Civil and Environmental Research
ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online)
Vol.10, No.1, 2018
www.iiste.org

# Towards Mainstreaming Environmental Impact Assessment into Housing Development Projects in Ethiopia: The Case of Koye-Feche Condominium Housing Development Project, Addis Ababa

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**Abstract**
Linking environmental impact assessment (EIA) and infrastructure development projects as a result of rapid urbanization reveals serious environmental problems in cities and towns of developing countries like Ethiopia. Ecological infrastructure is as vital as physical infrastructure for the functioning of the economy – a path that can meet both long-term economic and environmental imperatives. The city government of Addis Ababa has planned to address urban housing challenges strategically with the help of National Integrated Urban Housing Development Plan along with other plans. Koye-Feche Local Development and Neighborhood project is believed to have significant contribution for the realization of the vision of Addis Ababa Housing Agency. This study employed secondary and primary methods of data collection like focus group discussion, key informant interview, and field observations. The collected data were analyzed both qualitatively (narration and descriptions) and quantitatively (application of SPSS, ArcGIS, and ERDAS IMAGINE). The possible negative environmental impacts of the project identified were: land use change, evection of indigenous farmers, soil erosion, cutting of trees, degradation of soil resources, health risk to humans and animals, landslide, spread of malaria, fuel gas emission, air pollution, noise pollution, dust pollution, soil and water pollution, risk/injury to workers, soil compaction, disruption of natural water ways, ground and surface water pollution, spilling of grease, residual materials, soil disturbance, and disturbance of the landscape, water harvesting infrastructure resulting in mosquito breeding and hazardous environment for children, traffic congestion in pick time, Solid waste, liquid waste, Increased urban heat island, and increased number of population. Appropriate mitigation measures are required to reduce the aforementioned possible negative impacts of condominium housing projects in Ethiopia.
**Keywords:** Development; hazard; Housing; Impact; mitigation; planning; urban

## Introduction

The aim of EIA is the inclusion of environmental concerns in decision-making and ultimately promoting a more sustainable development (Buchan, 2012; Baines et al., 2013; Vanclay et al., 2013; Larsen, 2014; Laedre et al., 2015; Retief et al., 2014). Specifically, EIA is the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals prior to major decisions being taken and commitments made (Larsen, 2014). Environmental Impact Assessment (EIA) is a key aspect of many large scale planning applications (Morel et al., 2001; Geneletti, 2005; Geneletti, 2014; Dahlitz & Morrison-Saunders, 2015; Harris & Haigh, 2015). Moreover, it is a technique which is meant to help understand the potential environmental impacts of major development proposals (Friends of the Earth, 2005; Ali & Nsairat, 2009; Kahangirwe, 2012; González et al., 2014).

Environmental impact assessment (EIA) is believed to be an effective method which evaluates the effects of different sectors and activities of a project on environmental components and finally according to results of this assessment offers solutions to reduce negative effects (Taheri et al., 2014; Retief et al., 2014**;** Dalal-Clayton & Tarr, 2015; Hanna & Noble, 2015). In other words, effective EIA processes need to adopt various strategies to manage the risks inherent in the development of large projects. At a minimum the process should identify sources of uncertainty, describe and analyze risk, develop and implement strategies to reduce risk, monitor the effectiveness of mitigation, and ensure that proponents adjust procedures and activities if monitoring results are poor (Jiliberto, 2011; Graetz &Franks, 2013; Joseph et al., 2015; Morrison-Saunders et al., 2015).

Consideration of different alternatives is one of the fundamental requirements of environmental impact assessment (EIA). To this end, the analysis and comparison of sets of project alternatives implies balancing up the different impact types so as to reach an evaluation of the merit of each alternative, and eventually a suitability ranking (Geneletti, 2005; Geneletti, 2014). Furthermore, the scoping phase is fundamental to an effective impact assessment process. It determines the extent and level of detail of the assessment and the information to be included in the EIA process, and ensures the whole process focuses on central issues (Polido & Ramos, 2015).

Public participation (PP) is integrated in environmental impact assessment (EIA) and social impact assessment (SIA) processes, as the authorities may require execution of public consultations as part of EIA preparations (Olsen & Hansen, 2014; Joseph et al., 2015). Supporting arguments for PP includes that PP may contribute to conflict mitigation, serve as a tool for information exchange and mutual learning, and as a means to

 

avoid costly delays (Kengne et al., 2013; Olsen & Hansen, 2014). In addition, PP may provide proponents access to local knowledge, concerns and preferences, and the potentially affected communities arguably gain a better understanding of the proposed project or plans, facilitating their capability to make an informed opinion. Overall, PP may lead the way to a more democratic process, where transfer of power from government to the citizens enables the public to influence the decision-making process. However, to achieve these benefits, PP must be applied effectively in EIA, which has been a central theme among EIA scholars in recent years (Olsen & Hansen, 2014; Joseph et al., 2015).

Stakeholders should participate in EIA process and have the capacity to influence the outcome of the process (Kengne et al., 2013; Joseph et al., 2015). To this end, there are many models of stakeholder participation and these models can be grouped into three categories: information sharing, consultation, and collaboration (Joseph et al., 2015). Information sharing informs stakeholders without seeking their input; consultation seeks input from stakeholders through an interactive process without formal obligation to incorporate this input into the final decision; and collaboration engages stakeholders in an interactive process that ensures incorporation of stakeholders' views into the decision by seeking stakeholder endorsement of decisions through negotiation (Olsen & Hansen, 2014; Joseph et al., 2015).

Development of physical infrastructure in developing countries has been promoted at the expense of ecological infrastructure (Kahangirwe, 2012; Polido & Ramos, 2015). To reverse this undesirable situation in urban areas of developing countries like Ethiopia, local urban authorities are strongly advised to practice environmentally sustainable urban development where the improvement of the quality of life in a city, includes ecological, cultural, political, institutional, social and economic components without leaving a burden on future generations. In other words, there is a need to conserve existing ecosystems like wetlands in which ecological services are improved so that people can enjoy nature, including clean air and water, and even listen to birds sing beautifully. To this end, environmental impact assessment (EIA) is recommended to be an integral part of the project approval procedure for local government and other authorities (Ali & Nsairat, 2009; Kahangirwe, 2012; González et al., 2014).

The Ethiopian government attempts to integrate environmental concerns in its development strategies so as to address sustainable livelihoods of the population within the context of sound environmental management considerations in decision making and project planning (EPA 2012, EPA 2003). To this end, Environmental Impact Assessment (Proclamation No. 299/2002) of Ethiopia aims primarily at making the EIA mandatory for categories of projects specified under a directive issued by the Environmental Protection Authority (EPA) of Ethiopia (FDRE, 2002).

