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Environmental and Health Impacts of Effluents from Textile Industries in Ethiopia: The Case of Gelan and Dukem, Oromia Regional State

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Abstract

This study focuses on four textile industries (DH-GEDA, NOYA, ALMAHDI and ALSAR) established between 2005 and 2008 in the peri-urban areas of Dukem and Gelan. The objectives of the study were to generate baseline information regarding the concentration levels of selected pollutants and to analyze their effects on biophysical environments. This study also attempts to explore the level of exposure humans and livestock have to polluted effluents and the effects thereof. The findings of this study are based on data empirically collected from two sources: laboratory analysis of sample effluents from the four selected textile plants and quantitative as well as qualitative socio-economic data collection. As part of the latter, a household survey and Focus Group Discussions (FGDs) with elderly and other focal persons were employed in the towns of Dukem and Gelan. The results of the study show that large concentrations of BOD_5, COD, TSS and pH were found in in all the observed textile industries, at levels beyond the permissible discharge limit set by the national EPA. Furthermore, $S_{2,}$ R-PO_4^3 and Zn were found in large concentrations in DH-GEDA and ALMHADI, while high concentrations was also identified in samples taken from ALSAR and ALMHADI. In spite of the clear-cut legal tools, this study shows that the local environment, people, and their livestock are exposed to highly contaminated effluents. We therefore recommend that the respective federal and regional government bodies should re-examine the compliance to and actual implementation of the existing legal procedures and regulations, and respond appropriately.

Keywords: Pollution assessment; Environmental quality; Human health; Water pollution; Textile effluent.

Introduction

Industries are often considered as an '*engine*' of economic growth (Azadi et al. 2011; Siyanbola et al. 2011) by which many countries promote their rapid economic growth. The textile industry is one of the most important sub-sectors of the manufacturing industry that contributes or contributed to the transformation of economies in countries such as China, Bangladesh, India, Vietnam, Turkey, and Nigeria (Islam et al. 2011; UNIDO 2012; Tran 2013; Singh et al. 2013). In Bangladesh, e.g., the textile and garment sector contributes to about 77% of the country's foreign earnings and employs 50% of the industrial work force (Islam et al. 2011).

Albeit, studies have shown that textile industries also have strong negative environmental impacts, often associated with water pollution (Sponza 2002; Islam et al. 2011; Siyanbola et al. 2011; Khan and Malik 2014; *www.oecotextile.com* (21/7/2014)). In most textile industries operating in developing or transition countries, wastewater treatment is nonexistent, nonfunctional, or inefficient, leading to massive environmental pollution and health problems (Pamo 2004; Islam et al. 2011; Siyanbola et al. 2011; Paul et al. 2012).

Textile industries consume large volumes of water and chemicals at different stages of the wet processing phases. According to Khan and Malik (2014), one textile plant can use as many as 2000 different chemicals, from dyes to transfer agents. It can also use close to 2270 liters of water in order to complete the production of less than 10 meters of fabrics (Islam et al. 2011). Huge amounts of water are needed for bleaching, dyeing, and for conveying chemicals used in the dying process, as well as for cleaning the machines after each textile production phase. According to Govindarajalu (2003), the water consumption of an average-sized textile mill (with a production of around 8,000 kg of fabric per day) is about 1.6 million liters per day. This kind of textile plant can also generate up to 200-350 m^3 of effluents per ton of finished products (Ranganathan et al. 2007; Gozálvez-Zafrilla et al. 2008), resulting in an average pollution of 100 kg chemical oxygen demand (COD) per ton of fabric (Jekel 1997). The same studies have also revealed the presence of high amounts of pollutants in textile industry wastewater. For instance, the effluents from the dye bath had contained COD of 5000–6000 mg/l, 52,000mg/l of total dissolved solids (TDS), 2,000 mg/l of Suspended Solids (SS), and pH 9 (Verma et al. 2012; Khan and Malik A2014).

Many studies have also revealed the negative impacts of such pollution. Mark (2004), Kumer et al. (2012), and Manunatha (2008), for example, have shown that industrial effluents polluting the soil can affect plant growth, including agricultural crops and, apparently, affect the livelihood of farmers in the area. On the other hand, Kovaipunder (2003) studied the effects of water pollution on the health status of the people using polluted water, using the Noyyal River as a case study in three districts in Southern India. In this context, Kovaipunder proved that health problems such as skin allergy, respiratory infections, general allergies, gastritis, and ulcers are prevalent in all of the 31 sampled villages.

Khan and Malik (2014) also conducted a study on the environmental and health effects of textile effluents in India. They showed that untreated or insufficiently treated textile effluents contain chemicals that can pollute the air people breath, causing respiratory health problems. In this study, Khan and Malik also discovered that effluents with high concentrations of chemical pollutants affect normal functions of human cells, especially in the case of fetuses, infants, and children. According to the findings of Khan and Malik, some textile pollutants in higher concentrations can alter the physiology and biochemical mechanisms of humans, resulting in the impairment of the physiological functions such as Osmoregulation, reproduction, and can sometimes cause death. For instance, heavy metals present in textile effluents can easily accumulate in primary organs (i.e. heavy metals are not biodegradable) and can therefore cause cancer (Khan and Malik 2014), one of the main reasons for shorter life expectancy in many countries (WHO 2003). Beyond these health effects, effluents from textile industries can directly affect the income of farmers by reducing production and indirectly through higher medical expenses and reduced agricultural labor forces.

Effluents with concentrations above the legally permissible limits (e.g., table 1) are likely to degrade and destroy local environments directly and indirectly by affecting the physical and biological environment, such as land, water, and living organisms and human beings. For instance, high concentrations Biological Oxygen Demand (BOD_5) increase the demands of Dissolved Oxygen (DO) by decomposers, leading to the depletion of the Oxygen (O_2) required by other aquatic organisms to survive. From the perspective of human health, some pollutants suppress the immune system, which may have major - even deadly – health effects. This paper focuses on the negative impacts pollutants have on the natural environment (as well as their effect on aquatic life and DO concentration) and its implication on human health and livestock.

Ethiopia is an overwhelmingly agrarian economy. The agricultural sector absorbs around 85% of the labor force and adds more than 40% to the national GDP (MoFED 2014). While the industry sector only contributed 10% to the GDP in 2008/09 and 12% of the GDP in 2013, it’s role remaining very small. In 2011/12, the industry sector employed less than 5% of the labor force (MoFED 2013; GTP 2013) and since 1990s, the Government of Ethiopia has taken a number of steps in an effort to industrialize the economy and to promote industrial development. In general, the government has given specially emphasized manufacturing industries and textile industries in particular with the goal of utilizing natural resources and providing employment opportunities (IDS 2002; MoFED 2013).

In the Ethiopian Constitution, Article 44 grants all citizens the right to live in a clean and healthy environment. Furthermore, *Proclamation No*. 300/2002, article 3 (1), stipulates that, “No person shall pollute or cause any other person to pollute the environment by violating the relevant environmental standard”. Article 3 (2) of the same proclamation further states that the relevant authority or the relevant regional environmental agency may take administrative or legal measures against a person who, in violation of law, releases any pollutant into the environment.

