securing their Jobs

This section deals with seven items on the reflections of students' stances in securing their job related with attitudes towards corruption.

3.1.1.1 Priority Area of Students to Study when they joined the University

Regarding priority area of students to study when they joined the university, among 332 total respondents, about 221(66.56%) of respondents replied to join medicine and engineering and 104(31.43%) of respondents preferred Law, Business and Economics. Only, about 7(2%) respondents have chosen others. This implies that the students' value most inclined towards the above professions than others like teaching. Previous studies in Australia (*CEPS*, 2006) identified three types of behaviours for corruption to take place. These are pro-active behaviours, reactive behaviours and situational responses. Pro-active behaviours are those behaviours that actively seek for corruption which begins from selecting fields of study at higher institutions up to selecting organization in which they work. Likewise, reactive behaviour's which tend to commit corruption whenever there is a chance to commit it and finally situational response which is influenced to commit corruption.

3.1.1.2 Basis of Student's Preferences in Prioritizing their Study Area

Table.1: Respondents' Basis of Preferences in Prioritizing their Study Area

	Basis of student's preferences in prioritizing their study area when joined the University	F	%	Rank
1	Employment opportunity	79	23.8	3
2	Expectation for high salary	100	30.1	2
3	Prestige	26	7.8	4
4	Personal interest for the profession	127	38.3	1

Source: own field survey, 2014 *F=Frequency*

Regarding basis of students' preferences in prioritizing their study area when they joined the university in rank order, of all students, about 127(38.3%), 100(30.10%), 79(23.8%) and 26(7.8%) of respondents reported that they were prioritized on personal interest for the profession, expectation for high salary, on the basis of employment opportunity and the prestige of the study area has respectively (see Table 1). It seems that most of the students were inclined towards high salary and employment opportunity than personal interest for the profession during study area selection. This finding is also consistent with Tina (2002) report that individual job decisions can be affected by corruption. Talented youth apply for bureaucratic jobs instead of more scientific professions, in order to extract rents, especially where it is pervasive, corruption can deter honest people from entering government services honestly.

3.1.1.3. Preference Areas of Students to Work After their Graduation

With respect to the preference areas of students to work after their graduation, the students were asked to rate five (1-5) institutions in order of respondents' priority (**1st, 2nd, 3rd, 4th** and5th choices) from the given alternatives, the public

sectors they want to work after their graduation. As a result, the institutions the respondents indicated as their **1st, 2nd, 3rd, 4th**and5th choices were indicated below (Table 2).

Table.2: Respondents' Institutional Choices from the 1st to 5thAccording to their Priority

Choice		Institutions	SOE		SOA		SOHL		SONS		SOBE		Total	
			F	%	F	%	F	%	F	%	F	%	F	%
1st	1.	Custom	18	5.4	4	1.2	14	4.2	11	3.3	72	21.7	119	35.8
	2.	Municipality	64	19.3	1	0.3	1	0.3	2	0.6	1	0.3	69	20.8
	3.	Int'al NGOs	11	3.3	1	0.3	1	0.3	0	0	4	1.2	17	5.1
2nd	1.	Int'al NGOs	50	15.1	16	4.8	14	4.2	5	1.5	22	6.6	107	32.2
	2.	Custom	11	3.3	0	0	2	0.6	4	1.2	17	5.1	34	10.2
	3.	Municipality	21	6.3	0	0	0	0	2	0.6	8	2.4	31	9.3
3rd	1.	Municipality	74	22.3	13	3.9	4	1.2	0	0	23	6.9	114	34.3
	2.	Investment	11	3.3	3	0.9	0	0	5	1.5	5	1.5	24	7.2
	3.	Custom	15	4.5	0	0	3	0.9	2	0.9	23	6.9	23	6.9
4th	1.	Eth-Air lines	25	7.5	2	0.6	7	2.1	9	2.7	17	5.1	60	18.1
	2.	Int'al NGOs	20	6.0	4	1.2	1	0.3	2	0.6	12	3.6	39	11.7
	3.	Ethio-Telecom	14	4.2	0	0	0	0	1	0.3	8	2.4	23	6.9
5th	1.	Ethio-Telecom	25	7.5	2	0.6	1	0.3	4	1.2	27	8.1	59	17.8
	2.	Municipality	10	3.0	3	0.9	2	0.6	1	0.3	7	2.1	23	6.9
	3.	Eth-Air lines	6	1.8)	0	0	3	0.9	0	0	9	2.7	18	5.4

