

River Pollution in Ethiopia: An Exploratory Assessment of the Causes and Effects on Environmental Sustainability

Sebsib Hadis¹, Mulugeta Tesfaye¹, Shimelis Hailu²

¹Department of Peace and Development Studies, Wollo University, Dessie, Ethiopia

²Department of Political Science and International Relations, Wollo University, Dessie, Ethiopia

Email address:

hadissebsib@gmail.com (S. Hadis), mulugetaabateeee@gmail.com (M. Tesfaye), shimellishailu@yahoo.com (S. Hailu)

To cite this article:

Sebsib Hadis, Mulugeta Tesfaye, Shimelis Hailu. River Pollution in Ethiopia: An Exploratory Assessment of the Causes and Effects on Environmental Sustainability. *Social Sciences*. Vol. 8, No. 5, 2019, pp. 226-223. doi: 10.11648/j.ss.20190805.13

Received: July 14, 2019; **Accepted:** August 14, 2019; **Published:** September 10, 2019

Abstract: Ethiopia has been reflecting the environmental sustainability interests. However, questions have been raised regarding its effectiveness. Thus, this paper addresses one of the environmental sustainability issues specifically Borkena river pollution. Furthermore, it addresses the causes and effects of Borkena river pollution on environmental sustainability. By employing an exploratory approach, formative analysis and conclusions are made. As a result, Borkena River is found highly depleted due to wastes from households, institutions and industries. Mountainous farming, lack of environmental protection measures, alien weed, informal settlement, poor waste management system and inappropriate utilization of river resources are the major causes of Borkena River pollution. As a result, the river pollution affects the environmental sustainability in the area of natural resources, biodiversity and human ecology at large. Thus, the research outlines the following directions to be implemented for protecting Borkena River from pollution and maintaining environmental sustainability. Among these, (1) revisiting the rivers depletion and the extent of environmental pollution on a broader scale, (2) policy revision should be considered in responding river pollution and environmental sustainability measures, (3) expanding best environmental protection practices in Borkena river side, and (4) reconsidering river rehabilitation through realizing its economic benefits for the local community.

Keywords: Borkena River, Cause, Effects, Environmental Sustainability, Pollution

1. Introduction

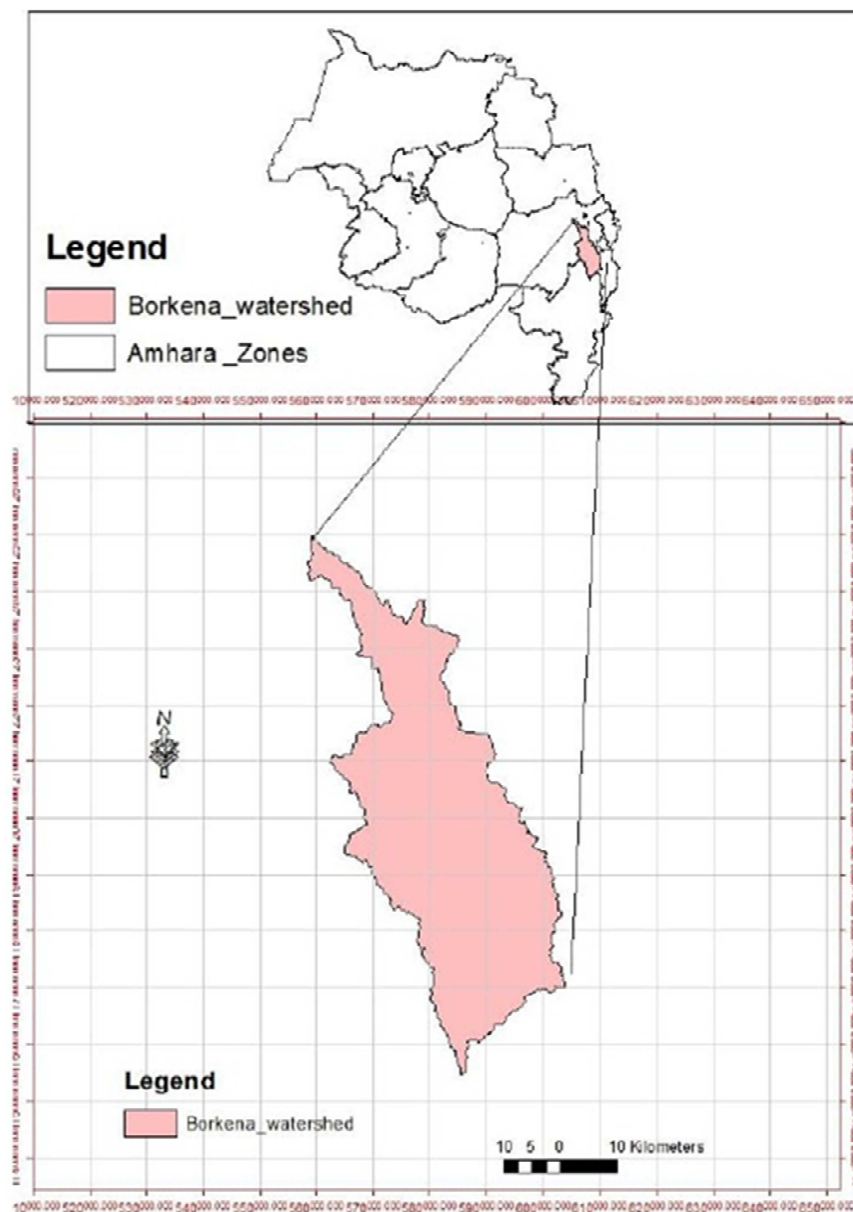
Water is one of the scarce resources that constitute 70% of our planet, earth. From total water coverage, around 97% of water is situated in oceans, where it has no great significance for domestic consumption [1]. The rest (3%) is found on the earth surface (rivers and lakes) and underground [1]. River water is among the basic resources required for human being to realize the socioeconomic (religious festivity and agricultural) interests [2]. It is also important to preserve the ecology and referred as an asset of the community and the country at large [1]. As a result, large numbers of peoples are dependent on the river for production and consumption purposes [3]. Due to this, world's river water is becoming limited due to raising consumption level and climate change. Furthermore, environmental hazards and poor management of water resources contributed significantly for the depletion