The towns of Dukem and Gelan in central Ethiopia were selected in 2004 in order to establish Industrial Development Centers (IDCs). So doing was part of the Ethiopian government’s strategy to accelerate economic growth by establishing industrial development corridors in the selected town’s four regions, namely Oromia, Amhara, Tigray, and the Southern Nations, Nationalities, Peoples and Regions (SNNPR), as well as in Addis Ababa and Dire Dawa since 2004. Thus, the selected IDCs, the federal government, or private companies in collaboration with the federal government, were enabled to establish Industrial Zones (IZs) that specialize in the manufacture of specific products in factories or industries set up in a single premise (e.g., IZs for leather and leather products). The towns of Dukem and Gelan are located close to Addis Ababa, near the country’s single railway line and major highway that connects Addis Ababa to Djibouti port. Both towns possess “sufficient converted agricultural land” for investment, cheap labor, and sufficient underground water reserves. The area around Dukem and Gelan have relatively low slopes - between 5% and 10% (OWWDSE 2011), making land preparation and construction more cost effective than in other IZs in Ethiopia.

In order to attract investments from the domestic and international private sector, the Ethiopian government offered investment incentives such as income tax exemption, customs duties for machinery, capital goods, construction materials and vehicles, as well as access to bank credit and loss carryforward in cases where it is needed (Regulation no. 270/2012). Attracted by these monetary and non-monetary incentives, large numbers of investors (mostly domestic) were licensed shortly after the establishment of IDCs in 2005. Our data obtained from the investment offices in Dukem and Gelan shows that between 2005 and 2013 more than 460 projects of all investment types in Dukem and 300 projects in Gelan were approved. Of these, 257 projects in Dukem and 279 projects in Gelan belong to the manufacturing sector: 23 textile and garment industries were licensed in Gelan town as were between 12 and 20 in Dukem town.

Generally, most of the licensed investment projects in the manufacturing sector were textile and apparel, agro-processing, food and beverage, still and metal industries, and non-metallic construction material industries. One of the pharmaceutical industries (Kadila Plc.) was also established in Gelan town. Field observations showed that, apparently, some of the operating factories have been discharging effluents directly into the drainage channels and the nearby streams, which likely has an impact on the quality of surface water, the environment and on the health of both humans and livestock. In addition to this, it was evident that effluents have significantly eroded the aesthetic value of the landscapes in these areas.

This study focuses on four textile industries (DH-GEDA, NOYA, ALMAHDI and ALSAR) established between 2005 and 2008 in the peri-urban areas of Dukem and Gelan. Three of them are established and owned by foreign investors from China and Pakistan; one (DH-GEDA) is owned by an Ethiopian company. With this as a backdrop, this case study focuses on the following objectives: understanding the concentration levels of selected pollutants from textile industries and analyzing their effects on biophysical environments. This study also tries to explore the level of exposure humans and livestock have to polluted effluents and their effects.

1 Methods and Materials

1.1 The study sites

The four case study textile industries, DH-GEDA, NOYA, ALMAHDI and ALSAR, are located in the towns of Gelan and Dukem, part of *Finfine* Special Zone (FSZ), Oromia Regional State, 27 and 35 km respectively south of Addis Ababa. NOYA and DH-GEDA are located between 8^{o}48'0''N - 8^{o}51'0''N latitude and 38^{o}49'30''E - 38^{o}52'30''E longitude in Gelan; and ALSAR and ALMAHDI are located in Dukem town between 8^{o}45'0''N - 8^{o}48'0''N latitude and 38^{o}52'30''E- 38^{o} 55'30''E longitude (see Fig. 1).

[insert Fig. 1]

Except for DH-GEDA, with close to 150 employees, the other three textile industries had a total of between 450 and 500 employees by the end of 2013. As defined by the Central Statistical Agency of Ethiopia (CSA, 2016), all four-textile plants are categorized as medium and large-scale industries from this point (MLSI). All four factories primarily dye and bleach fibers (polyester and acrylic yarn) as a raw material.

1.2 Data sources

The findings of this study are based on data empirically collected from two sources: laboratory analysis of sample effluents from the four selected textile plants and quantitative as well as qualitative socio-economic data collection. During the 1950s, in the early days of modern water and wastewater quality monitoring, particular issues were rarely focused on. However, the water and wastewater quality assessment process has now evolved into a set of sophisticated monitoring activities that include the use of water chemistry, particulate material, and aquatic biota (e.g. Hirsch et al., 1988). Many manuals on water and wastewater quality monitoring methods already exist (e.g. Alabaster, 1977; UNESCO/WHO, 1978; Krenkel and Novotny, 1980; Sanders et al., 1983; Barcelona et al., 1985; WMO, 1988; WHO, 1992). Standard Methods for examining water and wastewater represent the best current practices of water analysis. This comprehensive reference covers all aspects of water and wastewater analysis techniques. In this study, the laboratory test methods and procedures applied in order to determine the parameters were based on the standard methods outlined and recommended by APHA (1999) and WHO/UNEP (1996). As part of the latter, a household survey and Focus Group Discussions (FGDs) with elderly and other focal individuals were employed in Dukem and Gelan and the results from the different sources were triangulated. The procedures that were followed during the data collection are presented below.

1.3 Physical sample collection for laboratory test

1.3.1 Preparation for field sample collection (Phase I)

In Phase I, the sample sites were identified and all necessary preparations required for the sample collection were arranged in close consultation with the laboratory of the Environmental Protection Authority (EPA) in Addis Ababa. In the process of characterizing effluents from industries and on matters related to determining the quality of water, it was essential to work in close consultation with the EPA laboratory expertise in order to ensure the quality standards of the sample collection and the use of the analytical methods (see also APHA 1999). At the beginning of the fieldwork, we identified effluent discharge points for all industries and recorded their coordinates using Global Positioning System (GPS) devices. Furthermore, all required tools used to collect, preserve, and transport the samples were sorted, cleaned, and disinfected at the laboratory station. An icebox was prepared to transport the samples at a temperature of 4^0C to the laboratory in Addis Ababa within less than eight hours after the sample collection. Codes, names and source of the samples were indicated on polyethylene can in order to guarantee traceability.

1.3.2 Field work (Phase II)

In Phase II (in June 2013), the actual samples were collected in the field, using grab and composite methods. The grab method was utilized in order to take in-situ measurements of some parameters that otherwise would change their characteristics. A total of 200ml was taken from effluent discharge points and measurements for pH, EC, TDS and temperature were recorded using HANAN Instrument Model HI 98129.HI98130. In determining these parameters, appropriate calibrations and adjustments to all parameters were made at each stage before taking measurements. The Color and Turbidity level of the samples was determined with a Photometer 8000 (Palintest 8000 models). The next step was the collection of samples for laboratory tests. This was done using the composite method from which 250ml samples were collected five times at half an hour intervals. The samples were then mixed and put into one-liter airtight polyethylene cans (GEMS/WATER Operational Guide-3rd edition, 1992) that were stored in an icebox at a temperature of 4^0C and transported to the EPA laboratory in Addis Ababa for physico-chemical and microbial analysis.

1.3.3 Laboratory Analysis of the samples (Phase III)

Phase III included entirely laboratory-based activities for the determination of physical and biological parameters for all the samples. The laboratory test methods and procedures were applied in order to determine the parameters based on the standard methods outlined and recommended by APHA (1999) and WHO/UNEP (1996). Moreover, the Standard Analytical Procedure for water analysis developed jointly by governments of India and the Netherlands in 1999 was applied. In the laboratory, the samples were pre-arranged and then sent for physico-chemical and microbiological analysis of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD_5), Sulfide (S_2), Sulfate (SO_4^2), Total Nitrogen (T-N), Nitrate (NO_3), Nitrite (NO_2), Total Ammonia (T-NH3), R-Phosphate (R-PO4)3, Magnesium (Mg) and Zinc (Zn) as well as for biological determination (Total Coli form and Fecal Coli form). In the microbiology lab, the Fecal Coli form (F. Coli) was determined by applying the membrane filter procedure with Laurel sulfate broth. The F. Coli counts were measured by filtering effluent samples with a special filter paper with a pore size of 0.45µm and 47mm diameter. This filter paper allowd for the retention of all F. Coli bacteria on it, which was later placed on an absorbent pad (47mm diameter) saturated with a F. Coli of medium growth and incubated at 44^0C for 24 hours. After incubation, the yellow colonies were counted, recording the number of counts per 100ml.