In the past, development endeavors did not consider environmental issues in the evaluation of development projects. In other words, decision-making about implementation of development projects was merely focused on short-term technical feasibility and economic benefits (Ali & Nsairat, 2009; Kahangirwe, 2012). This negligence and unwise utilization of the natural resources resulted in degradation of the environment and scarcity of the resources (WCED, 1987; Ali & Nsairat, 2009; Kahangirwe, 2012; Laedre et al., 2015; Retief et al., 2014 ).

Addis Ababa is the capital city of Ethiopia and a diplomatic capital for African Union, the United Nations Economic Commissions for Africa, and regional quarters for UNDP, UNICEF, UNHCR, FAO, and ILO, etc (Regassa et al., 2011; PRIME Consultants Plc, 2012; Ogato, 2014; Desta et al., 2014). The city is sub-divided into three layers for administrative purposes namely city government, sub-cities administrations and district (Desta et al., 2014). The city has currently a population of about 3.5 million with density of 5936.2 $km^2$ and an area of 540 $km^2$ (Regassa et al., 2011; Desta et al., 2014). The altitude in the city ranges from 2000-3100 meter above sea level. The months from June to September are the periods of heavy rain with 80% of the annual amount falls at these periods and the average annual rainfall of the city is 1200 mm while the small rain occurs between March and May. The temperature is mild and warm climate with annual average temperature between 10 to 20$^oC$ (AAMS, 2007; Regassa et al., 2011; Desta et al., 2014).

The city of Addis Ababa being the capital of the nation is facing numerous challenges in trying to meet the demands aroused by the ever-increase population and high rate of urbanization. Consequently, the need for an increase in quantity and quality of shelter, infrastructure, employment and various social services become crucial to sustain the metropolitan life (CSA; 2007; Regassa et al., 2011; PRIME Consultants Plc, 2012; Ogato, 2014; Desta et al., 2014). Accordingly, the city government has planned to address these challenges strategically with the help of National Integrated Urban Housing Development Plan along with other plans. The national plan on housing has allocated about 250,000 housing unit to be constructed in the city of Addis Ababa in the years to come. Koye-Feche Local Development and Neighborhood project is one of these housing projects which are believed to have significant contribution for the realization of vision of Addis Ababa Housing Agency (PRIME Consultants Plc, 2012). The environmental impact assessment guideline document of Ethiopia recommends that housing development covering an area of 50 hectares or more require full EIA as they have adverse and significant environmental impacts (EPA, 2000; EPA, 2003). Koye-Feche Local Development and Neighbourhood Project has an action area of 208 hectares and planning area of 1019 hectares which demands full EIA.

 

An assessment of potential impacts on the environment prior to the approval of investment proposals provides a means of harmonizing and integrating the three pillars of sustainable development. Thus EIA, which is the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made (Kahangirwe, 2012; Mekuriaw and Teffera, 2013), has become one of the preconditions for permitting investment projects prior to implementation. However, housing projects in general and condominium housing projects in Ethiopia in particular have limited practices so far. Therefore, this study aims to demonstrate the importance of EIA for condominium housing development project at Koye-Feche area, district 09 of Akaki Sub-city of Addis Ababa, Ethiopia.

The general objective of the study was to identify potential environmental impacts of the project and formulate recommendations to ensure that the proposed development takes into consideration appropriate measures to mitigate/minimize any adverse impacts through all phases of its implementation. The specific objectives of the study were: to review environmental policies, legal and administrative frameworks relevant to the housing projects; to assess the existing physical, biological, and socio-economic environment of the project site; to identify, predict, and evaluate possible key environmental impacts of the proposed project; and to propose appropriate mitigation measures for possible negative impacts of the condominium housing development project.

## Methodology

### Description of the study area

The project site is located in the South-Eastern Part of Addis Ababa city in Akaki kality sub city of District 09 commonly called 'Koye-Feche' at a distance of about 7 Kms away from Akaki town in the eastern direction. In terms of astronomical location, the site extends from 8053'00"N to 8054'30"N latitude, and 38048'45"E to 38050'15"E longitude (see figure 1, and figure 2). The total palnning area of the project is estimated to be 1019 hectares. Except few residential houses, the site is covered by farm land and grazing. There is no as such a development nearby the site. However, Addis Ababa Science and Technology University, Kilinto and Tulu Dimtu condominium project are found at average distance of 2.5 km (PRIME Consultants Plc, 2012).

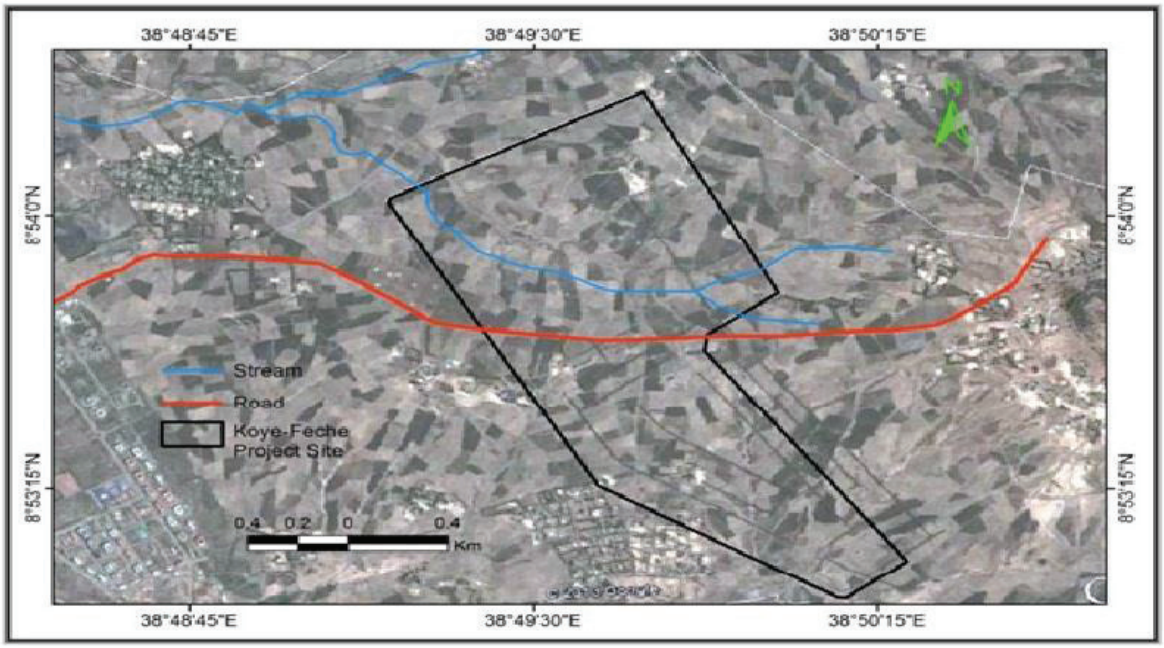


**Figure 1:** Map of the project area (Source: Authors' design based on Google Earth and Arc GIS).

 