and mismanagement of the river and the environment at large. To address these issues, government of different countries uses sustainable development projects and programs that prioritize resource protection and environmental sustainability at large [4].

Thus river governance with two paradigms was identified that emphasize on effective river water use for 'single and multi- sector purposes' [5]. It also stressed on the full utilization of river for agricultural production and hydropower purposes [5, 6]. However, these approaches couldn't protect the river from being polluted. These forced practitioners and local community to raise questions on environmental sustainability issues on the river. Nevertheless, several positive effects have been resulted, including measures on reducing drought vulnerability and improved natural resource development practices. However, different negative effects caused by the limitations of environmental policy were observed. These include lack of policy elements

and inconsistency that brought damages on natural resources like river water. Thus it is hard to find the unpolluted rivers that have been singled out as part of human failure on the sustainability of environment. As a result, river pollution became a cause for different diseases and challenges for peoples around the river. According to Sonakshi Hudda the

source of river pollution has a “point or nonpoint” sources [1]. In point source pollution, actors in depleting the river are clearly identified, whereas, a nonpoint source polluters occurs in conditions where polluters are not able to be identified clearly.



Source: Amhara National Regional states Water Resource Development Bureau [11].

Figure 1. Borkena River Catchment area.

Concomitant with the above principles, researchers like Yohannes, *Maschal and Truye* and Ademe and Alemayehu conducted a study on water pollution in general and river pollution in particular [7-9]. Their works are on rivers and water contamination, river water pollution and determinants of water pollution in Addis Ababa, Ethiopia. However, researches on Borkena river pollution and its implication on the environmental sustainability remain overlooked and nascent. Hence, this research is carried out to explore the

causes and effects of Borkena river pollution and its implication on environmental sustainability.

2. Materials and Methods

In order to assess the causes and effects of river pollution on environmental sustainability in the study area, the researchers employed an exploratory approach. The study is neither national, nor regional research. Instead, it focused on

a river in Amhara regional state; Borkena river. The study come up with a formative analysis that calls further research in different rivers of the country to summarize the current rivers status vis-à-vis the sustainability perspectives. The researchers collected primary data from the upper (Kutaber Woreda), middle (Dessie and Kalu Woredas) and lower (Antsokia and Gemza, and Dawa Chefa Woredas) catchment areas. Field observation was conducted alongside the river catchment areas as well as in-depth interviews were carried out with respondents selected via purposive and convenient techniques. A total of 25 interviewees and 8 focus group discussion (FGD) (5 discussants in each) were used as data source. Anonymity of respondents was employed to keep the privacy of respondents. Most of the respondents were individuals that are direct attachment with Borkena River.