1.4 Qualitative, quantitative data collection and Focus Group Discussion

Before initiating the household (HH) survey, Kothari's (2004) (Equation 1), simplified formula was used to determine the optimum and representative sample sizes required for the survey. Of the total seven *kebeles* in Gelan and Dukem, five *kebeles* (all the three of which were in Dukem with two out of four in Gelan)[1] were selected based on the presence of a large numbers of investments in the manufacturing industry in general and of textile industries that discharge liquid effluents in particular. A Kebeles is the smallest administrative unit of local government in Ethiopia, similar to a ward, a neighborhood or a localized and delimited group of people. Each Kebele consists of at least five hundred families, or the equivalent of 3,500 to 4,000 individuals. Out of 821 HHs living in the five selected *kebeles*, *Gelan K*, *Tulu Guracha, Gogecha, Koticha and Xadacha,* 262 HHs were distributed proportionally to each *kebele,* which were interviewed using systematic random sampling (SRS) methods. -Kanupriya (2013) suggests the use of SRS when the study population is small and homogenous. In order to obtain complementary qualitative information, two Focus Group Discussions (FGDs) were conducted with 12 elderly participants (6 each in Gelan and Dukem, Fig 2).

$$n = \frac{z^2 .\ \sigma_p^2 .N}{(N\text{-}1)e^2 + z^2 .\ \sigma_p^2} \qquad \text{Equation}$$

Where:

n = size of sample

N = size of population

e = acceptable error (the precision)

σ_p = standard deviation of population

z = standard variate at a given confidence level."

In this formula, the following assumptions were made: the size of population is 821, standard error (acceptable error) is 0.05, standard deviation of population is 0.5 and values of standard variant at 95% confidence interval (Z) is 1.96. Thus, actual sample size was calculated as follows:

$$n = \frac{(1.96)^2 .(0.5)^2 .821}{(821-1)(0.05)^2 + (1.96)^2 .\ (0.5)^2} = 261.92 \sim 262$$

Accordingly, 262 sample respondents were fixed for household surveys.

[1] Cafe Tumaa and Moreno *kebeles* without investment activities were not considered in this study.

[insert Fig. 2]

The FGD participants were selected based on the number of years lived in the *kebele*, and their role within their respective *kebeles*. Additionally, expert interviews with textile factory managers and technicians, veterinarians, and experts in the environmental protection units at levels of urban administration in the study towns were conducted.

2 Results

2.1 Physico-Chemical properties of the effluents

Table 1 presents a list of the parameters for the physico-chemical and bacteriological characteristics of textile effluents in Gelan and Dukem. Those parameters whose values exceed the permissible limits of discharge into the inland surface water sources as outlined in the EPA guidelines are highlighted in yellow. Accordingly, of the total 16 observed parameters in the samples from all investigated industries, three parameters (COD, BOD_5 and TSS) were found to be higher than the permissible discharge limit. Conversely, a high level of T. coli was recorded in effluents from ALSAR & ALMHADI while S_2 was observed in effluents from DH-GEDA.

[Insert Table 1]

2.2 Comparisons of the concentration level of selected pollutants among the industries

This section graphically presents the actual measured values of selected pollutants in all four observed textile industries. It aims to enhance the (visual) understanding of the concentration levels of pollutants against the limits[2] allowed by the EPA guideline. Graphs also show the differences between our measured values (the straight black lines in the figures) and the tolerable concentrations for discharge into inland water sources, as permitted in the EPA guideline (the broken blue lines).

i. Pollutants observed in high concentration in all selected industries

The Biological Oxygen Demands (BOD_5), Chemical Oxygen Demands (COD) and Total Suspended Solids (TSS) were found in high concentration in samples from all four of the selected industries (see Table 1). Analyzing the concentration level of BOD_5 is vital, as BOD_5 is one of the most important

[2] The maximum limit of discharge varies from one pollutant to the other one as it was stated in the EPA guideline (e.g., EPA Standard indicated in the last column of table 1).

indicators of water quality (WHO, 2008). Figure 3 shows that the concentration level of BOD_5 in all of the samples taken from the four textile industries in Gelan and Dukem are above the permitted concentration limit of this pollutant into the inland water sources (broken horizontal line).

[insert Fig. 3]

The highest concentration of BOD_5 was observed in effluents from ALMHAD (252mg/l), followed by DH-GEDA (139mg/l). The values of BOD_5 in effluents from NOYA (91.50 mg/l) and ALSAR (84.00 mg/l) were also higher than the concentration allowed by the EPA (Figure 3; Table 1: *footnote 1*). Another pollutant found in high concentrations was Chemical Oxygen Demand (COD). The COD content of the effluents from our case study strongly varies among the effluents from the sample industries. The lines in Figure 4 show that the lowest (130.28mg/l) and the highest values (733.5mg/l) were measured in DH-GEDA and NOYA respectively. In Dukem, the concentrations strongly vary between effluents from ALSAR (130.28mg/l) and ALMHADI (470mg/l). The COD level in effluents from NOYA and ALMHADI are nearly 5 and 3 times, respectively, higher than the concentration levels tolerated by the EPA. A study by Jekel (1997) shows an average pollution of 100 kg COD is the result of one ton of finished products of fabric. Accordingly, the higher COD level in effluents from NOYA and ALMHADI may be due to more tons finished products. Also, the low quality of effluent treatment techniques used in NOYA and ALMHADI could also result in inefficient removal of pollutants below the level expected. Furthermore, the type and quality of chemicals used in the COD treatment plant would also affect the efficiency of pollutant removal (Magarde et al. 2009).

[insert Fig. 4]

Another important parameter used to determine the pollution levels of effluents from the sample textile industries, is the concentration level of Total Suspended Solids (TSS). Textile industries uses organic and/or synthetic fibers as a raw material, which end up as part of the release of suspended solids in the wastewater.

[insert Fig. 5]

Figure 5 also shows that another pollutant, TSS, was found in the samples with a high concentration level. The highest concentration was found in effluents from NOYA (368mg/l), followed by ALMHADI (146mg/l), ALSAR (114mg/l), and DH-GEDA (46.5mg/l). The measured TSS values from NOYA, ALMHADI, and ALSAR are 12, 5, and 4 times, respectively, higher than the limit of 30mg/l allowed by the EPA. One implication high TSS concentrations have on the environmental is that it blocks sunlight from pervading the water, which negatively affects photosynthetic plants and hampers the oxygen production in the water (Prabu et al. 2008). Furthermore, in a study by Bukhari (2008), raw municipal wastewater was electro-coagulated in order to remove TSS using stainless steel electrodes. The result showed that the efficiency of TSS removal depends on the amount of iron generated from the anode of the reactive electrode. Also, according to Meybeck et al. (2003), the temporal variability of TSS decreases with an increased basin size, lake abundance, and is higher for basins influenced by glacier melt and snowmelt.

ii. Pollutants limited to certain industries

Although, Total coli form (*T. coli*) & Escherichia coli (*E. coli*) are not directly related to the textile industries, they were found in effluents from ALMHADI (820mg/l) and ALSAR (712mg/l) in higher concentrations (Figure 6). Coli forms are the most common indicators of the microbiological contamination of water used for domestic uses (WHO 2008).

The presence of all types of coli forms, especially of *E*. coli (also code-named *E*. coli 0157:H7), in water used for domestic consumption can cause health problems for humans, children in particular (WHO 2008). In spite of the potential health risk of water in streams or waterways, local people rely on the water to meet their demands, especially for sanitation and livestock.