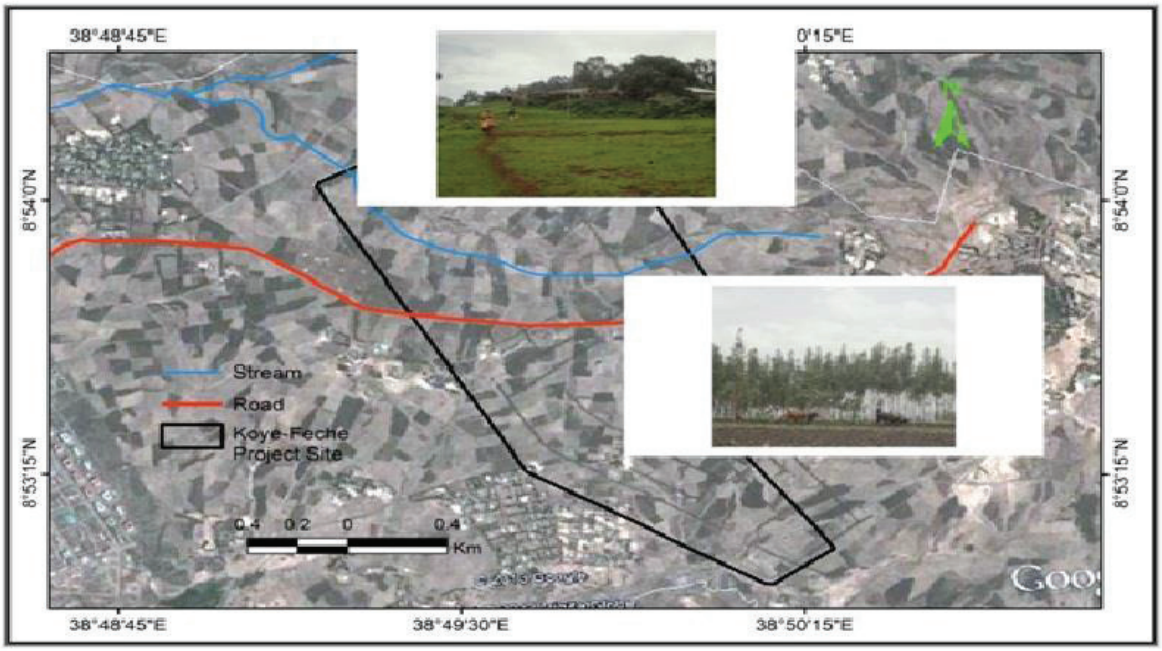


**Fig 2**: The site appearance and characteristics of Koye-Feche area (Source: Authors' design based on Google Earth and Arc GIS).

The topography of the area is characterized by gentle and relatively flat topography. The slope of the site is generally inclined downward from North-East to South-West. The entire site has a slope between 0 to 8 per cent. This indicates that large part of the area is more or less flat. The following map (see figure 3) indicates the topographical characteristics and landscape of Koye-Feche area, showing contours at 10 meters interval and slopes ranging from 0% to 3%, 4% to 8%, 9% to 15%, 16% to 25%, and greater than 25%.

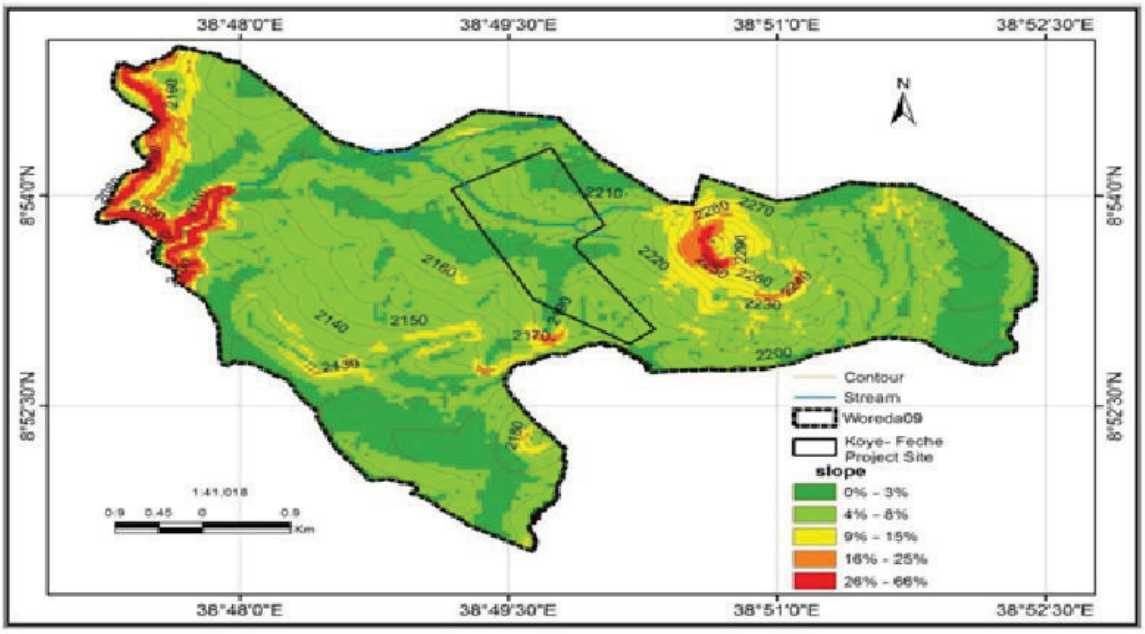


**Figure 3:** Topography of the project Site (Source: Authors' design based on Arc GIS).

The action area is about 208 hectares of farm land. The area is formely occupied by the indigenous farmers of the two villages called Koye and Feche. Except few residential houses, the site is coverd by farm land and grazing. There is no clear and defined road acess that connect the site with other areas of the city except some local road constructed by the Water supply and Sewerage authority that pass through the study site to the Kilinto riservior. There is no as such developments near by the site. However, the Kilinto Science and Technology institute, Kilinto and Tulu dimtu condominium project areas are found at average distance of 2.5 km from the site (PRIME Consultants Plc, 2012).

 

The mean annual rainfall computed from data of National Meteorology Agency (NMA) of Ethiopia for the period between 1975 and 2007 shows that, there is a variability in trends of mean annual rainfall in Koye-Feche with a very high variability in total rainfall (Std. deviation=159). In other words, the mean annual rainfall for Koye-Feche over the 33 years was found to be 1038.66 mm with the standard deviation of 159 (table 6.2 and figure 6.6). The highest total rainfall was registered in the year 1977(1487.30 mm) while the lowest one was registered in the year 2002 (771.30 mm) (see figure 4).

