American Research Journal of Humanities & Social Science (ARJHSS)

E-ISSN: 2378-702X
Volume-05, Issue-01, pp-37-53
www.arjhss.com

Research Paper Open Access

AN ASSESSMENT OF SAND EXTRACTION ENVIRONMENTAL EXTERNALITIES AS A SOURCE OF MARKET FAILURE IN GWERU DISTRICT OF ZIMBABWE

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ABSTRACT : This study sought to assess the environmental externalities of sand extraction as a source of market failure in Gweru District. The research instruments used included direct field observations, structured Contingency Valuation Survey (CVS) questionnaire, key informant interviews and secondary data sources. The researcher used purposive sampling to select the key informants for the interview whichincluded two Gweru District Environmental Management Agency officers and the local leaders of Ward 11. Simple random sampling was used to select the respondents for CVS. The interview respondents identified land degradation and increased turbidity in Vhungu and Ngamo Rivers as the major negative environmental externalities of sand extraction in the District. The key informants identified desilting of Vhungu and Ngamo Rivers as the main positive externality. The CVS revealed that only 26.9% of the respondents expressed Willingness To Pay (WTP) for the sand conservation program. Thirty percent of the respondents expressed Willingness to Accept compensation for the loss of open access to the sand resource.The study concludes thatsand extraction is a source of market failures like negative environmental externalities and opportunity costs.The study also recommends that the Government of Zimbabwe must amend the Environmental Management Act (Chapter 20:27) so that sand extraction is also listed in its First Schedule. This would make it a legislative requirement for EIAs to be done prior to any sand extraction project. The government of Zimbabwe must incentivize the use of alternative raw materials so as to reduce the rate of sand extraction.

Keywords: Sand extraction, environmental externalities, market failure, opportunity costs, EIA

I. INTRODUCTION

Sand is one of the most commonly found resources on earth's surface. It is naturally occurring and results from the weathering of rocks [1]. The resource does not need any prospecting for it to be mined as it is easily identifiable on the surface. For sand's direct use value to be realised it has to be extracted. Sand extraction, also known as sand mining, occurs everywhere around the globe and the resultant problems are equally ubiquitous [2]. The world consumes more than 40 billion tonnes of sand annually and the construction industry accounts for 75% of this [3]. The demand for sand worldwide stems from the rapid urbanisation and the growth of the middle class. The middle class demand good housing, offices, big shopping malls and infrastructure [3].

Singapore has hitherto been increasing the size of its city state since the 1960s and it has launched "sand wars" on its neighbouring countries (Indonesia, Malaysia, Cambodia and Thailand) to meet the sand demand [4]. Its population has increased three fold since 1960 (from 1.63 million to 4.84 million in 2010). This has forced her to reclaim more land from the sea using sand. This has made Singapore by far the largest importer of sand in the world and the world's highest consumer of sand per capita at 5.4 tonnes per inhabitant. Sand is also used in the manufacturing industry as a blasting material. Despite the sand resource's applicability in various economic sectors, its extraction is consumptive in nature and results in environmental externalities which are dual in nature (both positive and negative)[2].

In Africa sand extraction activities are providing informal work for people who would otherwise be out of employment, but destroying the environment [5]. Lack of proper methods and technology for river sand

extraction has led to indiscriminate sand extraction from rivers in Africa [6]. Trading of sand is lucrative business in Africa due to the infrastructural boom. Weak legislative frameworks on the sand mining activity and corruption have led to widespread illegal sand mining on the continent [5]. In Sierra Leone the sand miners who are more concentrated in the Western Area Peninsula are driving away tourists from the beaches due to coastal erosion which is proceeding at approximately six metres per year[7]. Inland sand dredging is having detrimental effects on the economic activities which rely on the physical environment in rural Nigeria [8].

In Zimbabwe sand extraction is occurring in both urban and rural areas. Rural to urban migration has contributed to rapid urbanisation which has sparked infrastructural developments. The developments demand sand in the urban areas. Rural business centres are also using sand for construction activities. There are also construction activities taking place in resettlement areas and the new farmers are extracting sand.

Gweru is expanding at a fast rate and this expansion entails infrastructural development. The students enrolled at the Midlands State University need housing facilities and suburbs like Senga and Nehosho have since expanded. All these projects require sand and this sand is supplied mainly from the Ngamo area, Vhungu River and Ngamo River. The newly resettled farmers in the Ngamo area have shunned farming citing poor rains and are now engaging in sand extraction to eke a living . Sand has a significant value to society, but with this consumption rate extraction cannot occur without significant externalities on the environment (both negative and positive). This is what this research seeks to assess.

Sand extraction is rampant in Gweru District and the sand is mainly being used in the construction industry. With the expansion of the District's housing and infrastructural developments, sand is used in the production of bricks and to make mortar in various upcoming suburbs and new resettlement farms in Gweru District. Despite the pronounced negative environmental externalities associated with it, sand extraction is not a prescribed project in the First Schedule of the Environmental Management Act Chapter (20:27). Sand extraction is consumptive in nature (use value) since it involves removal of the resource for tangible utilization. Pit Sand extraction decimates arable land and leads to the depreciation of land values in the sites and areas adjacent to it. Sand extraction also exacerbates soil erosion as it involves site clearing of vegetation, loosening of the soil structure and creating of voids which can promote head ward erosion. This is happening in areas like Ngamo in Gweru District. River sand in areas such as Vhungu River is currently being overexploited to the detriment of the aquatic ecosystem. These constitute the negative environmental externalities of sand mining which are not reflected in the market value of the resource. This precludes other non-consumptive uses like fisheries and recreational functions like beaches. Local councils (Vhungu Rural District Council and Gweru Town Council) are faced with the dilemma of continuing with the sand extraction or lobby for alternative sources of the raw material like quarry dust which is expensive. The study seeks to assess the externalities of sand extraction as a source of market failure in Gweru District.

This study extends the knowledge frontiers on the externalities of sand mining in Gweru District. The value of sand has hitherto been expressed in monetary terms and its value has not been assessed in the context of environmental economics. The assessment of the value of sand to Gweru District in the context of environmental economics would bring out its value which is not reflected by the market value. The examination of the opportunity costs of the goods and services forgone after the exhaustion of the sand deposits would help local authorities in their decision making in allocation of resources in the District. Assessment of the regulation of sand mining in Gweru helps in the review of the legislative framework of sand mining which seemed to have been an afterthought during the crafting of the environmental legislation despite its destructive nature to the environment.

The area under study, Gweru District is found in the Midlands Province of Zimbabwe. The District is at an altitude of about 1.422m above sea level and located at 19°25'S 29°50'E. Gweru is the capital of the Midlands province and is the third largest city of Zimbabwe. The city has 8 urban wards with a population of 158 233 people comprising of 73 768 (46.6 %) males and 84 465 (53.4%) females. The rural part of Gweru has 18 wards with a total population of 91 847 comprising of 45 609(49 %) males and 47519 (51%) females making a total population of 251 361 people for the district as a whole. In terms of population size, Gweru is the fourth largest town in Zimbabwe. Gweru District lies within the Savannah Agro- Ecological Region III with a mean annual rainfall of 852 mm.

II. LITERATURE REVIEW

Global sand extraction environmental externalities.