Source: Own field survey, 2014 Int'al NGOs = International NGOs F=Frequency
SOE= School of Engineering, SOA= School of Agriculture SONS=School of Natural Sciences
SOHL= School of Humanities & Law, SOBE= School of Business & Economics

Regarding preference areas of students to work after their graduation, about 5.4%, 1.2%, 4.2%, 3.3% and 21.7% of school of Engineering, school of Agriculture, school of Humanities and Law, school of Natural science and school of Business and Economics of respondents respectively reported that they want to be employed in Custom and Revenue Authority as their first choice (Table 3). Similarly, about 15.1% from school of Engineering, 4.8% from school of Agriculture, 4.2% from school of Humanities and Law, 1.5% from school of Natural science and 6.6% from school of Business and Economics respondents rated International NGO's as their second choice institution.

Out of all 332 respondents, 22.3% from school of Engineering, 3.9% from school of Agriculture, 1.2% from school of Humanities and Law, 0% from school of Natural sciences and 6.9% from school of Business and Economics showed their interest in Municipality as their third choice institution.

With respect to preference areas of students to work after their graduation, 7.5% from school of Engineering, 0.6% from school of Agriculture, 2.1% from school of Humanities and Law, 2.7% from school of Natural science and 5.1% from school of Business and Economics rated Ethiopian –Airlines as their fourth choice. Finally, about 7.5% from school of Engineering, 0.6% from school of Agriculture, 0.3% from school of Humanities and Law, 1.2% from school of Natural science and 8.1% from school of Business and Economics rated Ethio-Telecom as their fifth choice. Generally, from the above data, out of 332 respondents 35.8%, 32.2%, 34.3%, 18.1% and 17.8% of respondents were showed their interest in Custom and Revenue Authority, International NGO's, Municipality, Ethiopian – Airlines and Ethio-Telecom respectively. From the above figure, it can be concluded that, despite the irrelevance of their field of study, considerable number of students has chosen institution which is potential area for corruption and improprieties. It seems that there is high tendency of students aspiring to join institutions either which has attractive salary payment or high opportunity for rent-seeking. Moreover, this indicates that a student psychological make-up has been pre-occupied to commit corruption.

This finding is similar with Tanzi (1998) which stated that in corrupt environment, able individuals allocate their energies to rent-seeking and to corrupt practices, and not to productive activities. Furthermore, the researcher argued that in situations where rent-seeking provides more lucrative opportunities than productive work does, the allocation of talent will be worse; talented and highly educated individuals will be more likely to engage in rent-seeking work than in productive work, with adverse consequences for their countries growth rate. Moreover, Klitgaard (1988), and Caiden and Dwivedi (2001) in their organizational culture theory state that once an organizational culture (or country) is corrupt, every person who comes in contact with it also runs a big risk of becoming corrupt. Therefore (and interestingly enough) corruption itself seems to be the 'cause' of corruption (even though the specific causal relationship is hard to define). Not becoming corrupt in certain organizational cultures means betraying the group (Punch, 2000).