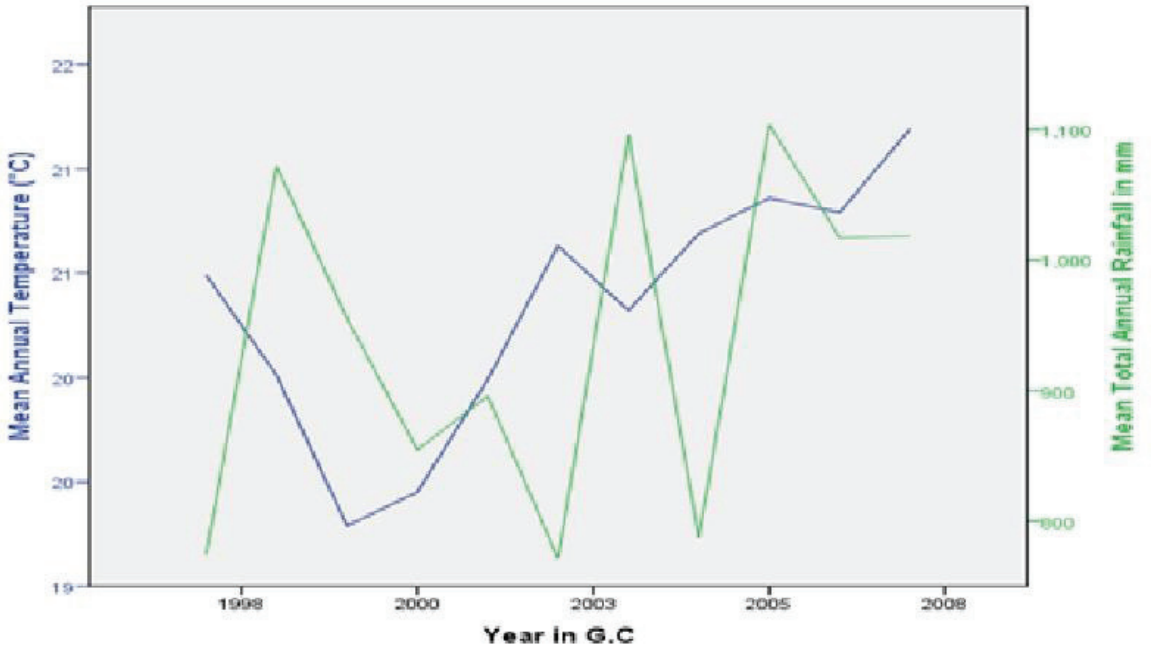


**Figure 4:** Trends in Total Rainfall in mm and Mean Annual Temperature in °C for Koye-Feche, District 09, Akaki Sub-City, Addis Ababa (Source: Authors' Computation based on Data of NMA of Ethiopia, 2013).

The mean annual temperature computed from data of National Meteorology Agency (NMA) of Ethiopia for the period 1997-2007 shows that there has been a variability in trends of mean annual temperature over 11 years in Koye-Feche though the variability in mean annual temperature is less **(**Std. deviation=0.6). In other words, the mean annual temperature for Koye- Feche over 11 years (1997-2007) was found to be 20.33°C with the standard deviation of 0.6. The highest mean annual temperature was registered in the year 2007 (21.19°C) while the lowest one was registered in the year 1999 (19.29°C) (see figure 4).

The mean annual relative humidity computed from data of National Meteorology Agency (NMA) of Ethiopia for the period between 1988 and 2007 shows that, there has been a variability in trends of mean annual relative humidity in Koye-Feche though the variability in mean annual relative humidity is less **(**Std. deviation=1.4). The mean annual relative humidity for Koye-Feche over 20 years (1988-2007) was found to be 212% with the standard deviation of 1.4. The highest mean annual relative humidity was registered in the year 1999 (215%) while the lowest one was registered in the year 1988 (210%) (see figure 5).

 

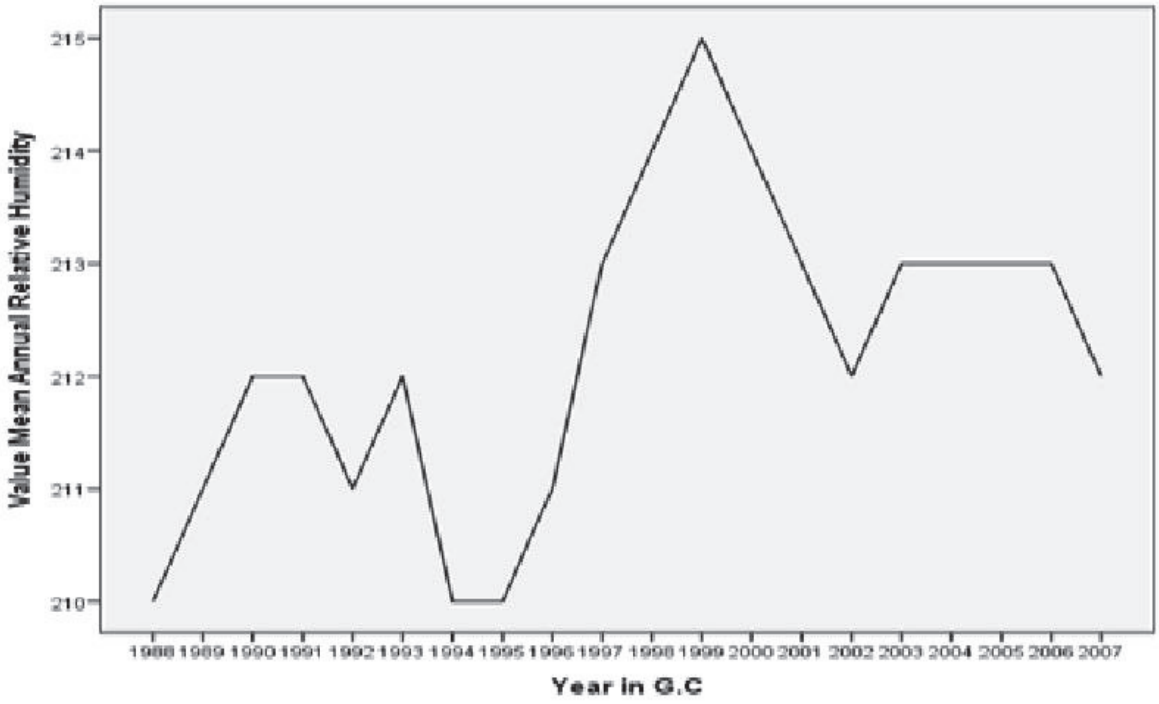


**Figure 5**: Mean Annual Relative Humidity (%) for Koye-Feche Area, District 09, Akaki Sub-City, Addis Ababa (1988-2007) (Source: Authors' Computation from Data of NMA of Ethiopia, 2013).

The project site is drained by seasonal streams flowing from north east to south west direction. Some of the streams are small, intermittent and shallow while there is one relatively big river bordering the site to the western direction with deep gorge. The drainage pattern of the site is depicted on the map (PRIME Consultants Plc, 2012).