Sand extraction is a ubiquitous worldwide economic activity which is carried out either illegally or legally [9]. The sand resource is an important raw material especially in the construction industry. According to [10] many countries are well developed with advanced infrastructure which is a positive effect of sand mining. However, the rate at which it is being extracted is a cause for concern when one considers the fact that sand is an extremely slow formation and regeneration processes [11]. The world consumes more than 40 billion tonnes of sand annually and the construction industry accounts for 75% of this and the demand for sand worldwide mainly

stems from rapid urbanization [3]. This excessive demand and extraction cannot be without environmental externalities. The main environmental aspects of sand extraction are clearing of vegetation, construction of access road to the site, diverting the flow of a river, altering the banks of a river, extracting sand from a deposit and dewatering a river to facilitate extraction [12].

Ecologically, sand extraction on marines has led to the disturbance of the seabed faunal and floral characteristics [13]. Sand extraction from the benthic zones (that is the bottom of the sea) destroys the seabed faunal components, their habitat and the ecosystem. This lead to a loss in the marine biodiversity [14]. The direct removal of vegetation leads to destruction of habitat and results in loss of biodiversity. Even without complete removal of vegetation, sand mining site vehicular movements can disturb vegetation [15]. In inland rivers, sand extraction incites changes in fluvial morphology [16]. The abstraction of the sand aggregate material lead to the channel incision both in the upstream and downstream of the extraction point.[17] contends that the abstraction of sand in an active channel creates a localisedknick point which then erodes upstream in a process called head ward erosion According to [18] the lowering of the Vembanad Lake in India by 7-15 cm per year can be attribute to the extraction of 12 million tonnes of sand per year from the Lake. The changes in the Vembanad Lake's channel morphology reduced its flood regulation capacity [18].

The impacts are not limited to the aquatic environments only, but even on non-riparian terrains. Sand extraction can also lead to soil erosion which occurs due to the removal of the of the vegetation binding material during extraction site clearing and the removal of the sand itself [2]. Sand extraction on the Monterey Bay has led to accelerated beach erosion [17]. [19] reports that sand harvesting threatens to displace 7 000 people in Nyadorera village of Kenya due to gully erosion sparked by sand mining.

Economically, beach erosion has affected tourism in the Western Area Peninsula of Sierra Leone and this is driving away tourists [7]). The sand extraction activities have been proven to contribute indirectly to climate change [20]. The heavy load trucks which transport sand from the extraction site to the points of use emit a great deal of carbon dioxide which is a greenhouse gas. Goddard [21] asserts that sand extraction degrades the aesthetic value of scenic landscapes. Furthermore, sand extraction has some influence in geopolitics. The extraction of sand has changed international boundaries through for example, the disappearance of the sand islands in Indonesia. This has led to sand wars with Singapore [4]. In illegal sand mining there arise issues of corruption, sand mafias, crime and child labour [5].

Sand extraction environmental externalities in sub-Saharan Africa.

In sub-Saharan Africa, sand mining is common in the coastal states [22]. There exist surficial dune and paleo-dune deposits of chemically inert and physically resistant Heavy Mineral Sands (HMS) along the sub–Saharan coastline. Globally these are an essential source of titanium, titanium dioxide and zircon. Approximately 75% of the world's titanium is produced from HMS and 6 of the world's 8 largest new HMS projects are in sub-Saharan Africa [23]. This type of sand is mostly mined using the dredging method and this upsets the dynamic equilibrium of the coast. The predisposing factor is that coastline exists in a dynamic equilibrium near the shore continental shelf and dredging of sand enhances the shoreline retreat as beach erosion will be occurring [23]. Countries which have been experiencing this in sub-Saharan Africa are Sierra Leon, Nigeria, Tanzania, Kenya and Cote d'voire [22].

Even in terrestrial ecosystems of sub-Saharan Africa sand extraction has some negative impacts. Inland sand dredging is having detrimental effects on the economic activities which rely on the physical environment in rural Nigeria. A study carried out by [8] reveals that inland sand dredging in the Niger Delta region is jeopardising the region' s economic activities. Lack of proper methods and technology for river sand extraction has led to indiscriminate sand extraction from rivers in Africa [6]. Weak legislative frameworks on the sand mining activity and corruption have led to widespread illegal sand mining on the continent [5].

[24] observes that there is a lot of heavy vehicles involved in sand mining which compact the ground. The heavy vehicles generally damages the roads and bridges. The effect is felt more by people who live near mining sites as the continuous movement of heavy vehicles cause problems like air pollution [24]. According to [20] noise and air pollution occur as dust accumulates from the gravel roads used to access the mining sites. On the positive side [25] highlighted the creation of employment in Kenya particularly to people living near the mining areas as a positive impact of sand extraction. Wachira [26] also carried out a survey on sand mining in Machakos District of Kenya and the study revealed that sand mining is benefiting Kenya through the supply of construction raw material that is cheap and easily accessible.

Sand extraction environmental externalities in Zimbabwe.

[27] observed that sand is abundant in Zimbabwe's Zambezi Valley, particularly along the Ruckomechi and Chewore rivers. Most sand extraction activities in Zimbabwe are occurring without proper Environmental Management Plans (EMPs) having been done for them and this complicates environmental problems [28]. In Zimbabwe sand extraction is occurring in both urban and rural areas. Rural to urban migration has sparked urbanization which has sparked infrastructural developments which demand sand in urban areas. Rural business

centers are also using sand for construction activities. River sand is extracted from river beds while pit sand in extracted from inland areas.

Illegal Sand extraction is one of the major direct causes of land degradation in Zimbabwe [29]. Illegal sand extraction creates pollution and siltation problems in rivers that supply drinking water to the cities [29]. Sand poachers are at the brink of exhuming bodies at Granville cemetery in Harare. Sand extraction activities are threating the graveyard with gully erosion. In Bulawayothe defacing of graves at Hyde Park Cemetery due to illegal sand extraction. Most people extract sand from undesignated points and do not rehabilitate the land afterwards. The abandoned sites are characterized by severe land degradation, with huge open pits which are a death trap to human beings and animals. The gullies in Chireya area of Gokwe which are threatening the collapse of buildings resulted from sand extraction activities [30].

The extraction of sand along the Mucheke River and the Shagashe River has positively resulted in the removal of silt from the two rivers. This is a positive environmental externality since it helps prevent flooding. Sand extraction has also contributed to livelihood security of the urban poor in Zimbabwe through provision of employment and income [15].

Concept of Valuation in the context of Environmental Economics

According to [31] Environmental Economics functions on the theory of market failure which as far as [32] is concerned occurs when markets fail to efficiently allocate limited resources to generate the greatest social welfare. In order to address these market failures Environmental Economists must assess the value of environmental resources. The total economic value of environmental resources indicates the total value of the resource in so far as it affects human welfare and integrates two broad categories of values. These are use values, associated with the direct contact with the natural resource in some way, and non-use values which refer to the enjoyment people may experience simply by knowing that a resource exists even if they never expect to use that resource directly themselves. Use values include direct use, indirect use and optional value while non-use values include bequest value and existence value [33].

According to [33] direct use value refers to ecosystem goods and services that are used directly by human beings. They include the value of consumptive uses such as the abstraction of sand; and the value of non-consumptive uses such as the enjoyment of recreational and cultural activities that do not require harvesting of the resource. Indirect use value of natural recourses relates to functional benefits, the outputs provide a social benefit from ecosystem functioning (for example, natural sand water purification). They are derived from ecosystem services that provide benefits outside the ecosystem itself. Option value refers to where individuals are willing to pay for the future use of the resource for example future visits to national parks, clean surface and ground water, avoiding of erosion to enable future use of pastures). Provisioning, regulating, and cultural services may all form part of option value to the extent that they are not used now but may be used in the future [33].