3.1.1.4. Reasons for Students to Select Institutions in which they want to Work After Their Graduation

Table.3: Respondents' Justifications in Institutional Selection after their Graduation

	Reasons for students to select institutions in which they want to work after their graduation	F	%	Rank
1	Social interaction and experiences which help me to be familiar with diverse business owners and transactions, so that I can learn how to create my own business in the future	105	31.6	2
2	Attractive payments so that I can fulfil my financial needs with in short period	147	44.3	1
3	The popularity of the organization in its service provision, employee treatment and managerial skills	68	20.5	3

Source: own field survey, 2014 *F=Frequency*

Concerning reasons for students to select institutions in which they want to work after their graduation, the study revealed that the majority (44.3%) of respondents indicated their reasons is to get attractive payments so that they can fulfil their financial needs with in short period, about 31.6% for social interaction and experiences which help them to be familiar with diverse business owners and transactions, so that they can learn how to create their own business in the future (Table 3).

This finding is consistent with what Rose-Ackerman (1978) stated that, the public choice theory which is centred in the individual corrupt official who tries to maximize his or her utility claims that, public officials are corrupt for a simple reason: they perceive that the potential benefits of corruption exceed the potential costs. Furthermore, klitgaard (1988) states that, if the benefits of corruption minus the probability of being caught times its penalties are greater than the benefits of not being caught, and then an individual will rationally choose to be corrupt. This theory can be expanded when conditions that influence the cost- benefit calculations are taken into account. Collier (2002) also indicated that, in the public choice theory, actions of corrupt officials are caused by a rational, conscious and deliberate weighing process of an individual

3.1.1.5. Approaches of Graduates in Searching For Job after Graduation

With regard to reasons for students to select institutions in which they want to work after their graduation , the data gathered from students indicted that, about 147(44.3%) reported that their choice is because of attractive payments so that they can fulfil their financial needs with in short period, whereas 105(31.6%) said that a social interaction and

experienced with help them to be familiarly with diverse business owners and transactions, so that they can learn how to create their own business in the future, and about 68(20.5%) of respondents were replied that the popularity of the organization in its service provision, another reason for choosing their future institution are employee treatment and managerial skills. The remaining 12(3.6%) responded other options (Table 4)

Table.4: Respondents' Approaches in Searching for Job after Graduation

	Approaches	F	%	Rank
1	Approach through friends and relatives	111	33.4	2
2	Competing for relevant vacant positions announced	145	43.7	1
3	Paying some payments that do not harm my family	21	6.3	4
4	Examining or assessing market gap, so that I would start my own business	55	16.6	3

Source: field survey, 2014 *F=Frequency*

Similarly, regarding approaches of graduates in searching for job after graduation, of 332 respondents, 145(43.7%) preferred competing for relevant vacant positions announced, 111(33.4%) preferred approach through friends and relatives, 55(16.6%) preferred examining or assessing market gap and 21(6.3%) paying some payments that do not harm their family (Table 4). Therefore, one can understand that some of the students showed positive attitude towards bribe and nepotism.This shows that students are inclined towards what they perceive. This finding is consistent with Engudai (2011) finding that unethical behaviour and improprieties reflected by higher education institutions students. With respect to this Graaf, (2003) stated thatabout the occurrence of corruption in the existence of people with faulty (moral) character 'bad apples', is a causal chain from bad character to corrupt acts. Therefore, corruption is found in defective human character and predisposition toward criminal activity.

3.1.1.6. Bodies With Whom Discussions Were Made

Table.5: Respondents' Opinion Regarding With Whom Discussions Made

	Categories	F	%	Rank
1	Friends	191	57.5	1
2	family members	29	8.7	4
3	with fellow students in the class	32	9.8	3
4	with government corruption prevention agent	39	11.7	2
5	Teachers'	24	7.2	5

Source: own field survey, 2014 *F=Frequency*

In line with bodies with whom students were made discussions, respondents replied that, about 191(57.5%) made with their friends (colleagues), 39(11.7%) with government corruption prevention agent, 32(9.8%) with fellow students in the class, about 29(8.7%) with their family members and the remaining 24 (7.2%) of respondents replied that they made discussion with their teachers (Table 5). Though family and teachers are crucial individuals to bring about behavioural changes to fight against corruption, it was found that both family and teachers have very limited communications about corruption with respondents. Previous studies (e.g., Rumayntsak, 2005) stated that, as the purpose of education is to provide a way for society to model good behaviour for children or young adults, tolerate an education system to be corrupt may be more costly than allowing corruption in other institutions; it contains both immoral and illegal elements.