The terrestrial ecology of Koye-Feche area is composed of farmland, grazing land, scattered human settlement, scattered trees, shrubs, and soil and its microorganisms (see figure 6). In the area, the majority of land is used for agricultural production purpose. The Koye-Feche area has no any well established aquatic ecology. Nevertheless, there are seasonal streams and swampy areas (wetlands) in the project site (see figure 7).

There are no forest and permanent water bodies in the area. But, patches of trees around the settlement are used as nesting habitats for birds and other arboreals. Moreover, the ground and the soil are natural habitats for wildlife animals like hyena, rats, insects and worms.

**Fig 6:** Appearance of the terrestrial ecology of Koye-Feche area (source: Authors' field visit, 2013).

 

**Fig 7:** Sample swampy area (seasonal wetland) in Koye-Feche area (source: Authors' field visit, 2013).

The ecosystem services in Koye-Feche area can be categorized as: provisioning of services (food, freshwater, wood, medicine etc), regulatory services (climate regulation, water purification, pollination, erosion control, etc.), cultural benefits (tourism, recreation, spirituality, scenery. etc) and supporting services.

Regarding provisioning services, almost all of the farmers are dependent on agricultural activities such as crop production, livestock production, and rearing of other animals (equine) for generating income and other resources for house consumption. In addition, farmers utilize tree and tree products for their daily energy consumption, constructing houses, making furniture, medicines and fences. Moreover, the farmers utilize water and other resources from their surrounding environment for cooking and cleaning purposes. At the same time, the same ecosystem provides services for the farmers in regulating their local climate, purifying water, supporting crop production through pollination and minimizing soil erosion. It also plays important role in providing good scenery and shades in areas where religious practices are conducted.

The major part of the study area comprises of different land uses. The major part of the area is serving as cultivated and grazing land. There are also residential areas and some plantations around and within the residential areas. The land in the surrounding area of the proposed project has potential for agriculture. Since the land selected for the upcoming project is proposed within agricultural and settlement areas, it might require taking out some trees and misplacing of households.

The primary livelihood system of the indigenous farmers of Koye-Feche area is farming (crop production and livestock rearing). Since farming is the most valued livelihood system in the project site, it will remain to be a primary livelihood system in the project site in the absence of the project. However, there are also other supportive livelihood systems like small scale commercial activities like grain marketing and marketing of consumable household goods.

**Methods of data collection and analysis**

The approach to EIA exercise was carefully structured according to the requirement of EIA proclamation and guideline of Ethiopia. It involved largely an understanding of the project background, the preliminary designs and the implementation plan as well as commissioning. In addition, baseline information was obtained through physical investigation of the site areas, public consultations with members of the community in the project areas, survey, photography, and discussions with the Proponent.

The method of EIA study involved gathering of primary and secondary data on environmental situation of Koye-Feche area. To this end, a mixed-method research approach was employed. Mixed-method research approach is claimed to help local policymakers and community experts to better understand complex research problems. In working in a mixed-method investigation, the investigator is required to 'combine more than one research method to generate multiple data slices that are organized into a single research project. Mixed-method research projects involve the integration of quantitative methods (the collection of numbers) and qualitative methods (the collection of words and images) (Gaber & Overacker, 2012; Vanclay et al., 2013). The secondary data were collected from previous studies on environmental impacts of development projects in general and

 

housing development projects in particular. Primary data were collected through public consultation, site visits and focus group discussions with relevant stakeholders for screening, scoping, impact identification and prediction. Descriptions of the primary methods of data collection are briefly presented hereunder:

**1. Public consultation: c**onsultation with various stakeholders was an integral part of this environmental impact assessment study (Sims, 2012; Baines et al., 2013; Kengne et al., 2013; Vanclay et al., 2013; Olsen & Hansen, 2014; Joseph et al., 2015)**.** For instance, the affected parties (indigenous farmers) in Koye-Feche area were consulted about the condominium housing development project in all the major steps of EIA process (project screening, scoping, and description of the project, existing situation, impact identification, and mitigation plan) to understand their perception about the proposed project and their major concerns in the process of implementing the proposed project. Moreover, major stakeholders in the project area were consulted purposively.

**2. Site visits (Observations):** All the members of the EIA team did visit Koye-Feche project site six times to collect relevant primary data for the EIA study. Accordingly, pictures and GPS points of physical, biological, and socio-economic elements of the environment were taken to complement data collected through other methods of data collection (Gaber & Overacker, 2012; Vanclay et al., 2013).

**3. Focus group discussions and key informant interview**: four focus group discussions were made with affected parties (indigenous Farmers of the study area) while key informant interview was made with officers from Administration office, Agricultural Development Office, and Health Promotion Office of district 09, Akaki Kality sub-city, Addis ababa on pertinent matters of the project.

As far as the methods of data analysis methods are concerned, professional judgment with adequate reasoning and supporting data, past experience, narration and descriptions, physical and visual analysis, geospatial analytical tools in ArcGIS-10, and image processing and analysis tools in Erdas Imagine2010 were employed in the process of screening, scoping, and description of existing conditions, impact identification, prediction and evaluation.

## Results

This section presents identification and prediction of possible key environmental impacts of koye-feche local development and neighborhood project.

### 1. Identification of possible key environmental impacts

Impact identification is the process of characterizing a project and its main aim is to ensure that potentially significant environmental impacts (adverse or favorable) are identified and taken into account in the EIA process. The impact identification methods employed were: simple and descriptive checklist, quantitative methods (comparing relative importance by weighting), public consultation, discussion with affected parties, and overlay maps. The proposed project is expected to have both negative and positive environmental impacts. These environmental impacts are described as follows.

The activities of the proposed project to be undertaken are expected to have possible negative impacts on the Physical, Biological, and socio-economic environment during the construction phase. The possible negative environmental impacts to occur during the construction phase of the project were: land use change, evection of indigenous farmers, soil erosion, cutting of trees, degradation of soil resources, health risk to humans and animals, landslide, spread of malaria, fuel gas emission, noise pollution dust pollution, soil and water pollution, risk/injury to workers, soil compaction, disruption of natural water ways, ground and surface water pollution, spilling of grease, residual materials, soil disturbance, and disturbance of the landscape. However, the proposed project will have some possible positive impacts on the socio-economic environment like employment opportunity for local communities and skill improvement for employees of the project.

The possible negative environmental impacts identified to occur during the operation phase of the proposed project were: air pollution, surface and ground water pollution, water harvesting infrastructure resulting in mosquito breeding and hazardous environment for children, fuel gas emission, dust pollution, noise pollution, traffic congestion in pick time, liquid waste, Increased urban heat island, and increased number of population. Nevertheless, many possible positive impacts like better living conditions (housing) for inhabitants, employment opportunities resulting from collection and sell of recyclables an production of natural fertilizer from waste management, provision of ecosystem services (fresh air, regulated local climate, aesthetic value, and created ecosystem, and ground water recharge), better waste management, better access to water and sanitation services, better access to electricity resulting in reduced cost, time and labour in energy consumption, and improved social services (health, education and market services) were identified.