The research area, Borkena River; is a tributary of Awash River [10]. It is entirely within the awash basin. Borkena River originates from Kutaber Woreda.

The river passes through three administrative zones, namely South Wollo, Oromia zone and North Shewa zones from the upper to the lower catchment area which covers a total of 1709.63 km².

The river flow begins from its origin, named 'Mariam Wuha/Mariam Water' down to Awash valley travelling across Kutaber Woreda, Dessie and Kombolcha towns, and in the near far from Mekoy, *Kemisie* and *Sembate* towns. Borkena River water passes through many cliff and swampy areas. The river has different tributaries from three zones contributing to the raise of its volume.

3. Result and Discussion

3.1. Borkena River Pollution

This sub-section of the paper tried to show the depleting actor from individuals to government institutions. Households, companies and industries direct and indirect role in pollution of Borkena River was discussed. The researchers have seen a number depleting and conserving activities from upper to lower Basin of Borkena River. Not surprisingly, majority of human action on the river is against the wellness of the river as well as the wellbeing of environmental sustainability at large.

The discussion consider the following three category of pollutant actors; institutional, thematically and riparian issues. Institutionally: public institutions, business organization, household and individuals are the major pollutant actors of Borkena River. Thematically solid wastes and liquid wastes, and in terms of riparian issues upper, meddle upper, meddle lower and lower riparian polluters were identified.

In *Kutaber* Woreda (upper riparian) many water spring are tending to be closed by depleting activities. Individual households contribute the largest share in depleting the springs by over using the spring water to small scale irrigation and by planting water consuming plants around the springs. For example, 'planting Eucalyptus trees on swampy

areas is the major depleting activity on the flow of Borkena most upper segment'. Most swampy areas in most upper basin are invaded by Eucalyptus tree. Furthermore, water reservoir constructed by the support of European Union (EU) in collaboration with the Woreda's Water and Sewerage office consume swamp areas which was the major source of the river Borkena at *Kutaber*. Indeed, the project planned to enhance springs by excavating the ground water. In its opposite it tend to dried the swamp areas. The Woreda water and irrigation expert argued that the new project dried the swamp areas because it is built by inexperienced artisan graduated from Technical and Vocational, Education and Training (TVET) colleges. The artisans are not equipped with modern technology and sufficient geological knowledge. Due to this the artisans do not now the site of spring water and misinformed by local people in order not to evict from their land in search of water springs. Generally, spring water, swamp area and eucalyptus tree invasion are critical issues in *Kutaber* Woreda.

From the most upper to the lower catchment area water volume are decreased due to water consuming trees like eucalyptus tree. Mass plantation of eucalyptus tree in the canal, and swampy area of the river, ill management and the alien weed invasion affect the river water amount to be reduced highly. Thus, in the upper part of *Borkena* River especially from *Kutaber* to *Dessie* town, the most depleting factors are 'Eucalyptus tree and both solid and liquid wastes pumped from household and hospitals. Dairy and beef farming, building extract, construction excavation, and dumped wastes are the major polluters of the tributary of the river, *Aba Sharew* River. *Borkena* river canal was blocked by the excavated materials from the river side. Therefore, in terms of actors, the major depleting one is the residents (households-by cultivating Eucalyptus tree on the water spring of *Borkena* River) and public institution (*Boru Hospital* and *Dessie Tissue Culture*).

Down to Wollo University (*Desso* River, a tributary of Borkena), sewerage lines are directly run into the *Desso/Aba Abdella*, without any treatments. The solid wastes (food remnants, detergent bottles, sponges, plastic containers and bags, office wastes, ruins of the construction and soil extracted from building) are left into the river. During the observation, the University didn't have solid waste management mechanism (well managed burning place and burial mechanism) in the area. As a result, solid wastes were observed burned in an open space very close to *Desso* River. Liquid wastes flowing from the University directly run to the grazing field which serves the University and surrounding communities as Sport field, grazing for the diary, refreshment and studying field for the students.

There are alien water weeds over the river. According to the respondents they observed this water weed this year (2018/19 G.C). This alien water weeds were observed around *BoruMeda*, *BoruSilassie*, *Bahirshesh*, and *Kombolcha* in different quantities. Particularly the respondents in *BoruSilassie* told us the weed has been observed for the last two years. The respondent complain for bad smile, water

loose and dirt due to the weed in Borkena river.