3.1.1.7. Attitudes of Students' Regarding Corruption

In understanding corruption for each of the three items, those who agreed or strongly disagreed were acknowledging a narrow definition or lack of understanding of corruption, whereas in behaviours which considered to be acceptable, for each of three statements, those who agreed or strongly agreed were expressing a broader range of what considered to be acceptable behaviour by individuals. Similarly, with respect to moral condemnation of corruption, for each of the three items, those who responded agreed or strongly agreed were expressing moral condemnation of corruption and lastly concerning reporting corruption, for each of the three statements, those who agreed or strongly agreed were expressing problems associated or no value with reporting corruption.

Table 6: Summarized Results of Attitudes towards Corruption in Terms of Frequencies and Percentages

Attitude statements	**Disagree**				**Agree**			
	SD		**D**		**A**		**SA**	
a. Understanding corruption	F	%	F	%	F	%	F	%
1 A given behaviour must be unlawful for it to be corrupt.	68	20.5	52	15.7	111	33.4	101	30.4
2 If something is done for the right reasons, it cannot be called corruption.	38	11.4	76	22.9	105	31.6	113	34.0
3 You cannot call something corrupt if everybody does it.	32	9.6	50	15.1	125	37.7	125	37.7
b. Acceptable behaviours								
4 The government can afford to sustain minor theft without worrying about it.	54	16.3	72	21.7	132	39.8	74	22.3

5	There is nothing wrong with public servants receiving gifts from a customer to speed up efficient service.	20	6.0	34	10.2	85	25.6	193	58.1
6	As far as the job gets done efficiently, I don't mind how public servants go about receiving incentives.	43	13.0	80	24.1	95	28.6	114	34.3
c.	**Moral condemnation of corruption**								
7	Those who take as well as those who give bribes should be condemned.	84	25.3	105	31.6	50	15.1	93	28.0
8	Even if I were forced by the situation, I would not give grease money (facilitation payment).	50	15.1	107	32.2	89	26.8	86	25.9
9	Doing favours for public officials has severe impact on my life.	66	19.9	79	23.8	95	28.6	92	27.7
d.	**Reporting corruption**								
10	There is no point in reporting corruption because nothing useful can be done about it.	96	28.9	65	19.6	89	26.8	82	24.7
11	People who report corruption are likely to suffer the cost.	33	9.9	55	16.6	120	36.1	124	37.3
12	Most corruption is too trivial to be worth reporting.	58	17.5	92	27.7	122	36.7	60	18.1

Source: own field survey, 2014 SD=Strongly Disagree SA=Strongly Agree F=Frequency

Table.6, presented that, regarding attitudes towards understanding corruption, items 3, 2, and 1 the majority of respondents agreed by 75.4%, 65.6%, and 63.8% respectively on each item. Similarly, concerning attitudes towards corruption of the range of behaviours which considered to be considered acceptable for item 5, 6 and 4 about 83.7%, 62.9% and 62.1% of the respondents agreed respectively. Responses to the items 8, 7 and 9 presented in the Table.18, regarding attitudes towards moral condemnation of corruption**,** about 56.3% and 52.7% agreed respectively, while 56.9% disagreed. With respect to responses on the three items of attitudes towards reporting corruption (items, 11, 12 and 10) 73.4%, 54.8% and 51.5% of respondents agreed on each item respectively.