The possible negative environmental impacts identified to occur during the closing and decommissioning phase of the proposed project were: Solid waste, liquid waste, and degradation of land resources. However, some possible positive impacts like restored natural landscape were also identified to occur during the closing and decommissioning phase of the project.

### 2. Prediction of possible key environmental impacts

Prediction of environmental impacts involves the identification of the potential change in indicators of such environmental receptors and aims to identify the magnitude and other dimensions of identified change in the

 

environment with a project/action, by comparison with the situation without that project/action (EPA, 2000; Glasson et al., 2005).

In predicting the level of impact that an activity may cause, the EIA team considered key elements like spatial scale (local or regional or national), duration (short term, medium term and long term); Intensity (low, moderate, sever), probability (the likelihood that an activity will occur or will not occur) direction (positive or negative), significance (low, medium, high), and reversibility (reversible or irreversible). Accordingly, the EIA team predicted the identified impacts across three phases of the project-Construction, operation, and closing and decommissioning.

Many of the potential adverse environmental impacts identified under the construction phase were predicted to have high impact on the physical, biological, and socio-economic environments for intensity and significance. All the potential adverse environmental impacts identified were predicted to have local spatial scale except fuel gas emission which was predicted to have local, regional and national spatial scale. All the potential adverse environmental impacts identified were predicted to have a probability of occurrence and negative direction. All the potential adverse environmental impacts identified were predicted to be reversible and actual. Almost all the potential adverse environmental impacts identified were predicted to be both direct and indirect.

Many of the potential adverse environmental impacts identified under operation and decommissioning phase were predicted to have moderate impact on the physical, biological, and socio-economic environments for intensity and significance.

**Discussion**

This section discusses the adverse environmental impacts identified and predicted. The impact significance criteria considered in the evaluation process were: ecological importance, social importance, and environmental standards and regulations of the predicted impacts. The impact evaluation methods employed were: comparison of likely impacts against legal requirements and standards (eg. Air and water quality standards, building regulations), Scoring and weighting system. Moreover, the findings of the evaluated adverse environmental impacts were discussed in relation to the findings in literature.

**1. Possible adverse environmental impacts during construction phase**

The evaluated adverse environmental impacts were: land use change, evection of indigenous farmers, soil erosion, cutting of trees, degradation of soil resources, health risk to humans and animals, landslide, spread of malaria, fuel gas emission, noise pollution, dust pollution, soil and water pollution, risk/injury to workers, soil compaction, and spilling of grease. The impact evaluation of each variable under the construction phase is presented hereunder.

**A. Land Use Change (LUC):** LUC was identified as one of the adverse key environmental impacts associated with relocation of the settlers. It was predicted to have severe intensity and high significance. The land use was identified to change from farming and grazing land to urban housing land with negative impacts on the physical, biological, and socio-economic environment (Zeleke, 2000; Bewket, 2003). Urban Planning proclamation (Proclamation No 574/2008) of Ethiopia states that it is necessary to regulate the carrying out of development undertakings in urban centers, contemplated both by public and private actors so that they will not be detrimental to the general well being of the community as well as the protection of the natural environment (FDRE, 2008; Damtie, 2010). Appropriate mitigation measures were proposed based on the environmental policy**,** regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE; 1997; EPA, 2003; United Nations, 1992a; United Nations, 1992b; United Nations; 1994).

**B. Evection of indigenous farmers:** This was identified as one of the adverse key environmental impacts associated with relocation of the settlers. It was predicted to have severe intensity and high significance. Proclamation to provide for the expropriation of land holdings for public purposes and payment of compensation (proclamation No.455/2005) states that all persons who have been displaced or whose livelihood has been adversely affected because of state programs have the right to commensurate monetary or alternative means of compensation, including relocation with adequate state assistance (FDRE, 2005). However, the compensation does not take into account the value of land (EEPCo, 2010; Unifruit Ethiopia, 2011). Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (UNESCO,1972; FDRE; 1997; FDRE, 2005; EEPCo, 2010; Unifruit Ethiopia, 2011 ).

**C. soil erosion:** This was identified as one of the adverse key environmental impacts associated with clearing of the site, establishment of site offices, production and transportation of red ash (scoria), transportation and utilization of industrial inputs, construction of different roads, construction of water supply and sanitation system, transportation of raw materials, and installation of power supply system. It was predicted to have severe intensity and high significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE; 1997; United Nations, 1994; Zeleke, 2000; Bewket, 2003 ).

**D. Cutting of trees:** This was identified as one of the adverse key environmental impacts associated with clearing

 

of the site, establishment of site offices, excavation, production and transportation of red ash (scoria), installment of piped sewer line, and installation of power supply system. It was predicted to have severe intensity and high significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws. (FDRE; 1997; United Nations, 1992b; United Nations, 1994; Zeleke, 2000; Bewket, 2003 )

**E. Degradation of soil resources:** This was identified as one of the adverse key environmental impacts associated with clearing of the site, establishment of site offices, excavation, production and transportation of red ash (scoria), transportation of excavated soil, transportation and utilization of industrial inputs, and construction of different buildings. It was predicted to have severe intensity and high significance. Urban Planning proclamation (Proclamation No 574/2008) of Ethiopia states that it is necessary to regulate the carrying out of development undertakings in urban centers, contemplated both by public and private actors so that they will not be detrimental to the general well being of the community as well as the protection of the natural environment (FDRE, 2008; Damtie, 2010). Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE; 1997; United Nations, 1992b; United Nations, 1994;FDRE, 2008; Damtie, 2010).

**F. Health risk to humans and animals:** This was identified as one of the adverse key environmental impacts associated with excavation. It was predicted to have severe intensity and high significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (UNESCO,1972; United Nations, 1992a; United Nations, 1992b; United Nations, 1994; FDRE, 1997; Linz & Semykina, 2012).

**G. Landslide:** This was identified as one of the adverse key environmental impacts associated with Production and transportation of red ash (scoria). It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (UNESCO, 1972; FDRE, 1997; FDRE, 2008).

**H. Spread of malaria:** This was identified as one of the adverse key environmental impacts associated with Production and transportation of red ash (scoria). It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; FDRE, 2007a; FDRE, 2008; United Nations, 1994).

**I. Fuel gas emission:** This was identified as one of the adverse key environmental impacts associated with production and transportation of red ash (scoria), transportation of excavated soil, transportation and utilization of industrial inputs, construction of different roads, construction of water supply and sanitation system, and transportation of raw materials. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; FDRE, 2008; United Nations, 1992a; United Nations, 1992b; United Nations, 1994).

**J. Noise pollution:** This was identified as one of the adverse key environmental impacts associated with production and transportation of red ash (scoria), transportation of excavated soil, transportation and utilization of industrial inputs, construction of different buildings, and construction of different roads. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (UNESCO, 1972; FDRE, 1997; FDRE, 2002b; FDRE, 2008).