To the east of the University there is swamp of liquid waste and spit blackish liquid. This swamp produces bad smell. The plants grown around this liquid waste were observed died. Except the Universities' waste there is no pollutant actor around that place. Indeed there is septic tank at the south east edge of the University; the researchers observed that small amount of liquid waste relatively different from the pollutant liquid flow via the tank pump. The researchers observed that the septic tank is not properly connected to the sewerage lines, because liquid wastes are run into the river instead of the septic tank.



Source: Photo taken at Wollo University (field Observation, 2019).

Figure 2. Liquid wastes from Wollo University.

Among eleven Condominium sites in Dessie town, including the university condominium, ten of them release liquid (including toilet waste) wastes in to Borkena River. The Condominiums' septic tank is ill functioning. In most of the sites, liquid wastes create swamp and directly run into the river. Due to these factors, water turned into blackish color. As observed the amount of solid and liquid waste increases as close to the town. There are places where illegal slaughtering/Abattoir service, unprotected toilet, animal waste, garage, river side settlements are observed. Because, river buffer zone is not protected all over the river path. The river buffer zone is under permanent constrictions and business organizations (micro and small enterprises, garages, car wash, floor factory, soft drink factory and shops) directly bordered and attached to the river if not they are on the canal. These companies are alleged for pumping chemical. According to the expert analysis in Buanbuawuha Sub-city, these factories did not have treatment plant and thus release dangerous chemicals like caustic soda, black oil during production and cleaning the factory engine. In addition, the researchers observed that liquid waste canals were directly linked to the river. In the observation, soft drink factory spit whitish fluid which creates accumulated material at its outlet.

Micro and small enterprises shades constructed in the river side built toilets along the edge of Borkena River.



Source: Photo taken at MOHA factory (field Observation, 2019).

Figure 3. Whitish MOHA Factory Liquid Wastes.

Household toilet waste, hotels, restaurants, clinic and hospital waste also joining the river without treatment through pipeline. In both Dessie and Kombolcha, abattoirs liquid and solid wastes are unmanaged that the solid wastes are disposed in an open space a hundred meter distance from Borkena River in Dessie and Kombolcha towns.

The lower catchment areas of Borkena River became the waste dumping area which significantly comes from the upper catchment area via flooding. These wastes includes plastic bottles, detergent bottles, household materials like glass, pharmaceutical materials and equipment's, medical equipment's, garage remnant materials, seedling planting plastics, nursery planting, hospital needles, plastic shoes, crusher, industries and agricultural chemical and pesticide plastic bottles, condom, human/plastic hair. Furthermore, the lower catchment areas also contribute to the pollution from the remnants of factories (beer, textile, leather, beef and dairy farming) and pig rearing practices.

As the informants said that, with the increase in number of industries and factories in the town, pollution of Borkena River became worsen.

The researchers also observed dead animals, animal waste, bones, remnants of meat factory, barberry wastes, juice houses remnants dumped to Borkena River. Sadly, in the course of the river, a hundred meter below the dead animal picture (dead animal in the river), the researchers observed that youths are bathing, cows drinking, and children and women were fetching water for domestic consumption and other purposes.

As compared to the upper segments of Borkena River, the lower segment is highly polluted. The buffer zone of the river was exposed to illegal settlement and small scale irrigation. Trucks collecting sand and stone across the river harm the river biodiversity at large, and also worsening the river side erosions to be deepening and broaden in the catchment areas.



Source: Photo taken at Kombolcha (field Observation, 2019).

Figure 4. Dead Animal and other Solid Wastes at Borkena river Canal (observed in Kombolcha).

According to the environment and sanitation department leader in Dessie town, among the major pollutants; hospitals which do not have an Environmental Impact Assessment (EIA) and Environmental Monitoring Plan (EMP) are the first line polluter. The municipality also identifies University as the second most pollutant actor in the area. Industries are the third pollutants of the river, in which garages also has a pervasive pollutant role. Furthermore, it is highly related with poor attitude, mischief and corrupted culture of professionals in the construction companies. As discussed from officials of the municipalities from all catchment areas, professionals' illegally link household's sewerage line with the flood canal and changing the structure by inserting pipes for future linkages. The expert from Buanbuawuha sub-city confirmed that construction professionals hired by the municipals buried plastic pipe conduits while they built water canals and road side ditches for future use to link sewerage to the flood canal.