The findings of this study revealed that the majority of respondents indicated their agreement to the items related to understanding corruption. Accordingly, those who agreed were not acknowledging a broader definition of corruption. Therefore, the respondents have no relatively broad potential definition of corruption. Most respondents' definitions appear to be limited to either legal definitions or the criteria of the end justifying the means and common practice accepted as sufficient to exempt behaviour from the possibility of being corrupt.

Those who agree with these attitudes statements are saying that they consider such justifications to be legitimate. This finding is inconsistent with that of ICAC (1993) who found that the majority of respondents believe that behaviour can be corrupt even if, it is not specifically prohibited by law, the ends justify the means and everybody does it. As a result, a belief that such justification is not acceptable, as indicated by disagreeing with these attitude statements, assists in minimizing corruption. In addition, OEACC (2013) stated that ''what is wrong is wrong, even if everyone is doing it. Right is still right, even if no one else is doing it''. Therefore, there is no right way to do the wrong thing. Since it is difficult to control others unethical decisions, all individuals should focus on that which they can control, their own ethical behaviour.

This study finding revealed that regarding students' attitudes about what are acceptable behaviours, the majority of the respondents indicated their agreement. This implies that, the respondents expressed a broader range of what they considered to be acceptable behaviour, (that is, a narrower understanding of unacceptable behaviour). Even though people all over the world believe corruption is morally wrong, some types of corruption are still perceived as more acceptable than others. The forms of corruption, which are perceived as more acceptable or less acceptable, can vary among different contexts and potentially also among different policy areas (Kaufmann, 2002).

Furthermore, it was found that most of the respondents condone receiving illegal extra incentives from the customer and tolerated the existences of petty theft. As previously revealed in the literature, about workplace crime suggests that people may rationalize or excuse activities otherwise defined as corrupt (Horning, 1970). Similarly, in some environments, behaviour which might be labelled as corrupt is simply 'taken for granted 'by the community (Malec and Gardiner 1987, P.277). For example, Graonbeck (1990) described behaviours' such as ' graft, kickbacks, overzealous promotion through meritocracy, such founds which have public effects without public accountability (and) favours which bypass normal channels' as ' behaviours' which may people take as part of the everyday cost of government' (P.174).

Others (for example, Deakin University, 1994, P.35) have suggested that there is general community acceptance that' petty pilfering of stock and equipment from employers is fair game almost a fringe benefit for employee.

From this study analysis, it was found that concerning moral condemnation of corruption, the respondents' opinions were slightly fairly divided. When the responses of each of the three items combined about 50.7% of respondents agreed with the idea, whereas 49.3% of respondents reflected their disagreement. Therefore, still considerable numbers of respondents were expressed tolerance of corruption incidents. This seems that there is a positive tendency towards tolerance of corruption among some respondents. This might be resulted from less sensitivity of the respondents due to fear of reprisals.

Regarding attitudes to reporting corruption, this study finding indicated that the majority of

respondents agreed with the statement ‘ there is no point in reporting corruption because nothing useful will be done about it’, people who report corruption are likely to suffer the cost and most corruption is too trivial to be worth reporting. Therefore, for each of these statements, those who agreed expressed their little value in reporting corruption. This finding is consistent with that of (ESCPS,2012) reported that there was some reluctance on the part of citizens to get involved directly in reporting incidents of corruption to which they may be witness. A major factor for this reluctance seemed to be fear of reprisals whether physical or psychological.

4 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

There was individual variation in the combinations of perceptions of scenarios which were considered the behaviour as corrupt. Thus, the respondents’ understanding of corruption may not be shared by his or her colleagues. It is apparent that, lack of commonality of understanding adds to the difficulty of controlling corruption. Hence, from the findings, it can be concluded that prospective graduating students differ in the way they perceive corruption.

From the result, it can be concluded that, the majority of respondents were not ready to report corrupt behaviours internally or externally and more likely to say that they would do nothing for corrupt behaviour. This implies that, it is not possible to assume that once behaviour is identified as corrupt, people will necessarily taken action about it. Respondents were also significantly more likely to report the matter outside organization than within their organization. It seems this might be resulted from fear of retaliation.