[insert Fig. 6]

2.3 Effects of industrial effluents in the study areas

2.3.1 Aesthetic values and quality of local environment

In spite of their importance for economic growth, industrial plants are generally associated with the generation and discharge of solid or liquid wastes. The reduce, reuse and proper recycling of these wastes require adequate financial and technological resources. In this regard, most industries in Gelan and Dukem have established neither treatment plants nor adequate storage or discharge channels for their wastes. As a result, polluted liquids are directly discharged into the open landscape (Fig. 7).

[insert Fig. 7]

The volume of some discharged effluents was so high that they block local resident’s walkways. Some of them were discharged without even using decolorizes in order to remove the different dyes used during the process of dying or bleaching the fibers and/or yarns (Fig. 7: a and b) or effluents with high turbidity levels (Fig. 7: c) that were discharged from NOYA, DH-GEDA and ALMHADI textile industries respectively.

2.3.2 Impact of Effluents on People's Health

Another aspect of this study was to assess the effects of contaminated effluents from textile industries on the health of people living around the textile factories, especially those living very close to the factories and downstream along the discharge channels. According to data obtained from special reports from the Oromia Regional State, close to 84% of the total population of Oromia Regional State live in rural areas, with an average tap water supply of less than 50% (ORS 2012). Accordingly, most of the households living around the textile factories in Gelan and Dukem depend on surface water for domestic use (Fig. 8).

[insert Fig. 8]

Table 2 illustrates households' access to potable water for domestic use in the towns of Gelan and Dukem. It shows that most households have access to potable water for domestic use in both towns. Accordingly, nearly 84% and 82% of the households in Gelan and Dukem, respectively, replied that they have access to potable water. On the other hand, nearly 14% and 12% of the interviewed households in Gelan and Dukem, respectively, replied that they do not have access to potable water at all.

[Insert Table 2]

In this context, having access to potable water does not necessarily mean that these households are connected to a public water pipeline system in their compounds or at least close to their residences. Information obtained from the water and energy offices in Dukem and Gelan indicate that potable water supply coverage is less than 40% and that households obtain their water from different sources: public tap water, private houses and/or from the premises of some investors, and from open surface water sources such as streams and open channels. In some parts of Dukem and Gelan, investors have constructed ground water wells for industrial purposes, and at times, they allow residents who live close to the premise to tap these resources (Fig. 7). Yet, obtaining water from these sources is tedious and access is restricted. Wells remain closed during daytime working hours, between 8.00 am to 5:30 pm, and before and after residents have to wait in long queues to obtain a jerry cane of water every two or three days. Households who live close to the urban centers travel longer distances in order to fetch water from public taps, for which they have to pay. Others buy water from private water traders. Particularly poorer households and those who reside in areas that are rural, have to rely on surface water from nearby rivers or streams – which is often contaminated by effluents from industries, textile industries in particular.

The participants of the FGDs stated that residents who live along channels that transport textile effluents and those who live downstream are more vulnerable than those who live faraway. Thus, in the face of a very limited potable water supply and open surface discharge of industrial wastewater, the likelihood of local people being exposed to effluents would by high. With this in mind, respondents were asked if they think that any of their household members ever became sick because of the exposure to industrial effluents locally discharged into open spaces, canals or streams.

The responses of the interviewees are shown in Table 3. They indicate that the perceived nexus between health problems and the exposure to industrial effluents induced by textile industries was null in Xadacha *kebele*, in Dukem (0.0% or 'Yes' answers), and relatively high in Gelan K (9.1%), T/Guracha (12,5%), and Gogecha (14.7%) *kebeles* in Gelan. In the Koticha *kebele* in Dukem, however, 30.6% (19) of the interviewees said that at least one of their household members had become sick following exposure to industrial effluents. Unlike all other kebeles, Koticha hosts both ALMHADI and ALSAR textile industries. The incidence of health problems mostly related to skin allergies and stomach health problems.

[Insert Table 3]

One of the participants in the FGD explained the health effects of polluted water in the following way:

> *"At the very beginning no one realized that sickness such as skin disease (allergy) and other internal (stomach) health problems were related to the exposure to polluted water in the stream that we used to rely on for many years in the past. We were not given any orientation or warning against the potential health risks of polluted water. Those who walk bare foot and cross through the flow lines of effluents or polluted streams contracted skin allergy and internal disease. Besides, most of our children who look for the livestock in the open filed walk bare foot through polluted water; some of them who took bath in the polluted water contracted health problems, skin allergy in particular. As time goes on local people began distancing themselves from all the surface water except* potable *or pond water".*

2.3.3 Health effects on livestock

Livestock is a major source of income for many households in the study area and rearing livestock depends on the availability of safe drinking water. Table 4 shows the principal sources of water for livestock drinking are rivers and streams in Gelan *K* (66.2%), Gogecha (58.8%) and T/Guracha (50%) *kebeles* in Gelan. Conversely, households in Xadacha (83.3%) and Koticha (72.6%) use tap water to water their livestock.

[Insert Table 4]

In spite of these differences, livestock is set free in order to graze in the open landscape during the long dry season and on the fields after harvest. Hence, the provision of tap water does not mean that livestock is not exposed to effluents (Fig. 9). This was also witnessed in the FGDs, where particular worries were expressed about the health of children who rely on milk and milk products from their own livestock.

[insert Fig. 9]

Based on the prevailing scenarios, an assessment was made in order to understand the magnitude of livestock health problems and the accompanied effects for which the result of the household survey data was displayed in Table 5.

[Insert Table 5]

Tabel 5 shows that the magnitute of assumed effects of effluents on the health of livestock vary in each studied *kebele*, depending on its location and the level of access to the municipal water supply. The livestock of residents who live in the downstream *kebelesof* Gelan *k* and Koticha (Fig. 10) are relatively more affected than those in upstream *kebeles*, like Xadacha and Gogecha. Most residents in Gelan K, Koticha, and parts of T/Guracha *kebele* live downstream. Accordingly, 64.5%, 56.3% and 50% in Gelan K, Koticha and T/Guracha *kebeles*, respectively, reported cases of sick livestock, compared to 11.1% and 32.4% in Xadacha and Gogecha *kebeles*.

[insert Fig. 10]

In order to assess the sources of water for livestocks and the health condition of livestock at the *kebele* level, a *Chi-Suare test* was conducted and the results show that The *Pearson Chi-Square test* result shows that there is a link between the location of the study *kebeles* and the sickness of livestock: ($\chi^2 = 122.45$, df = 6, $P < 0.05$) (Table 6).

[Insert Table 6]

In order to identify the types of livestock that are more vulnerable to health problems assumed to be cuased by polluted water, respondents were asked to reflect on their past experiences. Accordingly, of the five livestock categories considered in this study (cattle, donkey, horse, sheep, and goat), cattle were identified as most vulnerable, followed by donkeies, in all the study *kebeles*. Furthermore, in an expert interview, a veterinarian expressed his view on the nexus between livestock sicknesses and effluents as follows:

> "*Generally, microorganisms, pathogens are known for causing human or livestock health problems and that some of the effluents discharged from industries hold high amounts of organic loads: textile, food and beverage, tannery, etc. The presence of high organic loads amounts to the presence of microorganisms (aerobic/anaerobic) that survive by decomposing organic loads. Therefore, the use of water infected with pathogens means high risks of contracting disease by the livestock. Based on this fact, most of the livestock that were brought to the veterinary clinics for treatment were diagnosed for bacterial infections mainly "Salmonella". Based on our recorded data, more cases were reported for cattle and donkeys than other livestocks which were in fact much less in number among the livestock types owned by most households" (Question no. 8; expert interview conducted 20.02.2014).*

The role of livestock on the livelihoods of households in the study area is immense. Therefore, their long lasting sickness or even death can easily disrupt the economic situation of a household.