The non-use values are categorised in to three groups which are bequest, altruist and existence value. Bequest values refer to value attached by individuals to the fact that future generations will also have access to the benefits from species and ecosystems (intergenerational equity concerns). As far as [33] is concerned altruist value refers to value attached by individuals to the fact that other people of the present generation have access to the benefits provided by species and ecosystems (intra-generational equity concerns). Existence value refers value related to the satisfaction that individuals derive from the mere knowledge that species and ecosystems continue to exist. [34] puts it the existence non-use value reflects the “moral” or philosophical reasons for environmental protection, unrelated to any current or future use.

The Conceptual and Theoretical Understanding of Contingency Valuation Survey (CVS)

Contingent valuation Survey (CVS) method is the stated preference method that is based on the direct expression of individual Willingness To Pay (WTP) for a resource conservation and Willingness To Accept (WTA) for any change in environmental qualities [35]. The method is based on hypothetical rather than actual behaviour, where people’s responses to questions describing hypothetical situations are used to infer their preferences [34]. The CVS attempts to assign a dollar values for the public goods by asking people the maximum amount the individual would be willing to pay (WTP) to obtain the non-market amenity or goods and service or the minimum amount of financial incentive they will be willing to accept (WTA) to compensate for loss of environmental amenity [32]. The best way to elicit WTP and WTA in a CVS is through a structured questionnaire surveys [36].

Regulation of sand extraction in Zimbabwe.

Sand extraction in Zimbabwe is regulated by section 140 (k) of the Environmental Management Act (Chapter 20:27) as read with Section 3 (1) of Statutory instrument 7 of 2007 Environmental Management (Environmental Impact Assessment and Ecosystem Protection) Regulations [37,38). The Water Act chapter 20:24 also touches on river sand extraction. Section 46 of the Water Act Chapter 20:24 details the application for permit to conduct operations in a public stream. However, extraction of sand is exempted from applying for the permit by Section 46 (5e) of the Act.

The opportunity costs against the goods and services forgone after exhaustion of the sand deposits in Zimbabwe.

The depletion of the sand resource because of dredging by Geo Associates has destroyed crocodile nests along the Ruckomechi and Chewore rivers creating human wildlife conflict. The dredging of the sand in the two rivers has disturbed safari operations through increased human traffic. The sand miners made noise for the tourist who visited the Zambezi Safari [27]. The Mana Pools is a UNESCO World Heritage site and it came under threat from the sand mining activities in Ruckomechi and Chewore rivers [27]. [39]) assert that river sand extraction destroys the Sand Abstraction Systems (SAS) which are a source of potable water for small rural communities.

III. RESEARCH METHODOLOGY

Research Design

A triangulation approach was used whereby both quantitative and qualitative techniques were used to achieve the objectives of the study. The quantitative approach was employed by the use of Contingent Valuation Survey (CVS) questionnaires to assess the value of the sand resource to Gweru District in the context of Environmental Economics. The qualitative approach was employed using direct field observation, secondary data analysis and key informant interviews. The qualitative approach was used to cater for the objectives of the study which require explanation. Direct field observations were used to identify the environmental externalities of sand extraction in the District. Key informant interviews were used to examine the opportunity costs against the goods and services forgone after exhaustion of the sand deposits. Interviews were also instrumental in assessing the regulation of sand extraction in Gweru District

Target population

The target population for the Contingent Valuation Survey in this study constituted households at Macfadden farm, Ngamo resettlement farm, Stains farm and Getluk farm. They were chosen because they are sand extraction hotspots in Gweru District. The target population for the key informant interviews included Gweru District EMA officials and local leadership who have jurisdiction in the farms under study. These were crucial because they provide technical and informed assessments of sand extraction issues within their jurisdictions.

Sample size Determination

The primary study units for the Contingent Valuation Survey were the households in the areas where sand extraction activities are occurring. The research areas which were purposefully selected includedMacfadden farm, Ngamoresttlement farm, Stains farm and Getluk farm.These were used as study population to solicit data for the Contingent Valuation Survey ofthe value of the sand resource to Gweru District in the context of Environmental Economics. The 4 farms have got 373 households in total. The sample size for the CVS questionnaire were determined using the formula propounded by [40]. The formula provides a confidence level of 95%.

The formula: $\boldsymbol{n=\frac{N}{1+N(e)^2}}$

Where N- Total population

n- Target population

e- Precision

Target population $=\frac{373}{1+373\,(0.1)^2}$

$= \frac{373}{1+373\,(0.01)}$

$= \frac{373}{4.73}$

=78 respondents

Sample Selection

In each of the farms, simple random sampling method was used to select the respondents. Simple random sampling avoids bias by ensuring that every member of the study population has the same chance or probability of being included in the sample.

To make sure that the farms were proportionally represented the researcher had to calculate the sample size for each farm (Table 1).The sample size of each farm was calculated as:

Sample size in each farm $= \frac{\boldsymbol{number\ of\ households\ in\ the\ particular\ farm}}{\boldsymbol{total\ number\ of\ house\ holds\ in\ all\ the\ 4\ farms}} \times \mathbf{78}$

For example, sample size for the Ngamo resettlement farm was calculated as follows:

Sample size for Ngamo resettlement farm $= \frac{110}{373} \times 78$

$= 0.294 \times 78$

= 23 respondents

Table 1: Number of respondents for each farm

Farm	Number of households	Sample Size
Macfadden farm	133	28
Ngamo resettlement farm	110	23
Stains farm	53	11
Getluk farm	77	16

The sample for the key informant interviews was arrived at through purposive sampling which is defined as the selection of participants who have knowledge or experience of the subject matter being investigated. According to Kent (2008**)** purposive sampling is a type of non-probability sampling in which the choice of the sample is based on the judgment of the researcher as to which respondents best fit the criteria of the study.

The snowball method of sampling was also used in which the researcher asked EMA officers for people who had important information about sand abstraction. The initial respondents in this case were the 2 Gweru District EMA officers who comprised of the DEO and DEEPO . The researchers asked EMA respondents where sand extraction was taking place in Gweru District. The researchers were refered to Ngamo resettlement, Stains, GetlukandMacfadden farms. The visited the local leadership in the referred areas for interviews. Snowball sampling made the research cost effective, since the researcher was referred straight to the sand extraction hotspots in Gweru District. Snowball sampling also enabled the researchers to save time.

Data analysis

Analysis of data collected using direct field observations was done using observer impressions from the field. Observations were presented using descriptions and in some cases photographs were necessary. Data from interviews recorded in the form of notes and the text analysis were conceptualized and presented in a descriptive manner. As such, much of the data was in prose format. Analysis of WTP for the conservation of sand resource responses involved the calculation of frequency distribution, cross tabulation of WTP responses with socio economic characteristics and other variables using the Binary Logistics Regression model. The relationship between sand resource conservation and employment was tested using the Chi-square method. The hypothesis which was tested using chi-square was:

H_o -There is no relationship between sand resource conservation and employment.

H_1- There is a relationship between sand resource conservation and employment.

The total economic benefits (total WTP) was calculated by multiplying the population by mean WTP to estimate the aggregate benefits of the conservation of the sand resource. The information was presented in a statistical manner using bar graphs and charts.

IV. RESULTS AND DISCUSSION

4.1The environmental externalities of sand extraction in Gweru District

Negative Externalities

A total of nine negative environmental externalities were identified through the interviews with the Gweru EMA officials and the local leadership as well as the direct field observations by the researcher. Figure 1 shows the negative environmental externalities that were identified.