Despite the irrelevance of their fields of study, considerable number of students has chosen custom and revenue Authority, International NGO, Municipality, Ethiopian- Airlines and Ethio-Telecom institutions, which is either highly potential area of corruption or attractive salary payment. This indicates that a student psychological make-up has been pre-occupied to commit corruption.

In this study, the finding reveals that, the majority of respondents were limited on legal definition than social definitions of corruption, justifications for the end justify the means and ‘everybody does it‘. Therefore, it can be concluded from finding that, behaviour which is not specifically prohibited should be allowed.

The majority of respondents condone petty theft and receiving extra illegal incentives. Therefore, this indicated that there is high tolerance of petty theft, bribes and nepotism. This is therefore; it implies that there is a positive tendency of respondents towards corruption.

4.2 Recommendations

On the basis of finding of the study, the following could be recommended.

5.2.1. Short Term

The community of higher education, particularly the leadership of higher education and instructors, needs to be models for students, show their determination against corruption, and produce followers by distancing themselves from corruption and malpractices.

The mass media could play a pivotal role in creating a citizen that does not crave for corruption, and in changing the views of the society as well as in exposing corrupt persons by organizing enlightening programs using notable quotes and proverbs that enrich the society's consciousness on the one hand and mortifying and isolating corrupt persons on the other hand by using legally confiscated properties as an illustration.

Some sectors, such as Revenue and Customs Authority, Land Administration unit of the Municipality, Telecommunication, HIV/AIDS Secretariat and the like, could make relentless efforts not to be prone to corruption and malpractices, and should be seen as exemplary by the society in providing speedy and corruption free services. In addition, the fight against corruption should not be left to the anticorruption commissions alone, but the management and workers of all sector offices should institutionally work determinedly to make their institutions corruption and malpractice free.

The government needs to make payments to various sector offices in proportion to the burden of services they provide; the government should also narrow the gaps in payment between these sector offices.

5.2.2 Long Term

Before students graduate from higher education, the Ministry of Education needs to design curricula for professional ethics to be offered as a course in all fields of study so as to help students have love for their profession, and offer continuous training that helps teachers become models for their students, and conducting continuous evaluation for results.

The promotion of ethics in society right from the beginning is indispensable in order to eradicate corruption. On top of the promotion of ethics in society, in order to produce a citizen who is equipped with good discipline, and who cannot tolerate corruption, the responsibility and role of parents to bring up children, who are the hopes of future, with good discipline is irreplaceable. This is because; children learn bad and good disciplines from their parents. Therefore, to enable children to achieve their goals and to become productive citizens, families need to be give due attention to their children's discipline. In that sense, the fight against corruption is a long-term battle, and begins with the family unit.

6. REFERENCES

African Development Bank Group (ADBG) (2003). Proceedings of the Regional Learning Workshop on combating Corruption in Africa, 27-30 January 2003, African Union Conference Centre, Addis Ababa.

African Institute of Management, Development and Governance (AIMDG) (2008) Ethiopia Country Self-Assessment Report, Draft Report Submitted to the Governing Council of the National African Peer Review Mechanism.

Atuobi, S. M. (2008). *Corruption and state instability in West Africa: An examination of policy options*. KAIPTC Occassional Paper no7. Retrived from www.kaiptc.org/ conflict_prevention/details.

Caiden, G. E., Dwivedi, O.P. and Jabbra, J. (2001). Introduction, in G.E. Caiden, O.P. Campaign." [Online]. Available: http://www.anticorruption.info/corr_def.htm 15 challenge of subverting corruption.

Centre of Excellence in Policing and Security (CEPS), Griffith University, Australia (2006, pdf).

Collier, M.(2002).Explaining Corruption: An Institutional Approach. Crime, Law& Social Change.Consequences.1–9. Washington D.C.: University Press of America.