2.4 Economic costs of human and livestock treatments

2.4.1 Cost of medical treatment for a family member

Another aspect of this study was to assess the economic costs of human and livestock treatments. This section shows the estimated costs that a household might pay for a medical treatment that is needed due to exposure to industrial effluents at a Kebele health post. The mean costs for a treatment for a sick individual were more or less similar in Gelan (US$ 5.9) and Dukem (US$ 4.0) in 2014 (Table 8). Based on the interviews made with drug dealers in Gelan and Dukem, the lowest costs arise when sick individuals purchase 'Paracetamol' (also called "pain-killer") in order to get relieve his/her pain or from an itching skin due to a skin allegey. In extreme cases, however, a patient may pay total costs up to US$ 11.5 (and Dukem) and US$ 15 (in Gelan) respectively (Table 7).

[Insert Table 7]

2.4.2 Economic costs of livestock treatment

In this regard, an attempt was made to collect information on the economic costs of livestock treatment in a veterinary health post. Table 8 outlines the mean costs for treatment of cattle per visit.

[Insert Table 8]

The variations in livestock treatment costs between US$ 1.8 in Gelan and US$ 1.6 in Dukem, the slight variation in the treatment cost was mainly attributed to the level of sickness and the type of veterinary health posts visited.[3] On the other hand, the loss of livestock due to health problems, which might be due to the exposure to polluted surface water, is a serious economic loss for the concerned households. Table 9 gives a summary of the average price of the livestock at local markets.

[Insert Table 9]

The mean market price of sick/affected cattle in Table 10 was calculated based on the estimated cattle price of the local markets. Respondents have estimated the price of their cattle at the local market between US$50 and US$ 600 (Table 10), based on age, size and health status of the animal. Therefore, losing cattle costs a household, on average, about 300 US$ per animal.

2.5 Community trainings and consultations

According to proclamation no. 300/2002, the environmental awareness of local communities should be raised through community training and/or consultations that would enable them to protect themselves, as well as their property, against the danger posed by toxic substances. Against this backdrop, the question was raised to the interviewees if they ever received any form of training or consultation from local or regional governments aimed in order to create awareness of how to protect their household

[3] Usually, private owned health posts are costlier than public ones. In Dukem town, most people bring their sick livestock to public health posts for which they pay less compared to Gelan where the prices are set by private clinic owners.

members and/or their livestock against effluents from the nearby industries. The findings are shown in Table 10.

[Insert Table 10]

It is evident from Table 11 that the large majority of the respondents (79.4%) did not receive any form of information, training, and/or consultation at all. In the face of widespread and uncontrolled discharge of effluents into the open environment (Fig. 2), this is an astonishingly high figure. Only 15.2% of the interviewees reported that they received information on the potential harm caused by the industrial effluents.

3 Discussion

The environmental and health related problems associated with wastewater discharged from textile industries have since long been sources of global concern. Textile effluents consisting of high concentrations of toxic chemicals and organic loads – often beyond the permissible limit - can alter the physico-chemical characteristics of humans, animals and plants, as well as whole ecosystems (Zaharia et al. 2011). Through this they produce multiple indirect economic costs, e.g. by reducing agricultural production, or by increasing the cost of drinkable water and health treatment. Of the total sixteen parameters observed in the laboratory, this study focused on and selected ones that help to determine the quality of water for different uses. The discussion involved comparing the values obtained in the laboratory and the permissible limit of discharge allowed focusing on why some of these pollutants were observed in large concentrations and the implications of polluted surface water on the health of humans and livestock.

3.1 Major pollutants and their concentration levels against the national standards

In all samples collected from the effluents of the four case study textile industries, six variables were measured much higher than the permissible limit of discharge. Three of them (BOD_5, COD and TSS) were observed in effluents from all four textile plants while the others were plant specific. In this context, Islam et al. (2011) has found BOD_5, COD, TSS and T° values of 573.89mg/l, 1223.33mg/l, 1123.11mg/l and 5022°C, respectively, from samples taken from textile industry effluents in Gazipur and Narayanganj cities in Bangladesh. Likewise, Singh et al. (2013) had conducted a study on effluents from eight textile factories Punjab in India. Their results show concentrations of BOD_5 between 156mg/l and 790mg/l.

Likewise, the measured values for COD and TSS concentration levels from the same industries range from 120mg/l to 3050mg/l and 898mg/l to 5145mg/l, respectively.

Likewise, the results of a study conducted by Siyanbola et al. (2011) on effluents from five textile industries in Nigeria shows high concentrations of BOD_5, COD, and TSS, between 340mg/l and 560mg/l for BOD_5, between 615mg/l and 1245mg/l for COD, and between 0.11mg/l and 310mg/l for COD. The measured values of temperature in wastewater discharged from textile plants in most cases falls well within the national standards of their respective countries. In our study, however, an exceptionally high temperature of 77°C was measured in effluents from the NOYA textile industry in Gelan. This is nearly double the national and international permissible limit of the maximum temperature of 40° C for discharged effluents, as well as the highest temperature measured in effluents from textile industries worldwide. Islam et al. (2011) also measured an exceptionally high temperature (i.e. slightly higher than 50°C) in effluents discharged from a textile industry in Narayanganj city in Bangladesh. A wastewater temperature of 77°C is likely to have strong negative impacts on the surrounding animals, plants, soils, and wetlands. Another important pollutant identified in the sampled effluents was T. Coli, where 820±195mg/l and 712±37.0mg/l were found in the samples taken from ALMHADI and ALSAR industries, respectively.

The main reason for the presence of these pollutants in large quantities is attributed to the fact that most textile industries use organic materials and fibers as raw materials. More importantly, the absence of effluent treatment and/or the low quality of effluent treatment techniques used (e.g., due to age or model) results in the pollutants being removed to a level below expected inefficiently. Furthermore, the type and quality of chemicals used in the effluent treatment plant would also affect the pollutant's removal efficiency (Magarde et al. 2009; Govindarajalu 2003; Khan and Malik 2013). It is important to say that all industries investigated in this study, except NOYA, have their own effluent treatment plants and yet still discharge highly polluted effluents. The measured values of the sampled effluent taken from the NOYA industry showed that 8 of the 16 parameters are much higher than the national limits. According to the technician who works on the effluent treatment plant and the manager of the company (i.e. ALMAHDI), the design of the treatment plant and the chemicals they use were not effective. In an expert interview, the ALMHADI manager indicated that they are aware of the problem, but that the more effective wastewater treatment measures are expensive and priority of their company is profit.

Unlike ALSAR, ALMHADI was able to regulate the amount of most pollutants within the intended national limit. For instance, of the 16 investigated pollutant types, the values of only 4 pollutants were seen as slightly higher than the permissible limit. The values for all of the other 8 parameters were lower than the EPA regulation (Table 1). The manager of the company ALMHADI, was already aware of the problem and was focused on an appropriate industrial waste management strategy.