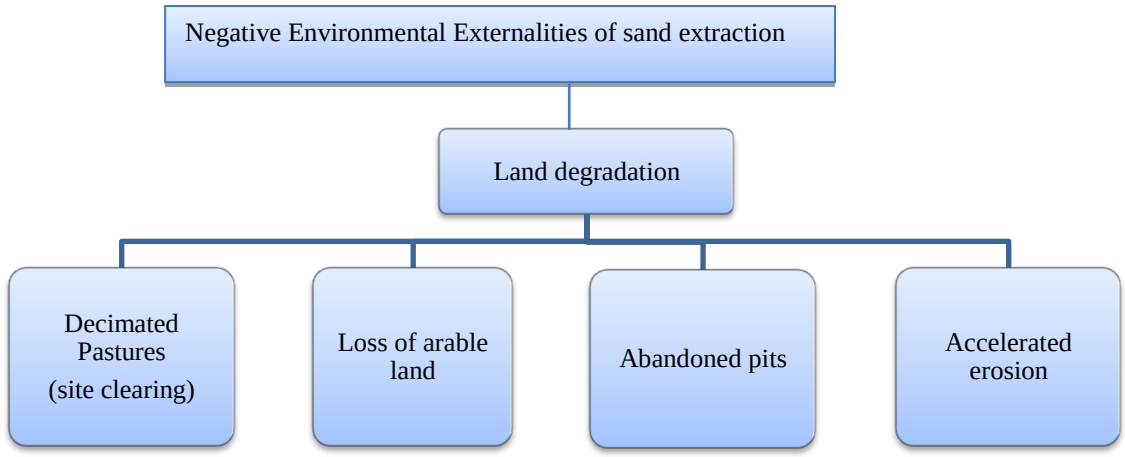

Figure1: The negative environmental externalities of sand extraction.
Source: Field data

All the key informants highlighted abandoned pits as one of the main negative environmental externality (100%). The Ward Environmental Committee Chairperson revealed that there was a tendency by the sand miners to abandon the site after exhaustion without backfilling the used pits.TheWARDCO Chairperson expressed concern over the danger posed by the abandoned pits to the local people and the animals. He observed that in 2014 a primary school pupil from Mkoba 12 drowned in one of the pits left open at Macfadden farm. The Councillor stressed that the pits become breeding places for mosquitoes which end up biting the people living in the vicinity of the abandoned pits. The researcher also observed the abandoned pits and they were 22 in total. The average depth of the pits is 1.5 metres. At the time of the study 16 pits filled with water were observed. The EMA Gweru District Environmental Education and Planning Officer revealed the area covered by the sand extraction activities in each farm.

Table 2: Area covered by the sand extraction activities in each farm

Farm	Total area covered by sand extraction sites
Macfadden farm	6 Hectares
Ngamo resettlement farm	15 Hectares
Stains farm	3 Hectares
Getluk farm	7 Hectares

Source: Field data

All the farms under study were visited to observe the condition of the extraction areas in terms of the active, abandoned and reclaimed sites. Figure 2 shows the condition of the extraction sites on each farm.

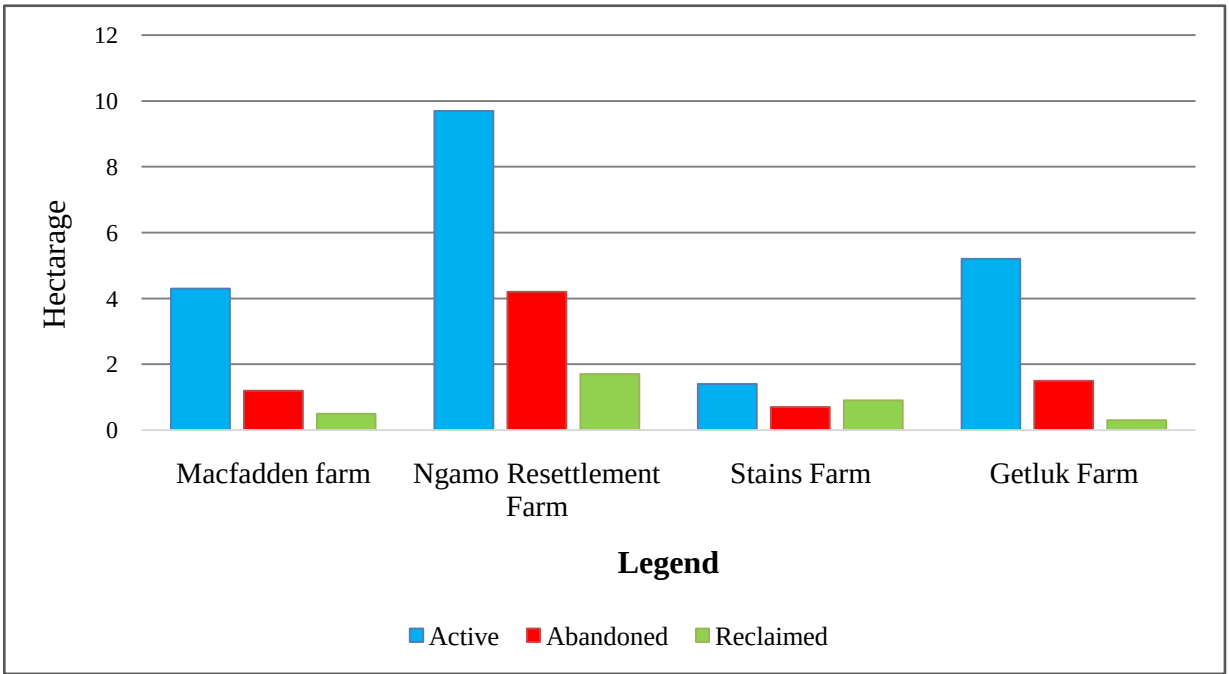

Figure 2: The condition of the extraction site on each farm.
Source: Field data

All the respondents identified loss of arable land as one of the environmental externalities of sand extraction on the farms. The EMA Gweru District Environmental Officer (DEO) observed that the haphazard way in which sand extraction activities were undertaken on the farms. The DEO singled out Ngamo resettlement farm as the area where most illegal sand extraction is occurring. This was due to lack of an Environmental Management Plan (EMP) in illegal sand mining. He also highlighted that even those who have the EMPs prepared by the Environmental Consultants only use them for licencing and never use them at operational level. The DEO also revealed that pit sand mining alters the soil profile and leads to loss of the soil nutrients. The Councillor, Environmental Committee Chairperson and all the EMA officials revealed that the clearing of vegetation for sand extraction leads to accelerated soil erosion. This is because of the removal of the binding effect of the vegetation. They noted that when the rains fall the soil is washed away. High turbidity levels at a sand extraction point at Stains farm along Vhungu River shown are shown in Plate 1. According to the Environmental Committee Chairperson, this is caused by the sand washing that is carried out at the river banks.