Deakin University. (1994) Fraud against organisations in Victoria, Summary of findings from a survey of medium and large organisations in 1994. Deakin University, Geelong.

Egbue, N.G.(2006) "Africa: cultural dimensions of corruption and possibilities for change", Journal of Social Science.

Engudai.(2011) Unethical Behaviors Reflected in Ethiopia Higher Institutions Students'(in Amahric).

ESCPS. (2012) Federal Ethics and Anti Corruption (FEACC) Federal Democratic Republic of Ethiopia. Kilimanjaro International Corporation Limited.

Faniel S. H. (2009) Anti- Corruption Strategies in South Africa Public Sector. Perspectives on the contributions of complexity Thinks and ICTs. PhD Dissertation.

Graaf, G.de. (2003). Tractable Morality. Customer Discourses of Bankers, Veterinarians and Charity Workers. Rotterdam: Erim.

Gronbeck, B. E. (1990). The rhetoric of political corruption. *Political corruption a handbook*. New Brunswick, New Jersey: Transaction Publishers

Hallack, J & Poisson M. (2007). *Corrupt Schools, Corrupt Universities: What can be done,* Paris International Institute for Educational Planning.

Hochschild. J. L. (2005). In: Citizens and Politics; Perspectives from Political Psychology. New York, Cambridge University Press.

Holmberg, soren , Bo Rothstein and Naghmeh nasiritousi (2009)'' Quality of Government:What you Get'' *Annual Review of Political Science.*

Horning, D. (1970) Blue-Collar theft: conceptions of property, attitudes toward pilfering, and work group norms in a modern industrial plant.

Independent Commission Against Corruption (ICAC). (1994). Unraveling Corruption. A Public Sector Perspective, Survey of NSW Public Sector Employees Understanding of Corruption and Their Willingness to Take Action. Sydney NSW 2001.

Institute of Educational Research (IER), (2001) Corruption Survey in Ethiopia, Federal Ethics and Anti-Corruption Commission, Addis Ababa.

International society of sustainability professionals Study Monitoring Report, (ISSP). (2004).

Israel, G.D. (1992). Determining Sample Size. University of Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences, EDIS, Florida.

Kaufmann, Daniel / Kraay, Aart (2002): "Growth Without Governance", *Economia*, Fall,

http://www.worldbank.org/wbi/governance/pdf/growthgov.pdf.

Klitgaard, R. (1988): Controlling Corruption. Berkeley: University of California Press.

Malec, K. L., & Gardiner, J. A. (1987) Measurement issues in the study of official corruption: A Chicago example. *Corruption & Reform*.

Mauro, Paolo (1995). "Corruption and Growth."Quarterly Journal of Economics''. Vol. 110, No. 3, MIT Press.

Oromia Ethics and Anti- corruption Commission (2013). The What of Ethics and Work place Ethics: (Unpublished).

Punch, M. (2000). Police Corruption and Its Prevention.European Journal on Criminal Policy & Research.

Rose-Ackerman, S. (1978).Corruption: A Study in Political Economy. New York Academic Press.

Rumyantseva, Nataliya L.(2005).Taxonomy of corruption in Higher Education,*'Peabody Journal of Education.*

Shimelis A.(2005) Corruption and Anticorruption in Ethiopia: A Case Study of the Ethiopian Customs Authority, MA Thesis, Addis Ababa University, Addis Ababa.

Tanzi, V (1998): "Corruption around the World: Causes, Consequences, Scope, and Cures", IMF Staff Papers Vol. 45 No. 4, Washington, D.C.

Tina, Soreide (2002), Corruption in Public Procurement: Causes, Consequences and Cures, Chr. Michelsen Institute Development Studies and Human Rights, Report.

Waite,D.,and Allen(2003) Corruption and abuse of power in Education Administration. The Urban Review.

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