3.2 The environmental implication of wastewater from textile industries

According to Kant (2012), effluents with high temperature and pH values above the tolerable limit (as proven in this study for the effluents from NOYA) could cause the extinction of important microorganisms. Likewise, the presence of high amounts of BOD_5 in wastewater has led to the depletion of DO, which is important for the survival of wetland ecosystems. The environmental implication of high BOD5 in wastewater is associated with the removal of Dissolved Oxygen (DO), which is central for aquatic ecosystems. The amount of DO available in water is directly affected by the amount of BOD5 loads in effluents. High concentrations of BOD5 could create an ideal environment for the growth of microorganisms that survive by decomposing the organic matter using DO. Thus, at higher concentrations, BOD5 remove more DO that are equally required for the survival of other aquatic life, mainly fish and other aerobic organisms that will be threatened in such circumstances (Islam et al. 2011; Prabu et al. 2008; Kovaipunder 2003). The removal of more DO affects the availability of DO required for the plant's metabolism and reproduction (Mallya, 2007). COD was another pollutant found in large concentrations in the effluents sampled from all of our four case study industries. The main problem related to high COD concentrations is that it depletes available dissolved oxygen. In this environment, anaerobic microorganisms use DO to oxidize inorganic loads in the water. Hence, sustained removal of DO has a destructive effect on aquatic biodiversity by reducing the metabolism and the water's ability to recharge water oxygen.

In this study, we also considered pH, S_2, NO_3, P-SO_4^3, and Zinc. The pH value is linked to the biological productivity of aquatic ecosystems in a way that does not deviate from the specified limit without risking damage to their productivity (Islam et al. 2011; Tüfekci et al. 2007). Given that, our study revealed that the pH value calculated for all industries was within the specified limit but that the measured value was very close to the margin of alkalinity (Table 1). According to WHO/UNEP (1999), pH values between 6.5 and 8.5 are within the typical range of most major drainage basins around the world and are usually referred to in order to indicate good water quality. According to our results, the concentration of Sulfate in effluents from DH-GEDA was slightly higher than the permitted discharge limit (table 1), indicating that its higher levels in the surface water would present health risks to people. Earlier studies have also demonstrated that high sulfate concentrations in water used by humans, could increases the chance of exposure to diarrhea (Khan et al. 2014).

3.3 Textile waste water and its effects on the health of the human and livestocks

Households who reside far away from the towns of Dukem and Gelan and those who live downstream were found to be the most vulnerable to health problems. Generally, the relative number of human health problems associated with polluted surface water was much lower than the figures indicated for livestock. According to the results of this study, children who live close to the wastewater discharge canals and those who live in downstream *kebeles*, were more affected than those who live farther away from wastewater sources and pathways. A verification of the principal causes of human health problems would, of course, demand medicinal diagnoses and specialized laboratory tests. Yet, the high levels of contamination in wastewater with different chemicals and the high T. Coli content as well as the high temperature of effluents, are considered as factors that contribute to human health problems. However, the magnitude of the problem varies within the study *kebeles*, especially with regard to the perceived nexus between health problems and industrial effluents (between 0,0% in Xadacha and 30,6% in Koticha). Residents in downstream areas and those who live in areas with limited or no access to potable water reported the highest occurrence of related health problems.

The main water-related problem for households is that the availability of public and private potable water sources was not sufficient to cover the demands of domestic households. Many households are thus forced to use water from open streams and drainage channels that are often polluted by effluents. Coli forms are the most commonly used indicators of contamination in drinking water. Water that contains coli forms should immediately be tested further for fecal coli forms or *E. coli* (see below). Boiling coli contaminated water for one minute is a reliable way to disinfect it. Of the two types of the pollutants, the presence of E. coli, also code-named E. coli 0157:H7, in the water used for domestic consumption, can cause human health problems, for children in particular (WHO 2008).

An important point observed in this study is the prevalence of livestock health problems to those observed for humans. Yet, we observe considerable variations in the distribution of the problems: at study town level, more livestock health problems were reported in Gelan than in Dukem (Table 5). At *kebele* level, however, the results reveal that households in *kebeles* situated downstream were more affected than those situated upstream. For instance, situated along the flow lines of the effluents where livestock could easily access the wastewater, sickness among livestock was reported in Gelan *k*, and in parts of T/Guracha and the Koticha *kebele*. This is primarily due to the absence of any alternative sources of drinking water for the livestock and the people in the study kebeles. Thus, unless the issue of environment and the livelihood of these people are properly handled, the ongoing senario suggests that there will be more damage to the environment and the livelihods of the local people.

4 Conclusions

Ethiopia is one of the least-developed countries worldwide and agriculture is the backbone of its national economy. Conversely, the industrial sector is in its infancy, accounting for less than 5% of the work force and contributing less than 13% to the national GDP. Since the formulation of the Industrial Development Strategy (IDS), the Ethiopian government has taken a couple of proactive measures in order to 'modernize' the economy by promoting the industrial sector. The main justification of the industrial development project is its economic benefits at local, regional and national levels. However, the project also showed some significant negative impacts.

Since 2005, Dukem and Gelan town have undergone rapid industrialization process that involved the rapid flow of investors, whose origin is local. The results of this study revealed that the concentration of some physico-chemical and bacteriological pollutants (BOD_5, COD and TSS) in textile effluents in Gelan and Dukem is higher than the permissible limit defined by the Ethiopian Federal Environmental Protection Authority (EPA). The concentrations of other pollutants, however, were below that limit. This study also indicated that the environmental consequences of disposing untreated or inefficiently treated wastewater into ambient environments damage the aquatic biodiversity. Moreover, one of the critical problems of textile industries in developing countries is the management of the vast amounts of waste generated. Challenges are particularly associated with disposal of wastewater into the ambient environment. Therefore, in areas where development activities take place, consultation with the local communities raise community awareness of development activities. Consultation or holding community training boosts, not only the awareness and participation/support for development activities in their locality, but also raises their awareness in protecting their family and properties from the negative outcomes of the proposed or ongoing changes.

According to the findings of this study, the indiscriminate conversion of large tracts of prime agricultural lands has been negatively affecting the livelihoods of the affected households in many ways. In the first place, intensive land conversion caused a sharp reduction in the total cultivated land size and the volumes of food crop production both at the study kebele and at household level leading to household food insecurity. The study showed that industrialization and land use change has affected household food security in three aspects. Firstly, they lost large agricultural land area (i.e. nearly half of what they owned at the start of the program in 2005) for the establishment of industrial projects, which did not ensure stable jobs or better wage for peasants. Secondly, the expropriation of farmlands significantly reduced the self-reliance of the households on food. Many of the surveyed households reported that they are not able to produce enough food for their own consumption and high living costs (i.e., due to reduced farmland size and production, none existence or limited opportunities of off-farm and non-farm employment incomes) and the price of stable food crops is also increasing. Finally, health problems (i.e. human and livestock) are found as an important result of deteriorating environmental pollution in general and from the high risk posed by the industrial effluents.

Based on the findings of this study, many of the farming households are not comfortable with the procedures involved in process of land expropriations. Because the lack of transparency during field measurements of the expropriated farmland size, the elements considered in estimating the values of their properties and in the final compensation amounts. The grievances of most of the affected households are so intense in relation to the inadequacy of the compensation money and the manner in which the compensation money was aid to them. Due to the very short notification period (sometimes 30 days), the affected families are not given much time to adapt to changing living circumstances when they lose their land.

Another grievance by the affected households was related to the low development level of the converted lands and lack of off-farm or non-farm employment opportunities for some of the households, where the income derived from agricultural activities is simply too low to cover all living expenses either due to too small farmland size or turned into landless. Moreover, the younger generations do not wish to work as farmers. Based on the results of the field GPS survey, although agricultural land was converted into IZs, many licensed investors did not develop the land, hence did not invest as initially proposed. This is confirmed by this study. It shows that the majority of the licensed investors (72% in Gelan and 63% in Dukem) did not develop their land in a stipulated period.