**K. Dust pollution:** This was identified as one of the adverse key environmental impacts associated with transportation and utilization of industrial inputs, construction of different buildings, and construction of different roads, construction of water supply and sanitation system, and transportation of raw materials. It was predicted to have severe intensity and high significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; FDRE, 2008; United Nations, 1992a; United Nations, 1992b; United Nations, 1994; Lantz et al. 2013; Wu et al., 2013).

**L. Soil and water (ground and surface water) pollution:** This was identified as one of the adverse key environmental impacts associated with transportation and utilization of industrial inputs, construction of different buildings, and transportation of raw materials. It was predicted to have moderate intensity and medium significance. Environmental Pollution Control (Proclamation No. 300/2002) of Ethiopia primarily aims to ensure the right of citizens to a healthy environment and to impose obligations to protect the environment of the country (FDRE, 2002b). The law addresses the management of hazardous waste; establishment of environmental quality standards for air, water and soil; and monitoring of pollution **(**Unifruit Ethiopia, 2011**).** Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; United Nations, 1989; United Nations,

 

2001; UNEP, 2001; FDRE, 2002b; FDRE, 2007a; FDRE, 2008; United Nations, 1992a; United Nations, 1992b ; Unifruit Ethiopia, 2011).

**M. Risk/injury to workers:** This was identified as one of the adverse key environmental impacts associated with construction of different buildings. It was predicted to have moderate intensity and medium significance. Labor Proclamation (Proclamations No. 42/1993) stipulates that an employer shall take the necessary measures to safeguard adequately the health and safety of the workers (FDRE, 1993; Unifruit Ethiopia, 2011). Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws. (FDRE, 1993; FDRE, 1997; Linz & Semykina, 2012).

**N. Soil compaction:** This was identified as one of the adverse key environmental impacts associated with construction of different roads. It was predicted to have severe intensity and high significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; FDRE, 2008).

**O. Spilling of grease:** This was identified as one of the adverse key environmental impacts associated with transportation of raw materials. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; United Nations, 1989; FDRE, 2008; United Nations, 1992a; United Nations, 1992b; Unifruit Ethiopia, 2011).

**2. Adverse environmental impacts during operation phase**

The evaluated adverse environmental impacts were: air pollution, surface and ground water pollution, mosquito breeding and hazardous environment for children, fuel gas emission, dust pollution, noise pollution, traffic congestion in pick time, liquid waste, Increased urban heat island, and increased number of population. The impact evaluation of each variable under the operation phase is presented hereunder.

**A. Air Pollution**: This was identified as one of the adverse key environmental impacts associated with collection and disposal of solid and liquid wastes. It was predicted to have moderate intensity and medium significance. Environmental Pollution Control (Proclamation No. 300/2002) of Ethiopia primarily aims to ensure the right of citizens to a healthy environment and to impose obligations to protect the environment of the country. The law addresses the management of hazardous waste; establishment of environmental quality standards for air, water and soil; and monitoring of pollution (FDRE, 2002b; Unifruit Ethiopia, 2011). Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; United Nations, 1989; United Nations, 1992a; United Nations, 1992b; United Nations, 1994; United Nations, 2001; UNEP, 2001; FDRE, 2002b; FDRE, 2008; Unifruit Ethiopia, 2011).

**B. Surface and ground water pollution**: This was identified as one of the adverse key environmental impacts associated with collection and disposal of solid and liquid wastes transportation and utilization of industrial inputs, construction of different buildings, and transportation of raw materials (Desta et al., 2014; Regassa et al., 2011). It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws.

**C. Mosquito breeding:** This was identified as one of the adverse key environmental impacts associated with water harvesting. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; FDRE, 2007a; FDRE, 2008 United Nations, 1994).

**D. Hazardous environment for children:** This was identified as one of the adverse key environmental impacts associated with water harvesting. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (UNESCO, 1972; African Union Commission, 1991; United Nations, 1992a; United Nations, 1992b; FDRE, 1997; FDRE, 2003; FDRE, 2008).

**E. Fuel gas emission:** This was identified as one of the adverse key environmental impacts associated with use of road. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws.

**F. Dust Pollution:** This was identified as one of the adverse key environmental impacts associated with use of road. It was predicted to have severe intensity and high significance.

Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws.

**G. Noise Pollution:** This was identified as one of the adverse key environmental impacts associated with use of road. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were

 

proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws.

**H. Traffic Congestion (Pick Time):** This was identified as one of the adverse key environmental impacts associated with use of road. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; United Nations, 1992a; United Nations, 1992b; FDRE, 2008).

**I. Liquid Waste:** This was identified as one of the adverse key environmental impacts associated with use of water and sanitation facilities. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; United Nations, 1989; United Nations, 1992a; United Nations, 1992b; FDRE, 2003; FAO & UNEP, 2005; FDRE, 2007a; FDRE, 2008).

**J. Urban Heat Island Effect:** This was identified as one of the adverse key environmental impacts associated with existence of built-up environment and population growth. It was predicted to have moderate intensity and medium significance. Proclamation for forest development, conservation and utilization (Proclamation No 542/2007) states that forests should be developed, conserved, and utilized wisely (FDRE, 2007b). Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; United Nations, 1989; United Nations, 1992a; United Nations, 1992b; United Nations, 1994; FDRE, 2007b; FDRE, 2008; Colombo & Byer, 2012; Chen et al., 2013; Demuzere et al., 2014).

**K. Increased Number of human Population:** This was identified as one of the adverse key environmental impacts associated with existence of built-up environment and population growth. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws(FDRE, 1997; United Nations, 1992a; United Nations, 1992b; United Nations, 1994; FDRE, 2008).

**3. Possible adverse environmental impacts during closing and decommissioning phase**

The evaluated adverse environmental impacts were: solid waste, liquid waste, and degradation of land resources. The impact evaluation of each variable under the closing and decommissioning phase is presented hereunder.

**A. Solid waste:** This was identified as one of the adverse key environmental impacts associated with demolition works, and dismantling of equipment and fixtures. It was predicted to have moderate intensity and medium significance. Solid waste management (Proclamation No. 513/2007) of Ethiopia states that any person shall collect waste in an especially designated place and in a manner, which does not affect the health of the society; and no person shall dispose solid, liquid or any other waste in a manner which contaminate the environment or affects the health of the society (FDRE, 2007a; Unifruit Ethiopia, 2011). Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; FDRE, 2007a; Unifruit Ethiopia, 2011; Regassa et al., 2011; Desta et al., 2014).

**B. Liquid waste:** This was identified as one of the adverse key environmental impacts associated with demolition works, and dismantling of equipment and fixtures. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE, 1997; (FDRE, 2003; FDRE, 2007a; FDRE, 2008).