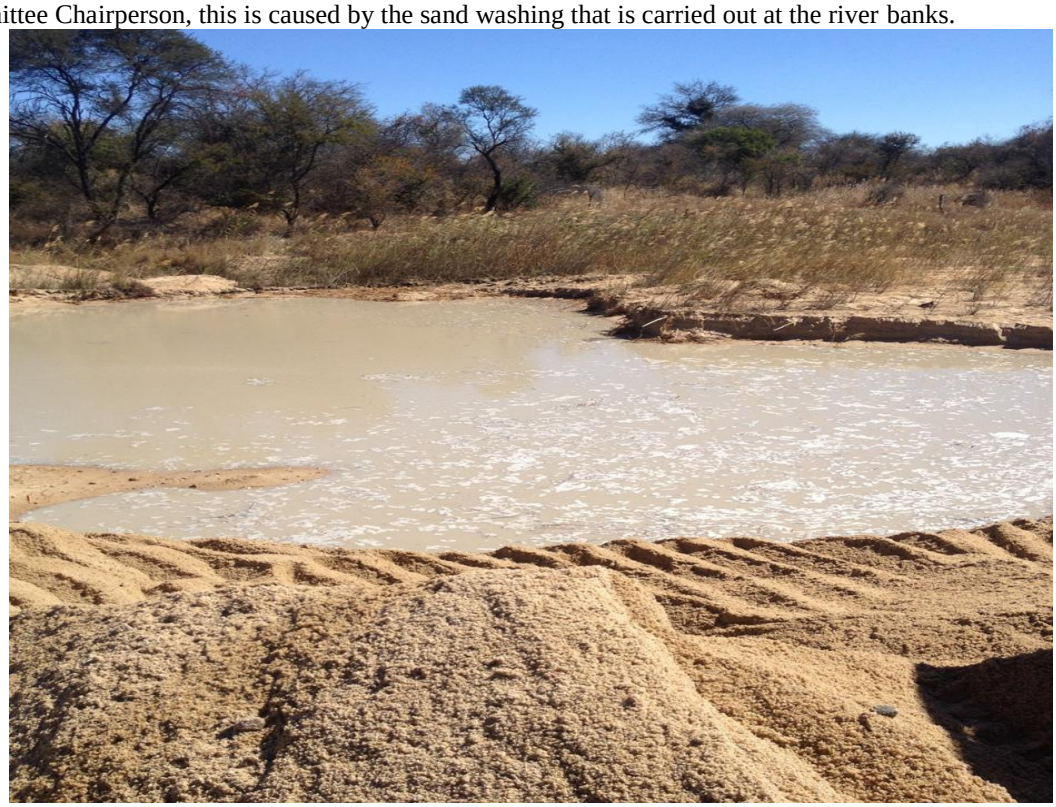

Plate 1: Increased turbidity due to sand extraction at Stains Farm along Vhungu River.
Source: Field data

Positive Externalities

The key informants also revealed positive environmental externalities as shown in Figure 3.

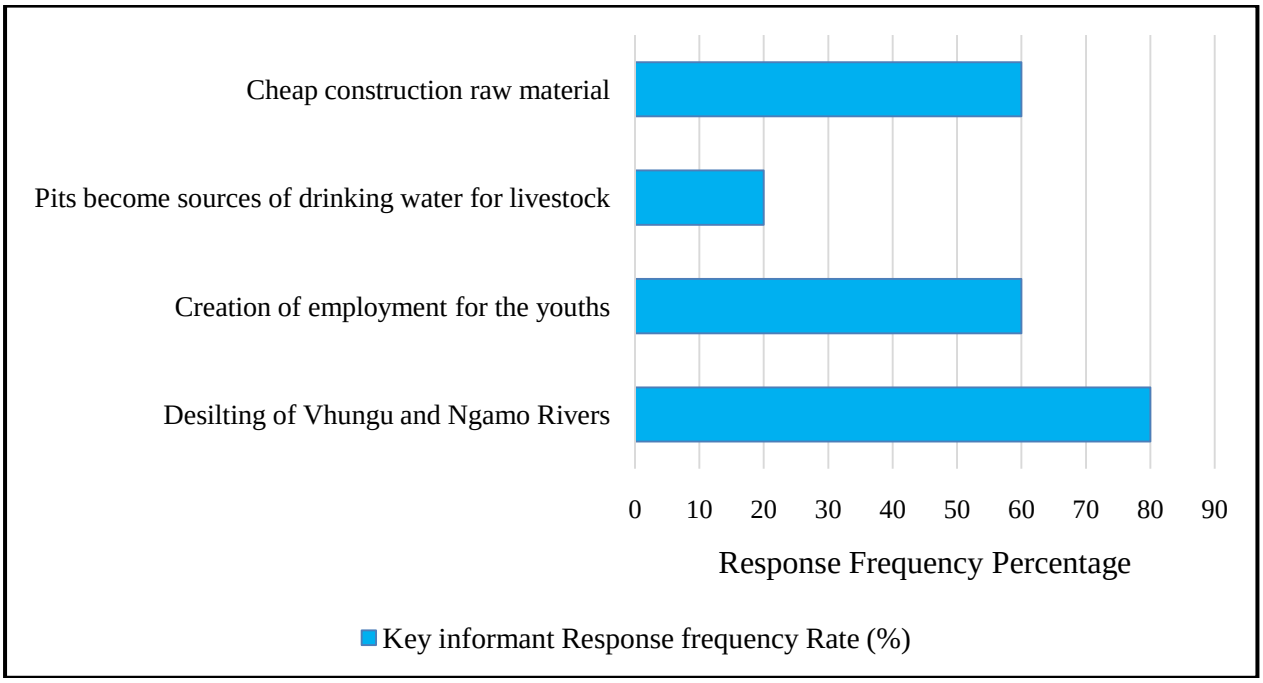

Figure 3: The positive environmental externalities of sand extraction.
Source: Field data

Four of the respondents also highlighted the importance of sand extraction in the desilting of Vhungu and Ngamo Rivers. The researcher observed and photographed the heavily silted Vhungu and Ngamo Rivers. The EMA Gweru DEO highlighted that the Agency awarded Rensburg sands to desilt part of Vhungu River which flow through their farm (Stains farm). Oliken sands was also given another part of Vhungu River to desilt. There are also other illegal companies whose EMPs were rejected by EMA but are carrying out desilting activities at points passing through Stains farm and Getluk farm. The Ngamo Sand Extraction Cooperative was licenced by EMA and is carrying out desilting of Ngamo River.

Plate 2: Heavily silted Vhungu River.
Source: Field data

Heavy machinery is used in illegal sand extraction to desilt Vhungu River along Vhungu River hence desilting the river as shown in Plate 3. The Gweru DEO indicated that they were carrying out blitz operations to stop such illegal activities.

Plate 3: Heavy machinery extracting sand along Vhungu River.
Source: Field data

The Councillor, WARDCO Chairperson and the Environmental Committee Chairperson said that sand extraction was creating employment for the local youths in the ward. The youths get employment to pile and load sand in the lorries which come to buy the sand. They said that this helped the youths to be occupied and desist from drug abuse and other criminal activities which may result from non-occupation. During the time of the field work, the researcher observed the youths loading the trucks at the sand extraction sites. Some were waiting on the road which the lorries use to access the sites soliciting for piece jobs to load the trucks.

The WARDCO Chairperson revealed that the abandoned sand extraction pits become sources of drinking water for the ward communities' livestock. He said the pits store rain water which the livestock from areas far from the local rivers (Vhungu and Ngamo) can then drink. The respondents said that sand extraction provides cheap raw material for building. The sand miners supply the sand to local customers in the farms, some brick moulding companies and some housing developers from around the District.

1.2 The value of the sand resource to Gweru District in the context of Environmental Economics

Benefits of the sand resource

Figure 4 shows the benefits of the sand resource as given by the respondents in the Contingency Valuation Survey questionnaires.