However, best practices of river side protection and greening activities were observed in the study area. An artistic houses built from plastic bottles were seen at Borkena river side. A little terracing activity was observed in the upper catchment area. Furthermore, river side greenery and refreshment sides, green area development, botany guarded, urban agriculture, city park, swimming pool construction at Borkena river side were observed as good practices that protect the river from pollution. Different vegetation activities, planting erosion resistant grasses in Borkena riverside, replacing eucalyptus tree by indigenous trees were among the good practice found by the research.

Besides, Borkena River has different topography that would have a role in the development of the area for cliff recreational project and waterfalls that significantly contribute for comprehensive recreational development in areas. Unlike plastic bottle, there was no such significantly polluting glass bottle found in the river. Thus, an urge revision on plastic pollution controlling mechanisms are

required using expanding plastic grinding industry practices and plastic reuse to control plastic bottle pollution to the extent of banning it from market.

3.2. Borkena River Pollution and Its Implication on Environmental Sustainability

Borkena river depletion caused environmental pollution, as a result, it affect environmental sustainability. To make it clear, the causes of environmental pollution can be seen as the major and worsening causes. Besides, the effect has a direct attachment with the natural resources, cultural practices of the community around the river, ecological and biodiversity effect together with the human ecology.

3.2.1. Causes of Environmental Pollution in Borkena River

A. Mountainous Farming and Lack of Environmental Protection Measures

Borkena, a river found in areas where mountainous farming is widely spread from its source to the lower basin. It is quite observed that the mountainous and river side farming, which is called slippery slope plaguing, is highly harming the mountain and river side vegetation, which would protect the river from being filled by flood and land slide. Lack of environmental protection measures like terracing, planting trees which is comfortable for raising the river water amount causes river damage worsen from bad to the worst.

B. Alien Weeds

This weed found in Borkena River and other small ponds and tributaries were observed with reddish color that covers the river, ponds and other water bodies of the tributaries from every corner. According to the respondents, this weed was seen for the first time in 2018/19 G.C. The water weed has negative effects on the life of the residents. It (seen in Figure. 5 below) causes the river water to develop bad sniff, muddy materials, cover the water surface and cause water loose. Consequently the alien weed effects to the river pollution causes the residents who are dependent on the river water to suffer from skin etch (especially the children), dried the river water swiftly, which ultimately create water shortage for their cattle drink and agricultural purposes. This effect is mostly observed in the upper stream of Borkena.

C. Informal settlement

In Borkena River, slums and shanty settlement were observed. Houses were constructed in the riverside where the swampy areas are the sources of water for the river. This is one of the causes that decrease water volume in both the upper and lower river, and worsen shortages of water for domestic and agricultural purposes.

This settlement has brought danger on water sources, and causes the human ecology to be affected by the river pollution and related danger like flood and contaminated and transmitted disease (common cold, influenza). (See figure 6 below).

D. Poor Solid waste management system

Solid waste accumulated mainly from households, business institutions while liquid wastes, observed poisonous were dumped from industries. The solid waste deposition in

the river bank is deep that different layers of deposition have been seen while local people dig the area for different purposes.

Borkena River affects the community to get clean living environment. Specifically, the abattoirs waste turns the tributary of Borkena to reddish color. So it affects the tributary to lose its water color and cause the local community suffered from health problem. However, the response of government in combating these effects was minimal, almost none.

The study found that the town pro-poor housings projects are built areas that is unsuitable for living, due to abattoir wastes and unstable land for resident These shortcomings together with abattoir wastes, the fermented solid waste that loam soil in the area, exacerbate the frequent occurrences of land slide and living compound to be polluted, confirmed by the community elders.



Figure 5. Alien Weed (in Borkena River).

Source: Photo taken at Borkena River (Wollo University backyard, Dessie) (Observation, 2019).



Figure 6. Informal Settlement at Kombolcha and Dessie Towns (Borkena River) from left to right.

Source: Photo taken at Kombolcha & Dessie Town (field Observation, 2019).



Source: Photo taken at Kombolcha Town (field Observation, 2019).

Figure 7. Kombolcha Town Solid wastes dumping area.



Figure 8. Dessie Town abattoir Solid wastes dumping area (Borkena River Side).

Source: Photo taken at Dessie Town, Hotie Sub-city (field Observation, 2019).

