Chapter

Environmental Impact and Sustainability of Aggregate Production in Ethiopia

Gashaw Assefa and Aklilu Gebregziabher

Abstract

The production of aggregate for the infrastructural development of the country has been increasing for the last three decades due to the high urbanization rates in the main cities of the country and the ever-growing demand for basic infrastructural facilities. The environmental impact of both fine and coarse aggregate production is now hard to ignore especially on the outskirts of the main cities. These impacts are clearly seen on the degradation of landscape and land stability, pollution of water resource, pollution of the atmosphere due to dust, and societal impacts. There are clear local and international laws that protect the environment from the negative impact of any project, whereas the observed fact from abandoned and functioning quarry sites shows these rules are not followed strictly.

Keywords: aggregate, sustainability, Ethiopia, production, environmental impact

1. Introduction

The construction industry in Ethiopia is a major driving sector for economic growth. Based on a report by the National Bank of Ethiopia [1], the construction industry in 2018 accounted for 71.4% of the nations' industrial output and expanded by 15.7% from its previous share signifying the leading role of construction sector. Massive government investment in infrastructure and residential building projects has made the sector to create jobs and improve standard of living. The rate of urbanization in the major cities is increasing, and this created a huge need for improved infrastructure systems and a big housing project. [2] reported that the urbanization rate between 1984 and 2007 has quadrupled from 3.7% to 14% over the two decades and still it was one of the lowest in the world, well below the sub-Saharan African average of 37%; it is projected that in 2028 the 30% of the country people live in urban areas [3].

Coarse and fine aggregates are the major inputs for most of the infrastructural systems and building projects. Approximately three quarter of the volume of concrete is occupied by aggregate and 90% of asphalt pavement is aggregate [4, 5]. This increased the demand of aggregate in line with the sectoral development. Yasmin, in 2015 based on the annual cement production volume, estimated the demand of Ethiopian for sand would be approximately 1.5 million tons per year [6].

2. Sourcing and aggregate production for Ethiopian construction industry

2.1 Sources of aggregate in Ethiopian past, present, and future trends

The natural aggregates are formed as a result of the processes of weathering and abrasion or through crushing a large parent mass [7]. Engineers are first of all concerned with technical requirements. However, in the future, probably the environmentalists will take over much of the standardization work. Quarrying and transport of materials have environmental impacts on the local neighborhood and society, for instance, with regard to noise, dust, pollution, and effects on biodiversity [8]. The city of Addis Ababa is growing from time to time very rapidly. Its area which is 54,000 Ha is being covered by buildings, houses, roads, bridges, etc. [9]. To meet the overgrowing demand, the number and production capacity of quarry sites, coarse aggregate, and sand deposits are aggressively increasing. Admasu [7] (2015) reported that based on the data from Addis Ababa Environmental Protection Authority in 2005 to 2015, the number of aggregate production plants in the capital has increased from 152 to 257.

2.2 Production of fine aggregate type, quality, production, and quarrying trend and method

For central and southeastern part of the country, the most common sources of sands are from Meki, Langano, Sodere, Koka, Metehara, and Minjar [10]. Generally, the existing quarry nationwide are not well organized; for example, from all sites in the capital, Denamo [9] reported, only 10 of the existing aggregate producing firms are well organized in manpower, machinery, and finance. Gravel and stone quarry operations result in extensive manipulation of the landscape and of the ecosystems of indigenous to their sites [11] (**Figure 1**).

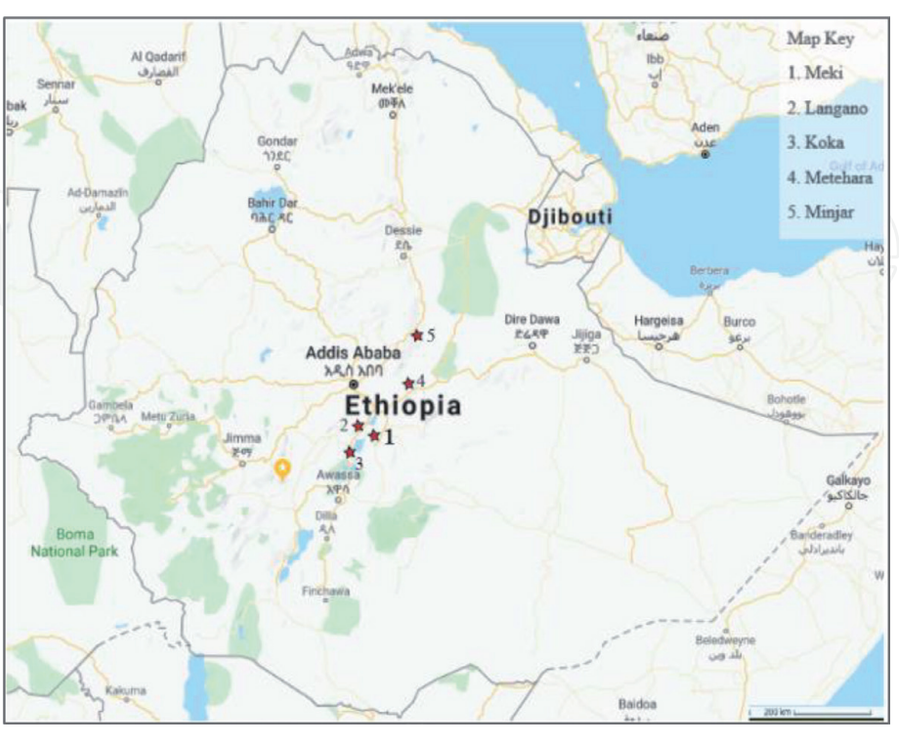

Figure 1.
Sources of sands for central and southeastern part of the country [source: Google Maps 2019].