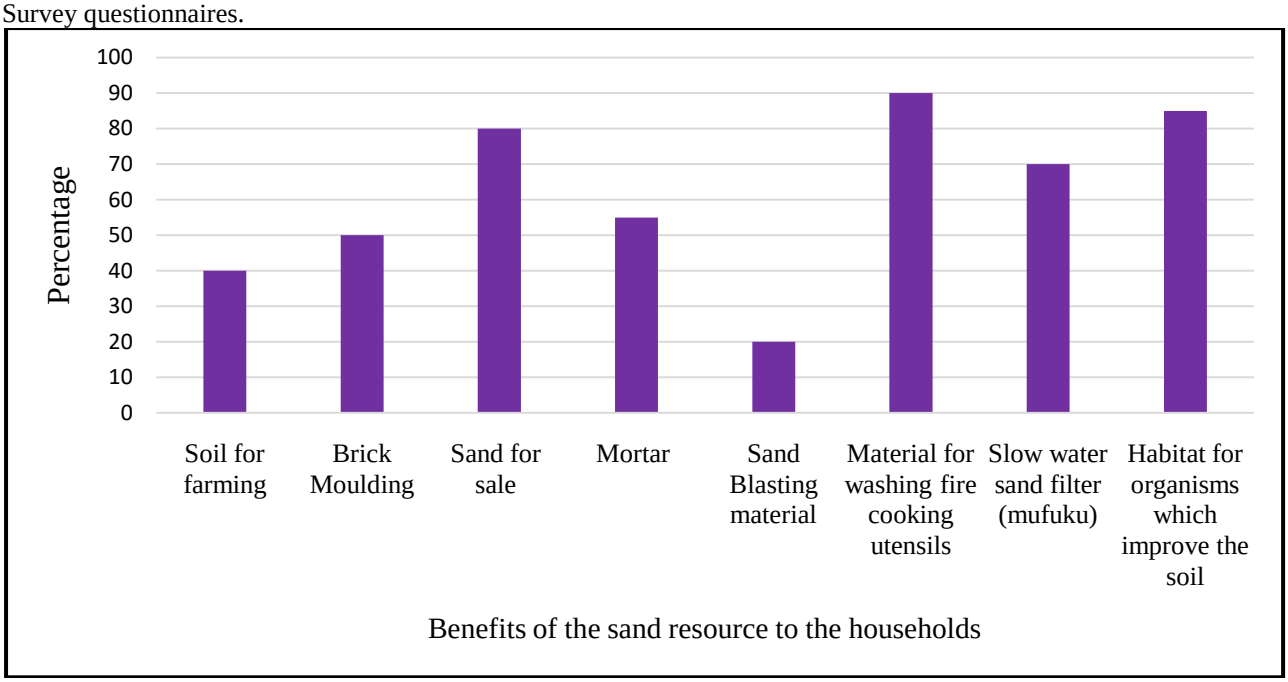

Figure 4: Benefits of the sand resource to the households.
Source: Field data

At household level sand is mostly used as material for washing fire cooking utensils. They take advantage of its abrasive effect to scrap off the dirt. Ninety percent of the respondents indicated that they used sand in their houses to scour the fire cooking utensils and 80% revealed that they benefited much from the sale of sand. It was noted that sand had become a source of livelihood for them since farming was not being fruitful owing to the poor fertility of the sand soils which characterise the area. The situation was exacerbated by low rains. Sand extraction was proving to be panacea to the poverty stricken households. Some were engaging in illegal sand extraction while some had joined cooperatives to register with EMA so as to legalise their sand extraction business. Only 42% of the respondents revealed that sand soil was beneficial for farming. This is because of its poor fertility and low water retention capacity. Almost half of the households revealed that they use sand as one of the key raw materials in the moulding of bricks. These moulded bricks for subsistence and to sell to some local people in the farms. Brick moulding at household level is at a very small scale using simple tools and is labour intensive. The bricks are of poor quality and that is why the market is very small. Some said they benefited from sand in the Ngamo and Vhungu Rivers as a means of filtering water (73%). There is no taped water in the farms and there are very few community boreholes which are far apart. The slow water sand filter in the rivers is a vital source of drinking water.

The value of the sand resource to Gweru District expressed as willingness to pay for the sand extraction control program

Only 26.9 % of the respondents (21 respondents) expressed willingness to pay for thesand extraction control program (Table 4.4). 6.4 % expressed willingness to pay the $10 per annum expressed in the dichotomous question. Out of those who stated their unwillingness to pay the suggested $10 annually in the dichotomous question (7 out the 21) only 2.2 % indicated their preferred bid in the follow-up open ended question. 73.1 % expressed total unwillingness to pay.

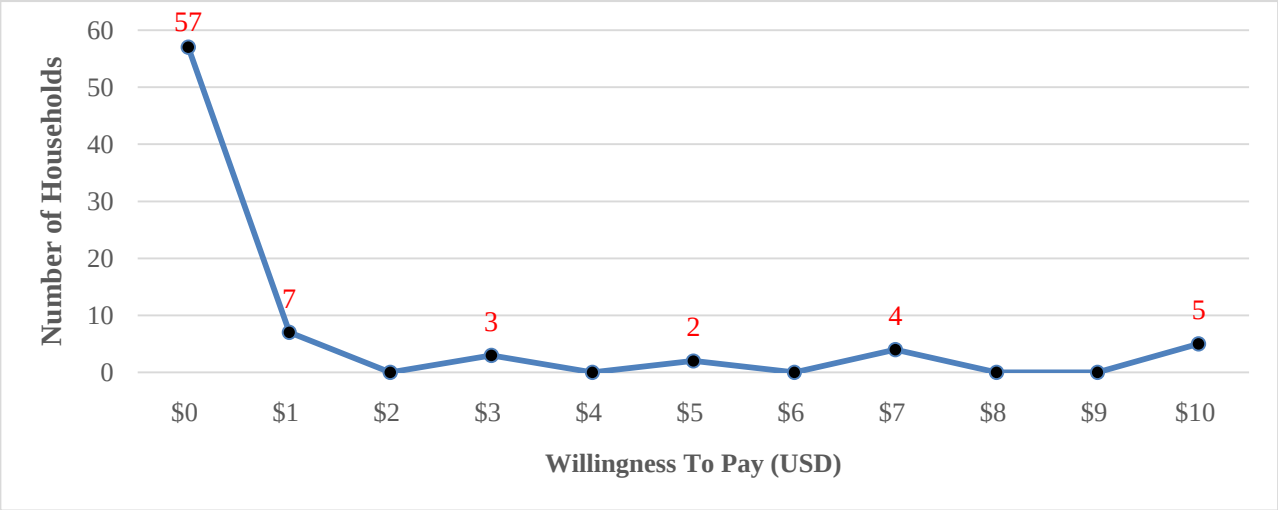

Figure 5:Distribution of the respondents' WTP.
Source: Field data

Figure 5 shows the frequency and distribution of the respondents' Willingness To Pay. Table 4 shows the respondents' reasons for their WTP while Table 3 shows the respondents' reasons for their unwillingness to pay with the percentage response rate.

Table 3: Respondents' reasons for their WTP (n-21)

Reason for WTP	Percentage response rate
I feel we have a duty to protect the sand resource	14.3 %
I feel we have to register sand extraction site with EMA	57.1 %
Rehabilitation of sites has to be funded	19.1 %
I feel we have to contribute to a good cause	9.5 %

Source: Field data

Among the respondents who expressed WTP, 14.3 % highlighted that they feel they have a duty to protect the sand resource while 9.5% said that they feel they have to contribute to a good cause. These are the people who expressed the non-use benefits of the sand and who do not extract sand for sale. Those who said that they feel

they have to register the sand extraction sites with EMA comprised of 57.1 % and these are people who were engaged in sand extraction. Their reason was motivated by the fear of EMA officers who may fine them for illegal extraction. In essence 19.1% indicated that rehabilitation needed to be funded and this involved farmers who feared for their livestock which could fall into the abandoned pits.