**C. Degradation of land resources:** This was identified as one of the adverse key environmental impacts associated with dismantling of equipment and fixtures. It was predicted to have moderate intensity and medium significance. Appropriate mitigation measures were proposed based on the environmental policy, regulations, and proclamations of Ethiopia, and ratified international environmental conventions and laws (FDRE; 1997; EPA, 2003; United Nations, 1992a; United Nations, 1992b; United Nations; 1994; Zeleke, 2000; Bewket, 2003).

## Conclusion

The broad objective of the environmental impact assessment was to identify potential environmental impacts of the housing project and formulate recommendations to ensure that the proposed development takes into consideration appropriate measures to mitigate/minimize any adverse environmental impacts through all phases of its implementation.

In the process of predicting the level of impact that an activity may cause, the authors considered key elements like spatial scale (local or regional or national), duration (short term, medium term and long term); Intensity (low, moderate, sever), probability (the likelihood that an activity will occur or will not occur) direction (positive or negative), significance (low, medium, high), and reversibility (reversible or irreversible). Accordingly, the authors predicted the identified impacts across three phases of the project-Construction, operation, and closing and

 

decommissioning.

The impact significance criteria considered in the evaluation process were: ecological importance, social importance, and environmental standards and regulations of the predicted impacts. The impact evaluation methods employed were: comparison of likely impacts against legal requirements and standards (eg. Air and water quality standards, building regulations), and Scoring and weighting system.

The evaluated negative impacts under the construction phase were: land use change, evection of indigenous farmers, soil erosion, cutting of trees, degradation of soil resources, health risk to humans and animals, landslide, spread of malaria, fuel gas emission, noise pollution, dust pollution, soil and water pollution, risk/injury to workers, soil compaction, and spilling of grease. The evaluated negative impacts under the operation phase were: air pollution, surface and ground water pollution, mosquito breeding and hazardous environment for children, fuel gas emission, dust pollution, noise pollution, traffic congestion in pick time, liquid waste, Increased urban heat island, and increased number of population. The evaluated negative impacts under closing and decommissioning phase were: solid waste, liquid waste, and degradation of land resources.

In conclusion, the identified, predicted, and evaluated negative environmental impacts and their proposed mitigation measures for each project action under each phase of the evaluated housing project entail the quest for mainstreaming environmental impact assessment in housing development projects in Addis Ababa and Ethiopia in the years to come.

**Recommendations**

The project actions, potential negative impacts and proposed mitigation measures recommended under the phases of construction, operation and decommissioning of the Koye-feche housing project are presented hereunder.

**1. Construction phase**

The following mitigation measures are proposed to reduce negative environmental impacts of the project during the construction phase:

- Green landscape and urban agriculture should be developed according to the standard to reduce the negative impacts of land use change;
- Appropriate compensation, creation of livelihood options, and provision of entrepreneurship training are recommended to rehabilitate the evicted indigenous farmers;
- Appropriate dump site for the cleared soil, Safe use of machineries, and conservation of trees are recommended to reduce the negative impacts related to site clearance;
- Prevention of spillover effect of oil and constructing impermeable layer for sanitation are recommended to prevent water pollution and soil degradation;
- Provision of temporary protection structure and appropriate transportation and dumping of excavated soil are recommended to reduce health risks to humans and animals due to in inappropriate excavation;
- Following the natural slope during excavation, conservation of trees, provision of drainage for the water to prevent spread of malaria, fencing, avoiding outdated machines, and limiting working hours at the working time are recommended to reduce negative environmental impacts related to Production and transportation of red ash;
- Sprinkling of water and covering construction materials while transporting , avoiding outdated machinery and limiting working hours at the working time, Safe use of machineries and appropriate use of burned oil for construction purpose, and appropriate storage and dumping are recommended to reduce negative environmental impacts related to transportation and utilization of industrial inputs and raw materials;
- Following construction safety rules, sprinkling of water, and use of appropriate cements were recommended to reduce negative environmental impacts related to Construction of different buildings;
- Provision of appropriate slope and plantation of trees, and opening water ways are recommended to reduce negative environmental impacts related to landscape work; and
- Filling of the excavated areas, avoiding leakage from sanitation, providing drinking water at higher slope as compared to the sanitation line, avoiding outdated machineries, and sealing openings to avoid leakage of sanitation gases were recommended to reduce negative environmental impacts related to construction of water supply and sanitation system.

**2. Operation phase**

The following mitigation measures are proposed to reduce negative environmental impacts of the project during the operation phase:

- Separation of waste before disposal, anaerobic disposal, appropriate disposal (reduce, reuse and recycle) are recommended to reduce the negative environmental impacts of air pollution;
- Avoiding leakage from the piped sewer line is recommended to reduce negative environmental impact related to surface and ground water pollution;
- Covering open water and fencing are recommended to avoid breeding sites for mosquito and reduce risks

 

to children;

- Provision of mass transportation , Provision of speed breaker, and provision of green buffer are recommended to reduce negative environmental impacts related to environmental pollutions related to use of road s;
- Proper periodic follow- up and maintenance are recommended for water loss and wastage associated with Use of water facilities; and
- Provision of parking spaces and access streets with permeable natural material, provision of green parking areas, building orientation along prevailing wind direction, and use of sustainable energy sources are recommended for urban heat island effect associated with use of built-up environment.

**3. Decommissioning Phase**

The following mitigation measures are proposed to reduce negative environmental impacts of the project during the decommissioning phase:

- Appropriate disposal is recommended for solid and liquid wastes resulting from demolition works; and
- Reuse, recycle and appropriate disposal are recommended for construction debris resulting from dismantling of equipments and fixtures.

**Competing interests**

The authors fully declare that they have no any competing interests in publishing the manuscript.

**Authors' contributions**

Arega Degife, Fikirte Demissie, Gemechu Shale Ogato, Kalkidan Asnake, Mare Addis Desta , Sileshi Azagew Mengesha, Meskerem Zewdie, and Haddis Rebbi actively participated in the project proposal development, data collection, and data analysis. Writing had been substantially contributed by Arega Degife, Fikirte Demissie, Gemechu Shale Ogato, Kalkidan Asnake, Mare Addis Desta , and Sileshi Azagew Mengesha. Meskerem Zewdie, and Haddis Rebbi had been involved in critically advising, revising the manuscript and made possible suggestions. All authors read and approved the final manuscript.

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**Acknowledgements**

We would like to thank Hailu Worku (Associate Professor, Ethiopian Institute of Architecture, Building Construction and City Development (EiABC), Addis Ababa University) who was a supervisor for a seminar paper written as a partial fulfillment of the requirements for PhD in Environmental Planning at Ethiopian Institute of Architecture, Building Constriction and City Development (EiABC), Addis Ababa University, Ethiopia. Our sincere thanks also go to administration offices of district 09 of Akaki kality sub city and the sub city, Addis Ababa Housing Agency, and local community members in Koye-Feche area for their endless support in providing primary and secondary data on the issue under investigation.

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