In consequence, the substantial conversion of farmland into ‘industrial land’ negatively affects local people not only through the loss of their farmland but through the lack of promised employment opportunities and improved infrastructure that might have otherwise offset their losses in the agricultural sector. In relation to employment opportunities, high labor migration coupled with labor selection turned against the chances of getting opportunities for the local people where the level of human capital development is very low and with no specific skill acquired by most of the unemployed people except activities related to farming. As a result, those households who heavily rely upon farming activities, on their own land or on the land of others by working as farm laborers, often have more difficulties in taking care of their families when agricultural land conversion takes place and agricultural land holdings decline. In short, although non-agricultural activities are considered positively related to higher income and sustainable livelihoods, the success of non-agricultural trajectories depends upon the households' 'starting position'. It is no given that people, especially the poor, can actually take advantage of new employment opportunities outside the agricultural sector."

Finally, the results of this study can highlight a significant lack of comprehensive studies that can indicate the impact of textile industries effluents on the health of people in the towns of Dukem and Gelan. Accordingly, a study on the impact of textile industries' effluents on people's health in Dukem and Gelan should be considered in future studies.

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Appendix

Survey questionnaire for sampled informants

PART I

General Information

I. Location identification

1. *Woreda*/town -----------------
2. Name of *Kebele*/village ---------------
3. Name of data collector -------------------
4. Date of data collection -----------------

PART II

I. Household demographic characteristics

1. Sex of household head: **a**. male ------------ **b**. female ----------
2. Age: ---------------------
3. Place of birth: ---------------------------
4. Marital status: **a**. single **b**. married **c**. separated **d**. widowed **e**. divorced
5. Educational level:
   a. Cannot read and write **b**. can read and write **c**. 1 – 4 d. 5 – 8 **e.** 9 – 10 **f.**11 – 12 **g**. > 12^{th}
6. Ethnicity:
   a. Oromo **b**. Amhara **c**. Tigre **d**. other, specify,----------------------
7. Religion:
   a. Waqefata **b**. orthodox **c.** protestant **d**. catholic **e**. Muslim **f.** other, specify, ---

PART III: Questionnaire on the Livelihood Assets of a household

N.B. Multiple answers is possible where required

I. Human capital/asset of a household

1. If you are married or heads a family, please, indicate your family size by age, sex, educational status and major occupation:

No	Pseudo name	Family profile				Remark
		sex	age	educational status	basic occupation (>1 answer is allowed)	
1						
2						
3						
4						
5						

6						

II. Access to Natural capital/assets of a household / Economic assessment

A. Land

1. Do you have agricultural land?
   a. yes b. no

2. Would you please mind indicating the size of each land use type for the years specified in the table?

Land use type	Size in local unit (i.e. qarxii)			Remark
	Before 2004/05	In 2008/09	In 2012/13	
Cultivated land				
Fallowed land				
Grazing land				
Planted Forest land				
Others,				

3. Would you please, tell total size of cultivated land and total amount of crops harvested over the years indicated?

Crop type	**Total size cultivated land (*Qarxii*)**			**Amount produced (*Qunt.*)**		
	2004/05	2008/09	2012/13	2004/05	2008/09	2012/13
wheat						
teff						
barley						
Oats						
maize						
peanut						
Horse bean						
Haricot bean						
Others, list						

4. For how many months of the year that you annual crop production could able to feed your family?
   a. <3 months b. 3-6 months c. 6-9 months d. 9-1 year e. >1year e. other, specify ---------
5. What has happened to the size of your agricultural land over the past 8 years?
   a. Increased b. decreasing c. intact d. other, specify, ----------
6. If your answer to Q5 is ‘decreasing’, what are the major causes for that?

a. converted to investment in industries   c. Shared with family member
b. fall within urban housing expansion   d. other, specify, --------------

7. If your answer to Q6 is **'a'**, how many hectare/*'qarxii'* is converted to industrial establishment?
   a. 0.25ha   b. 0.25-0.5ha   c.0.5- 0.75ha   d.0.75-1ha   e. 1-1.5ha   f. whole farm land   g. other, specify-----
8. Were you consulted by local/regional government authorities about the conversion of your land?
   a. Yes   b. No
9. If your answer to Q8 is 'yes', how did you decide/ were convinced to give up your land and properties on it?
   a. voluntarily   b. order to cede   c. other, specify, ------------
10. Were you paid compensation?   a. yes   b. no
11. If your answer to Q10 is 'yes' how much birr, -------------------
12. If your answer to Q10 is 'yes', how did you collect your compensation money?
    a. all in one installment   b. installment was made phase by phase   c. not yet paid   d. other, specify,-------
13. If your answer to Q10 is **'yes',** how did you rate/compare the amount of compensation money with your land and properties on it if any? Compensation money was:
    a. higher than aggregate value of my land and properties on it
    b. was equivalent to the value of my land and properties on it
    c. lower than the aggregate value of my land and properties on it
    d. very much lower than the aggregate value of my land and properties on it
    e. Other, specify ----------------------

14. What did you do with the compensation money? Explain, four major activities
    a. --
    b. --
    c. --
15. How do you rate your household's current living status and standards before collecting compensation money and after collecting compensation? Do you thing, your living status and standard improved significantly
    a. Strongly agree   e. disagree
    b. Agree   f. strongly disagree
    c. unsure
16. Have you ever displaced from your residential areas to cede your land for ongoing investment activities in your area?   a. yes   b. no
17. If your answer to Q16 is 'no', have you ever worried that you will be some day in the future?   a. yes   b. no
18. If your answer is yes, what is your plan as to solve the problems that might come because of displacement?
    a. --
    b. --
    c. --

B. <u>Agriculture - Industry linkages</u>

1. Do you have access to supply raw materials from your produce (crops, livestock, etc) for operating industries in your area? a. yes b. no
2. If your answer to Q1 is ‘yes’, would you please, specify top three items in order of their importance for you,
   a. --
   b. --
   c. --
3. Do you have an opportunity/possibility to purchase consumable products produced from operating industries in your area? a. yes n. no
4. If ‘yes’ to Q3, what type of consumable goods? Please list top three important items and compare prices with conventional market price
   a. --------------------------------- (cheap, similar, expensive)
   b. --------------------------------- (cheap, similar, expensive)
   c. --------------------------------- (cheap, similar, expensive)

C. Employment opportunities in relation industrial activities

1. Can you indicate employment history of your household members?

Employment Status	male	age	female	age	total	Remarks
employed						
unemployed						

2. Is there anyone of your family member who is hired in any of the nearby investment activities? a. yes b. no
3. If your answer is ‘yes’, can you indicate the type of employment? (>= one answer possible)
   a. Daily laborer d. professional work, specify --------------
   b. Foreman e. other, specify --------------------------------
   c. compound keeper
4. How much is the average monthly income for unskilled household member employed in industry? (in birr)
   a. <500 b. 501-750 c. 751- 1, 000 d. 1,001-1250 e.1251-1500 f. >1,500
5. What is the household monthly saving from the income obtained from employment in the industry?
   a. < 100 birr b. 101 – 150 c. 151-200 d. 201- 250 e. 251 – 300 f. other, specify ------
6. Do you and/or other people in your locality have access to employment opportunities in the processes of industrial establishment? a. yes b. no
7. If your answer to Q6 is ‘yes’, what type/s of employment/job opportunities are easily/ commonly available for local people in your area? Indicate in terms of their decreasing order of availability
   a. Wage labor b. daily labor c. compound keeper c. casual work d. other, specify-----
8. What are the major problems related to employment in industries?

a. lack of education b. lack of skill c. availability of excess labor from other places

d. employers are selective: prefer people from urban origin than from rural area e. other, specify --------

9. What implication (positive-negative) do you think employment in the industries has on own agricultural activities in your locality? Please, put in order of their importance

a. Diversify sources of household income b. divert/reduce farm labor

c. Affect agricultural production d. accelerate rural-urban migration e. other, specify ----------------