Table 4: Respondents' reasons for their unwillingness to pay (n-57)

Reason for not Willing To Pay	Percentage response rate
The program is not worth anything to me	3.5 %
I cannot afford to pay towards the programme.	56.1 %
It's unfair to expect me to pay for an open access resource like sand	26.3 %
I don't support any environmental program	14.1 %

Source: Field data

The WTP trend can be attributed to the income levels on the farms which were proved by the CVS to be too low. The minimum income of the respondents was $10.00 while the maximum was $400.00 and the mean was $65.58. The appreciation of environmental issues in the study area is very low and sand is considered a God given open access resource for which no restriction is supposed to be imposed on local communities.

1.3 Analysis of socio economic characteristics using the Binary Logistics Regression model

The Binary Logistics regression was used to analyse how the socio-economic variables were statistically significant for the respondents' WTP. The logistics model consisted of the cost of the sand resource conservation in the elicitation scenario which was $10/annum and the constant which were the socio-demographic characteristics of the respondents. The results showed that a household's average income was a significant variable in determining the respondents' WTP. Age and level of education were not significant determinants of the respondents' WTP. The Binary Logistics Regression model showed that income was important in influencing the WTP of the households for the sand conservation programme. The Hosmer and Lemeshow Test which is agoodness of fit test for logistic regression($P< 0.05$) proved that the model assumed by the study was correctly specified. The Binary Logistics Regression analysis also showed gender as an important variable in the determination of WTP. Males who expressed their WTP consisted of 90.5% of the respondents who expressed WTP while the females consisted of 9.5%.

The analysis proved that there is a significant relationship between a household's average income and WTP. The respondents did not want to commit to paying extra costs when their income was very low.

Willingness To Accept compensation for the loss of open access to the sand resource

Thirty-two percent were willling to accept compensation for the loss of open access to the sand resource whereas 68% were not willing to do so. Those who expressed unwillingness to accept the compensation were 53 constituting 67.8% of the respondents.

The CVS proved that many people are not willing to accept compensation after the loss open access to the sand resource. Since sand has become most households' source of livelihood losing open access to it means losing control over the resource. The sand miners are not prepared to lose the discretion to make decisions over the resource.

1.4 Opportunity costs against goods and services forgone after exhaustion of sand deposits in Gweru District.

The local leadership and the EMA officials revealed that if people choose to continue extracting the scarce sand resource for sale at the current rate there is a risk that the resource could be exhausted and this would lead to lossof the goods and services provided by the sand resource. Figure 6 shows the goods and services that may be brought about by the exhaustion of the sand resource.

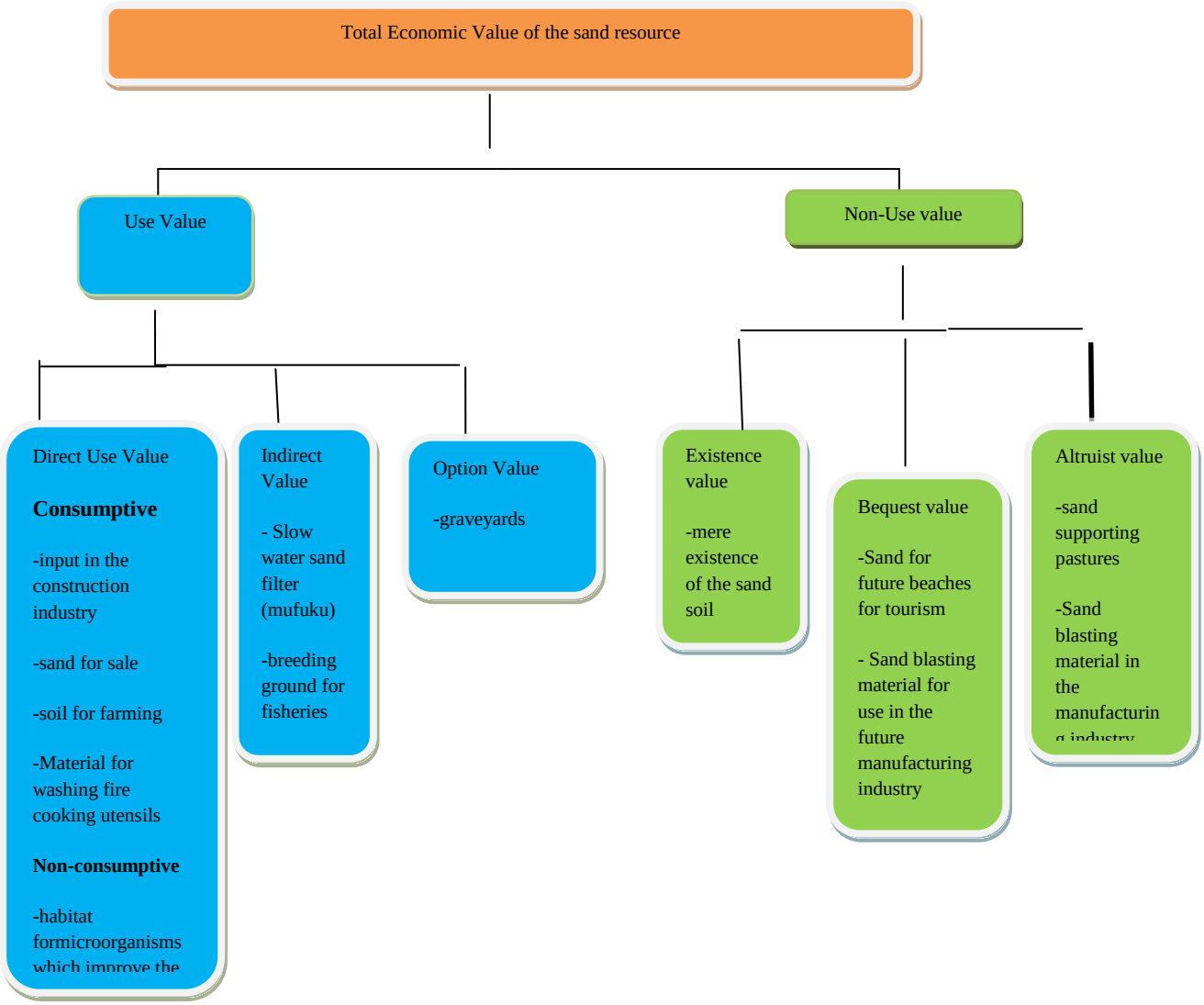

Figure 6: The total economic value of the sand resource that would be foregone after its exhaustion.
Source: Field Data

4.5The regulation of sand extraction in Gweru District

According to the EMA Gweru District Environmental Officer, there are 9 projects registered in Gweru District. The registered projects were awarded different points as shown in Table 5.

Table 5: Sand extraction projectsregistered by EMA in Gweru District.

Name of Project	Number of Points
Industrial Sands	4
Ngamo Cooperative	8
Ndezvashe Project	2
Varozvi Project	3
Oliken Sands	2
Chivake mines	1
Rensburg Sands	2
Siyawakuya Sands	3
Vandical Investments	1

Source: Field Data

Through the secondary data survey and the interview with the EMA officials the researcher managed to map the sand extraction legislative framework. Table 6 shows the summary of the sand extraction legislative framework. Sand extraction is regulated by section 140 (k) of the Environmental Management Act (Chapter 20:27) as read with Section 3-7 of Statutory instrument 7 of 2007 Environmental Management (Environmental Impact Assessment and Ecosystem Protection) Regulations [37, 38]. The Water Act chapter 20:24 also touches on river sand extraction. Section 46 of the Water Act Chapter 20:24 details the application for permit to conduct operations in a public stream. However, extraction of sand for desilting purposes is exempted from applying for the permit by Section 46 (5e) of the Act. The EMA officials also said that Statutory Instrument 3 of 2011 was enacted to cater for the licensing fees and the fine after the dollarization of the economy.