Figure 2.
Production of fine aggregate in Ethiopia [6].

Properties	Result	Properties	Result
Dynamic elasticity modulus (GPa)	64–129	Bulk density (g/cm^3)	2.6–3.1
Ultrasonic pulse velocity (m/s)	4000–7000	Compressive strength (MPa)	130–350
Open porosity (%)	0.33%–3.08		

Table 1.
Physical and mechanical properties of Termaber basalt [15].

Quarrying activity often has long-term social and environmental impacts. Social challenges related to the increase in quarrying activities in general include threats to health and safety, farming obstacle, blockage on free movement of animals, displacement of communities, reduction in agricultural yield, damage of cultural sites, and the formation of mining villages [12]. Production activities in any industry may harm the environment through their damaging effects on air, water, soil, and biodiversity [13]. Due to the production process and luck of standardization, there is a big problem in getting good sand for production of concrete due to different reasons (**Figure 2**).

2.3 Production of coarse aggregate type, quality, production, and quarrying trend and method

Production of coarse aggregates includes blasting of rock, transporting of the crushed rock by conveyor to the crushing plant, and adjusting the crusher so as to give a range of different sizes by passing the crushed rock through a set of sieves [7]. At the selected quarry sites, holes are drilled into the rock and are partially filled with explosives, and controlled sequential blasting commonly breaks the rock into pieces suitable for crushing. If the rubble is too large, secondary breaking may be required and usually is accomplished with hydraulic hammers [14].

A detailed study was conducted by Tesfaye A. and Giulio B. on Termaber basalt, a widely used basalt in the central highland of Ethiopia and that comprise the major source of local crushed rock aggregates and building stone. Based on field investigation and laboratory tests, it was concluded that the basalt was highly suitable to be used as construction material with listed properties in **Table 1** [15].

3. Environmental impact of aggregate production

Production activities in any industry may harm the environment through their damaging effects on air, water, soil, and biodiversity [6]. Sustainable supply of

aggregate mix goes beyond the need to ensure a secure supply of aggregates to the economy by adding the requirement that the selected blend of natural aggregates, quarry by-products, and recycled waste must be produced and transported in an eco-efficient manner that minimizes total negative impacts and maximizes overall benefits to society [16]. Locally there are different environmental impacts due to the quarry sites of aggregates; the major impacts are summarized in the following section.

3.1 Impact on landscape and land stability

Stripping, excavating, damping of the overburden soil, drilling, and blasting of the rocks are the serious causes of soil erosion due to the quarry sites. Due to this activity, frequent soil creeps, siltation of down steams, formation of pits, borehole, surface ragging or cliff are created. Besides, agriculture productivity redaction, losses of the natural aesthetic of the area, and the bio diversity are created [14] (**Figures 3** and **4**).

3.2 Impact on the atmosphere

When a blast is detonated, some energy will escape into the atmosphere causing a disturbance in the air. Part of this disturbance is subaudible (air concussion) and part can be heard (noise). Once again the same to noise effect, the repetition and the exposure of the workers repeatedly make potential causes for the airborne diseases, respiratory infection, etc. [14].

3.3 Impact on water resource

Groundwater flow in springs, gaining streams, and wells may be impacted by nearby aggregate operations that pump groundwater from the pit or quarry [9]. Due to resuspension of sediments, sedimentation due to stockpiling and dumping of excess mining materials and organic particulate matter, and oil spills or leakage from excavation machinery and transportation vehicles, increased turbidity in sand mining sites are common [6] (**Figure 5**).

3.4 Impacts on biodiversity

It has been reported that due to fine aggregate extraction, many hectares of fertile streamside land are lost annually, as well as valuable timber resources and wildlife habitats in the riparian areas. Degraded stream habitats result in loss of