10. Do you agree with the processes of rapid industrialization and the accompanied rural land conversion in your area?

a. Strongly agree b. agree c. unsure d. disagree e. strongly disagree

11. If rapid industrialization is associated with major negative impacts, what do you suggest to be undertaken by the government to avoid or reduce the negative impacts in your locality?

a. --

b. --

III. Access to physical capital/assets

A. Infrastructure

1. When did you get access to the following infrastructures in your locality/*Keble*? Please, put thick mark '√' based on the years indicated in the table,

Type of Infrastructure	2004/05	2008/09	2012/13	Remark
paved				
Gravel				
Coble stone				
Asphalt				
Potable water				
Power/electric				
Health centers				
School				
i. 1-4				
ii. 5-8				
iii. 9-10				

IV. Financial capital/assets

A. Income and saving

1. Do you have your own savings of money in liquid and/or grain form to be used for emergencies and/or other household use purposes?

a. Yes, I have own savings d. No, I do not have saved/savings so far

b. I do not have extra money/grain to save e. I am not interested in saving

c. I do not have any idea about saving

2. Did you or any of your family members involve in non-agricultural income generating activities?

a. Yes b. No

3. What do you or your family member do with the income obtained from non-agricultural activities?

a. purchase food c. pay back debts d. purchase farm implements and inputs

b. Save for future uses e. other, specify, -------------

B. Livestock ownership

1. Do you own livestock?

a. Yes b. No

2. If your answer to Q2 is 'yes', please give us the following details for the periods indicated in the following table

Livestock category	Year		
	2004/05	2008/09	2012/13
cattle			
oxen			
caw			
calves			
heifers			
bulls			
Sub-total			
Equines			
horse			
donkey			
mules			
Sub-total			
Ruminants			
sheep			
goat			
Sub-total			
others			
chickens			

3. Do you face animal feed problems such as communal and/or own grazing land shortages over the last five years back from 2011?

a. Yes b. No

4. If your response to Q3 is 'yes', what is/are the causes?

a. shrinking of own grazing land

b. lack of communal grazing lands

c. communal grazing land converted to investment and settlement activities

d. Lack of clean drinking water f. other, specify ------

5. If your answer to Q3 is 'yes', what measures did you take to overcome shortages of grazing lands/pasture?

a. Limiting livestock number b. avoiding equines to save pasture c. purchase fodder

d. sold to shift to employment in industry e. other, specify ------------

V. Access to Social capital/ social assessment

A. Schooling

1. Are there any children in your family who are not going to school over the last five years? a. yes b. no
2. If your answer is yes for Q1, what are the major reasons for not sending children to school? (> 1 answer is possible)

   a. Unable to afford school expense
   b. In need of child labor
   c. engaged in daily labor/wage in industries
   d. Absence of schools
   e. Schools are far from home
   f. Lack of awareness
   g. Abduction of girls
   h. Changing place of living
   i. Other, specify --------------------

3. Are there any children in your family who dropped out of school over the last five years?

   a. Yes b. No

4. What are the major reasons for school dropout? (More than one answer is possible)

   a. Economic problems (Unable to afford school expense)
   b. In need of child labor
   c. Absence of schools
   d. Schools are far from home
   e. Lack of awareness
   f. Abduction of girls
   g. Changing place of living
   h. Other (specify) --------

B. Socio-cultural aspects

1. What main socio-cultural **problems/prospects** is/are emerging and how do you rate their trends after industrial establishments in your locality? Please, write the later of your choice in front of each question

Types of social problems/opportunities	a. severe **b.** moderate b. low **d.** no problem observed yet	a.increasing **b.** decreasing **c.** constant **d.** not sure
Theft		
Conflict over grazing land		
Conflict over agricultural land		
Juvenile delinquency		
Commercial sex workers		
Beggary		
Unemployment		
Street-ism and orphan/child related problems		
Disability – related to working in industries		
Elders without support		
Alcoholisms		
Jigii		
Idirii		
Equbii		

Other, list and rate		

Part IV.

Environmental Assessment

1. What are your current sources of water for household consumption in your locality?
   a. River/stream water b. spring water c. pond in backyard d. tap water potable e. other, specify ----------
2. If you answer to Q2 is '**a**', what do you do with it?
   a. Drinking b. for cooking c. bath d. washing and sanitation e. other, specify ----------
3. How do you rate the quality of river/stream water in your area for human uses after the processes of industrial establishment based on your local knowledge/experience?
   a. excellent b. very good c. good d. bad/unclean/polluted
4. If your answer to Q3 is'd', did you or your family member get sick of using river/stream water for drinking?
   a. Yes b. No
5. If your answer to Q4 is 'yes', how many of family member got sick on average in a year? -----indicate age ----------
6. Did you or any of your family members visit health center for medical treatment so far up when sick?
   a. Yes No.
7. If your answer to Q6 is 'yes', how much money did you pay on average each time you or your family visited health centers? ---------------------------
8. Did any of your family member/ relatives die of sickness due to drinking river/stream water so far? Please indicate their age ------------------ a. Yes b. No
9. What are the most common diseases prevailing in your area over the last five years? (More than one answer is possible)
   a.. STD b. TB c. Diarrhea d. Typhoid Fever e. Intestinal parasites f. Gastric g. Ameba
   h. Eye disease i. Tonsillitis j. Other (specify) -----------
10. What other impact/s does using river water in your area bring on your family, livestock and agricultural activities?
    a. Children drop schools due to health problems c. Farm labor often affected
    b. Abortion and maternal health problems d. Deaths among children and elders
    c. Other specify --------------------------
11. What is/are the principal sources of water for livestock consumption in your area?
    a. River/stream water b. pond c. potable water d. other, specify ------------------
12. Did you or your livestock get sick of using polluted river water for drinking?
    a. Yes b. No
13. If your answer to Q12 is '**yes**', how many of your livestock got sick on average? -------------indicate age-----------
14. Did you take sick livestock to health center for medical treatment so far? a. yes b. no
15. If your answer to Q14 is '**yes**', how much money did you pay on average each time for treatment? ----------------
16. Which livestock types are more vulnerable to health problems up on using river/stream water in your area?
    a. Cattles: ox, caws, calves heifers, bulls b. equines c. small animals (sheep, goats) d. other specify ------

17. Would you please, mention **three** pressing health problems of your livestock after industrialization process begins in your locality in terms of their order?
    a. ---
    b. ---
18. What other impact/s does using river water in your area bring on people, livestock and agricultural activities?
    a. Farm labor often affected
    b. Affected agricultural production
    c. Livestock incomes such as milk and milk products declined
    d. Abortion and maternal health problems
    e. Deaths among calves
    f. Other, specify --------------------------
19. What do you think should be done by you, local administration, investors and government at higher levels do in order to reduce or avoid the principal sources of river/stream water pollution in your locality and enhance the usability of the river/streams?
    a. ---
    b. --
    c. --

Part V

Which of the following best represent your Copping and adaptations Strategies to farmland losses?

(Multiple responses are possible)

1. How do you cope with problems of land and food shortages for your household? Please, put '√' mark (>1 answer possible)

a. share cropping
b. land rent
c. work in others farm
d. diet change: type, quantity and quality reduction
e. livestock sale
f. ox/oxen, equines rent
g. farm land renting
h. buy food on credit basis
i. migrate to urban centers
j. consume less preferred food
k. borrowing grain from relatives/neighbors
l. cash/money loans from merchants
m. labor sale: work for the others farmers
n. grass sale
o. fuel wood and animal dung sale
p. daily labor in investment sites
q. sale of hand crafts
r. other, list