Solid waste disposal sites¹, was located in the cliff side of the river in Dessie and Kombolcha towns. The solid waste dumping sites were selected unprofessionally and irresponsibly. Because both sites are found in the jungle or river side where the wastes are producing deadly substance and drained into the river and the forests. Surprisingly domestic animals, wild animals, birds, and street boys and girls collect materials (plastic material, glasses, irons) which will be reused and reprocessed for domestic consumption (plastic bottles for packing locally taped water and food oil) and factory inputs respectively. The research found that, the solid waste disposal site is not appropriate, confirmed by the cities Environmental protection officer. As the researchers observation confirmed, Dessie site (Aziwa cliff) which is found in geologically unstable area caused land slide and cracked cliffs, and the Kombolcha site is nearer to town and farm land too. As a result the waste leach directly flew to the river and farm land of the surrounding farmers.

¹ Aziwa Cliff, a solid waste dumping site in Dessie town, named, Denbelkeye.



Source: Photo taken at Dessie Town, Denbelkeye, (field Observation, 2019).

Figure 9. Denbelkeye, Dessie Town Solid wastes Dumping area.

E. Absence of Liquid Waste Management System

Liquid wastes that caused the river polluted. This is due to lack of liquid waste management system along Borkena river side. Due to this, liquid wastes are directly linked to the flood canals and join Borkena River.

The liquid release of newly built houses, business institutions, resident compounds and institutions causes Borkena and its tributaries polluted. Besides the release of abattoirs, the waste management areas in both Dessie and Kombolcha towns create a swampy area. This in turn proves the management system inefficiency of both local governments.



Figure 10. Liquid Wastes drained to Borkena, from Abattoir and garage at Kombolcha and Dessie town respectively.

Source: Photo taken at Kombolcha and Dessie towns (field observation, 2019).

F. Inappropriate Economic Utilization of the River Resources

From the upper to the lower river basin, a number of households are dependent in securing their daily livelihood from the wealth of the river. Collecting woods, extracting sands and stones, fetching water for construction purposes, grazing the river side grasses, pig rearing, beef farming, car and horse washing are the most dominant economic engagement in the river. This inappropriate engagement causes the river to be polluted and loose its water content. Because, extraction of sands always create muddy, pig rearing and overgrazing of river side field cause the river

environment polluted by their wastes.

Through the course of the river, especially, in the lower stream, car travel in every side that harm the river catchment area to be eroded by small water flow. This in turn exacerbates the river water pollution. As a result, the river faces the allegory of “tragedy of the commons” - communal river – where the river is owned by no one but everyone. The perception of the river as a resource by the residents and local government in the area made the river an ownerless river. Thus we found that, Borkena River is a river without no one’s role and responsibility to preserve but every one’s right to extract the resource and left depleted. In the tragedy everyone wants to maximize their profit in the cost of the river, caused, the more the river extracted, the more the river became polluted. Therefore, like many tributaries, Borkena itself became an “ownerless river, but mastered by everyone”. This weak ownership and belongingness relationship between actors make the river an “orphan” from the upper up to the lower basin. The perception and practices of river owned by no one became the resources of everyone caused the river polluted. Therefore, everyone has a role in polluting the river, because Borkena became the “tragedy of the commons”.

3.2.2. Effects of Environmental Pollution in Borkena River

A. Effects of Pollution on Natural Resources

Environmental pollution in Borkena River affects natural resource. Even though water sources were ample in the countryside, most of them are not used for any purposes, except small scale irrigation. This is due to the effect of the pollution. Thus, it causes the community to suffer shortage of clean spring and taped water. Most of them got water access from towns (Dessie and Kombolcha) with insufficient amount. This effect was caused by the establishment of different institutions and industries in the route of the river basin. These institutions and factories cause their water polluted and loose at all. All solid wastes that were accumulated in the river caused the canal to be blocked which exacerbates the danger of flooding.

B. Effects of environmental pollution on biodiversity

This natural resource pollution affects the ecological system and makes animals life harder and challenging. Different types of birds (scavengers, *Gureza* Bird (local name), and raven) are living in the river where their major food source is polluted. Thus, it creates food shortage that they couldn’t even collect their food for survival. Ultimately it is possible to draw a conclusion that birds in the polluted areas can’t be free from the waste chemicals, because their unhealthy appearances were observable. As confirmed by the residents in the area, their number is decreased from time to time, and the researchers also observed limited numbers.