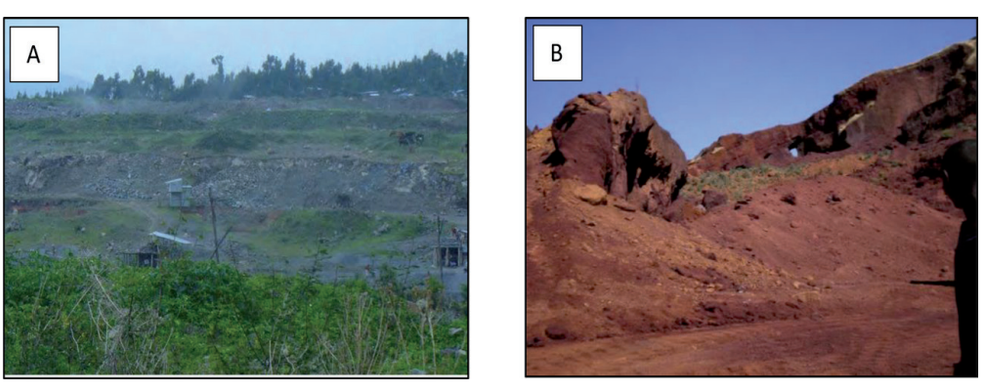

Figure 3.
(A) Degradation of quarries in Addis Ababa, around Debre Gelan [14] and (B) Scoria Source, Tullu Dimtu, around Debre Gelan [14].

Figure 4.
Abandoned quarry site at Augusta, Addis Ababa, Ethiopia [11].

Figure 5.
Water pollution by liquid waste discharge from one of the biggest quarry of Midroc, Addis Ababa [6].

Figure 6.
Coarse aggregate crushing plants have effect on nearby inhabitants [14].

fisheries productivity, biodiversity, and recreational potential. Severely degraded channels may lower land and aesthetic values [6].

3.5 Social impacts of quarry

If the proposed quarry is in urban center where it is surrounded by residential and recreational land of high scenic values, quarry operation will negatively impact on these values. The quarry would be visible to homes, parks, and open space.

The quarry operations will produce fugitive dust from blasting, vehicular emissions, and other mining operation which would deteriorate air quality. The dust will affect negatively the health and the well-being of residents [11]. A descriptive example of such incident is demonstrated by Semere [14]. He reported in 2013 that there was a functioning coarse aggregate quarry site 60 m from a cooperative apartment dwelling in the capital city of Ethiopia; this has an impact both on the structures and the dwellers around the vicinity (**Figure 6**).

4. Legal framework

Ethiopia has signed/or ratified a number of multilateral and international agreements that aim to protect the environment. In light of these agreements, the following paragraphs summarize the local proclamations and policies to laws.

The Provisions 1995 Constitution of the Federal Democratic Republic of Ethiopia provides a perfect basic framework on which detailed laws shall be developed for various sectors. It contains provisions that support the enactment of EIA legislation. Thereof, it stipulates that the design and implementation of development programs and projects in the country should not damage or destroy the environment. It makes sure that the right of the people to be consulted and express their views on the planning and implementation of environmental policies and projects that affect them. It also states citizens have the right to live in a clean environment and, where displaced or livelihood has been adversely affected by the development projects undertaken by the government, the rights to get commensurate monetary or Overview of EIA in Ethiopia alternative compensation, including relocation with adequate state assistance [14, 17].

The 299/2002 Article 5 Environmental Impact Assessment Proclamation defines any projects that are likely to have a negative impact on the environment and requires an EIA process for any planned development project or public policy. With regard to development projects, the proclamation stipulates that no person shall commence implementation of proposed project identified by directive as requiring EIA without first passing through environmental impact assessment process and obtaining authorization from the competent environmental agency [18]. Additionally **Table 2** states the local policies and proclamations which aim to legally mitigate and control environmental impacts [19].

As per the classification of the above proclamation, aggregate quarries fails under the category of project that can likely to have a negative impact on the environment, and as per the directives given, the environmental impact assessment

Local proclamations or policies	Year
The Environment Policy of Ethiopia (April 1997)	1997
The National Policy on Biodiversity Conservation and Research (1998)	1998
Environmental Impact Assessment Proclamation 299/2002	2002
Pollution Control Proclamation 300/2002 27	2002
Prevention of Industrial Pollution: Council of Ministers Regulation No. 159/2008	2008
Environmental Organs Establishment Proclamation	

Table 2.
Local proclamations and policies related to environment protection.

study must be prepared before the aggregate production plant is established. Moreover, the proclamation imposes a fine of between 50,000 and 100,000 Birr on any project owner who commences implementation of a project without obtaining authorization from environmental agencies or who makes false presentation in the environmental impact assessment study report [18]. In addition, the proclamations clearly state that the public particularly the communities that are likely be affected by the project should comment on the environmental impact assessment study and their concern must be addressed.

5. Conclusion

The need for increased infrastructural and housing requirements due to the growing rate of urbanization has led to an ever-increasing demand for both fine and coarse aggregate. This increase in an unregulated system is raising the environment concern to a level that immediate intervention is required. Locally quarry activity has created several environmental and social problems. These problems include change of landscapes and loss of aesthetic value, contamination of soil, erosion and sedimentation, air and water pollution, loss of biodiversity, and health problems on the workers and local residents. Even if there are relatively sufficient laws and proclamations for the protection of the environment, quarry sites are not regularly inspected of by the authorized bodies while they are operational or after they have been closed for reclamation purposes. Most quarry sites are just left abandoned. The only environmental mitigation practices in few quarry sites are planting of trees and collection of waste [6, 12, 14].

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