Table 6: Summary of the sand extraction legislative framework

Legislation	Relevant sections	Provisions
Environmental Management Act (Chapter 20:27)	Section 140 (k)	Provides for the crafting of sand extraction regulations by the Minister
Statutory instrument 7 of 2007 Environmental Management (Environmental Impact Assessment and Ecosystem Protection) Regulations	Sections 3-7	Provides for the Licensing of sand extraction
Water Act (Chapter 20:24)	Section 46 (5e)	Provides for the exemption of the extraction of sand for desilting purposes to apply for a permit toconduct operations in a public stream from ZINWA
Statutory Instrument 3 of 2011	All sections	Sand extraction licensing fees and fines

Source: Field data

A standard sand extraction point measures 20X20 metres. There are two licences for sand which include sand extraction and sand transportation certificate. The licensing process is shown in Figure 7.

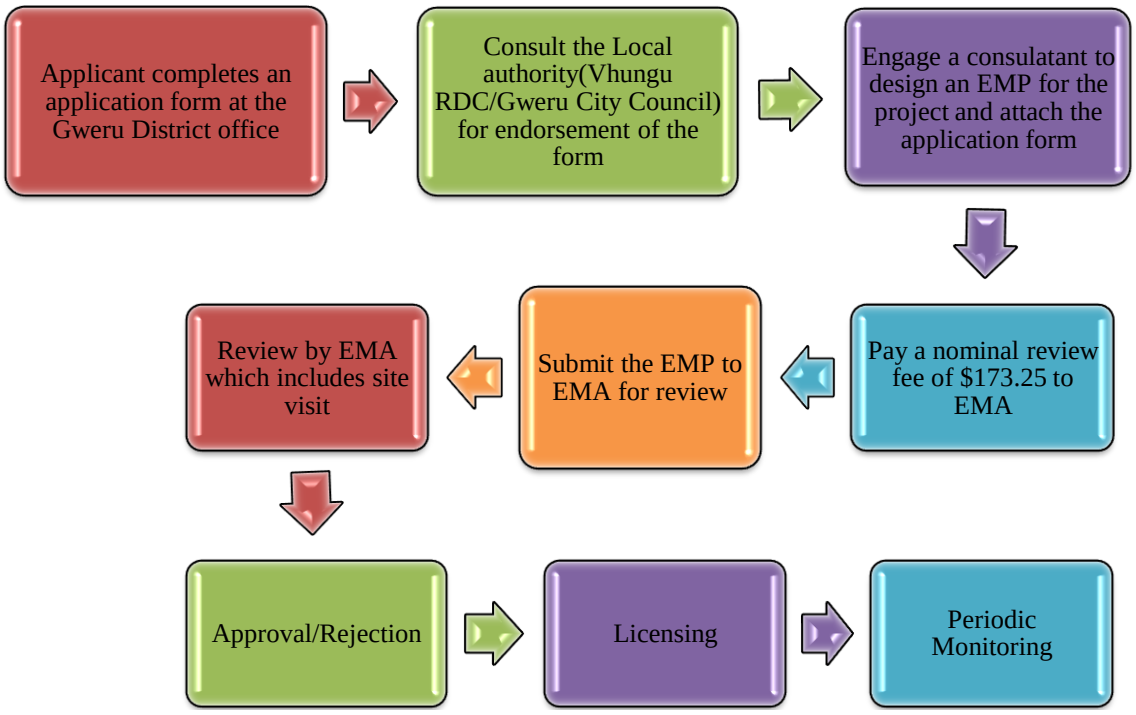

Figure 7: The EMA Gweru District sand extraction licensing process

Source: Field Data

For the sand transportation licence the applicant completes an application form which is submitted to EMA together with copies of certificate of fitness of the vehicle, photographs of the front and rear of the vehicle, the vehicle registration book, national identity card of the vehicle owner, and certificate of incorporation for

companies. According to the EMA Gweru District Environmental Officer, the sand transportation activity is an integral activity of the sand extraction. Licensing is therefore key to the regulation of sand extraction in Gweru District.

CONCLUSION AND RECOMMENDATIONS

Sand extraction is a source of market failures such as negative environmental externalities and opportunity costs. Sand extraction leads to decimated pastures, loss of arable land, abandoned pits, accelerated erosion and increased turbidity in rivers. The communities at large are subsidising on the cost of sand in the form of the externalities associated with its extraction. The rate of extraction of the sand is not proportional to rehabilitation. On the positive side sand is being used as a raw material in the construction industry. At household level sand is being used as a source of livelihood contributing income. Despite having positive externalities they are outweighed by the negative externalities. There is need for promoting sustainable sand extraction since the study revealed thatif people choose to continue extracting the scarce sand resource at the rate it's being done, there is a risk that the resource would be exhausted and this would lead to loss of goods and services provided by the sand resource. The low rate of the households' Willingness To Pay (WTP) indicates that people have no concern for the sand resource conservation programmes. This is mostly because of the low income levels among the communities. The low Willingness To Accept compensation for the loss of open access to the sand resource if the local authority assumes overall ownership of the sand mining rights show that people are not prepared to lose their discretion to make decisions over their source of livelihood. The results also indicated that despite sand extraction being a consumptive liability to the environment, it is not bound by the Environmental Impact Assessment (EIA) policy. Sand extraction is not listed in the in the First Schedule of the Environmental Management Act (Chapter 20:27) where all project that require EIAs prior to their implementation are listed. It is not a legal requirement for sand extraction proponents to consult a registered environmental consultant to draft an Environmental Management Plan (EMP) for the projects. The results of study also showed that monitoring of the sand extraction by EMA is not robust.

The Government of Zimbabwe needs to amend the Environmental Management Act (Chapter 20:27) so that sand extraction is also listed in its First Schedule. This would make it a legislative requirement for EIAs to be done prior to any sand extraction project. The amendments should ensure the sand extraction environmental taxes reflect the full value of the resource.EMA must ensure that all sand extraction project proponents do EIAs for their projects to internalise all the environmental externalities associated with them thereby promoting sustainable sand extraction.EMA could ensure that every sand extraction project have a progressive rehabilitation plan so that extraction is kept proportional to rehabilitation.

Sand extraction project proponents must have a robust project decommissioning plan which becomes part of the EIA report. EMA must make sure that the decommissioning plans are followed to avoid abandoned pits. EMA and local authorities need to liaise so as to come up with rehabilitation plans for the abandoned pits whose proponents can no longer be traced. The rehabilitation plans must then be implemented. The government of Zimbabwe could also incentivise the use of alternative raw materials so as to reduce the rate of sand extraction. These alternatives include quarry dust, chrome mining waste and the crushed mine material from the ore mills. The department of housing and the physical planning should also make it a legislative requirement for all the housing developments and major infrastructural developments to declare and account for their sources of sand. EMA must not register individual sand miners since it is difficult to monitor them. Individuals who wish to extract sand must buy it from registered companies and cooperatives or local authorities or form cooperatives to facilitate EMA registration. EMA must strictly monitor all sand extraction projects to ensure that the EMPs and progressive rehabilitation plans are being implemented.

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