C. Environmental Pollution Effects on Human Ecology

Under the ecological system, the research found that human interaction with the nature has been influenced seriously by the pollution. Recreational sites which has been dominant in the town, has found closed due to bad sniff of the river flow. As a result entertainment sites turned into polluted space.

4. Conclusion

This exploratory research emphasized on responding to knowledge gap on the causes and effects of *Borkena* River pollution and its implication on environmental sustainability. By employing qualitative research approach the research found that Borkena River water is depleted by individuals, institutions and organizations. Though conservation measures were implemented, its performances are found below the levels that cope with the depletion of the river. However, best practices of river side protection and greening activities, building recreation houses from plastic bottles, terracing, botany garden, urban agriculture, city park, swimming pool construction, planting erosion resistant grass in Borkena riverside and replacing eucalyptus tree with indigenous trees were among the good practice observed.

Starting from its source (upper catchment area), middle and lower catchment areas, the level of river pollution gets worse to the extent that *Borkena* River water became deadly water as a result of its poisonous substances and chemicals in it. Eucalyptus tree constitutes the significant share in harming the water volume especially in the upper catchment area. Inexperienced professionals and corrupted practices in the canal construction sector contributed to the river pollution. Furthermore, local government role in the study area were found in weak to protect the river from pollution. Institutions and industries were not implementing the treatment plant. As a result industries environmental management plans were ineffective. As a result environmental pollution effects were imminent and observed.

Generally, this pollution was caused by different contributing factors. Mountainous farming, lack of environmental protection measures and alien weed (a newly discovered weed in *Borkena* River) affects the river to be dumped and polluted to the extent that affects its purposes. As a result it significantly escalates the local community's water scarcity. Informal settlement, poor waste management system and inappropriate utilization of the river resources result the river to become the "tragedy of commons". The findings of the research identifies that the river pollution has a paramount effect on the surrounding environmental sustainability. These effects were seen on natural resources, biodiversity and human ecology. Thus, the study identified awareness gap, policy gap and regulation related constraints. Thus, the study implies the following directions for maintaining environmental sustainability; (1) revisiting the river depletion and the extent of environmental pollution on a

broader scale, (2) policy revision should be considered in responding the environmental sustainability measures, (3) expanding best environmental protection practices in Borkena river side, (4) reconsidering river rehabilitation through realizing its economic benefit by building recreational sites and conservation measures.

References

- [1] Sonakshi Hudda (nd) River Pollution: Causes, Actions and Revival For a better tomorrow, act today, Janhit Foundation.
- [2] UNWWAP (United Nations World Water Assessment Programme) (2015). The United NationsWorld Water Development Report 2015: Water for a Sustainable World. Paris, UNESCO.
- [3] Mirumachi and Naho (2015). Transboundary Water Politics in the Developing World. London: Routledge.
- [4] Berhanu Hailu. (2009). Water Resource Management in Ethiopia: The Case of Addis Ababa.
- [5] Hooper and Bruce P. (2005). Integrated River Basin Governance: Learning Experiences. London: IWA Publishing.
- [6] Molle, Francoise and PhilippusWester (2009). River Basin Trajectories: an inquiry into changing waterscapes. In Molle, Francoise and PhilippusWester (Eds.) River basin Trajectories: Societies, Environments and Development. Pp. 1-19. UK: CAB International.
- [7] Yohannes H, Elias E (2017) Contamination of Rivers and Water Reservoirs in and Around Addis Ababa City and Actions to Combat It. Environ Pollut Climate Change 1: 116.
- [8] Maschal Tarekegn M, Truye AZ. Causes and impacts of shankila river water pollution in Addis Ababa, Ethiopia. Environ Risk Assess Remediat. 2018; 2 (4): 21-30.
- [9] Ademe AS, Alemayehu M (2014) Source and Determinants of Water Pollution in Ethiopia: Distributed Lag Modeling Approach. Intel Prop Rights 2: 110. doi: 10.4172/2375-4516.1000110.
- [10] Fantaw Mengesha (2008). Channel Stabiltiy Analysis -The Case of Borkena River. Unpublished Master Thessi, Addis Ababa University, Addis Ababa: Ethiopia.
- [11] Amhara National Regional states Water Resource Development Bureau (BOWRD) (2016). Feasibility Study and Detailed Design of Borkena-Sakli Intake Small Scale Irrigation Project: Volume I Watershed Management Final Report, Dessie, Ethiopia.