Sustainably managing natural resources and the need for construction materials in Pacific island countries: The example of South Tarawa, Kiribati

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Abstract

The growing demand for construction materials in South Tarawa, a remote atoll in the South Pacific, provides an example of the environmental and social challenges associated with the use of non-renewable resources in the context of small island countries threatened by coastal erosion and climate change. In many small Pacific island countries, the availability of construction materials is limited, with the majority mined from beaches and coastal reefs in an unsustainable manner. Growing demand for construction aggregates is resulting in more widespread sand mining by communities along vulnerable sections of exposed beach and reefs. This has serious consequences for coastal erosion and impacts on reef ecosystem processes, consequences that cannot be easily managed. Construction materials are also in high demand for infrastructure projects which are financed in part with support from international development agencies and donors. This paper reviews the various challenges and risks that aggregate mining poses to reefs, fish, and the coastal health of South Tarawa and argues that the long term consequences from ad hoc beach/reef mining over large areas are likely to be far greater than the impacts associated with environmentally sustainable, organized extraction. The paper concludes with policy recommendations that are also relevant for neighboring island countries facing similar challenges.

Keywords: Developing countries; transport; coral reefs; aggregate mining; Pacific island countries; natural resources management; poverty

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1. Introduction

In small, low lying Pacific island countries (PICs), identifying sources of sustainable construction material is a common problem. It is exacerbated by the demand for better housing engendered by economic development and its associated infrastructure improvements. A common source of materials in PICs is from unsustainable beach mining, mechanical extraction from the inshore area, and dredging of reefs (McKenzie et al., 2006; Maharaj, 2001; Worliczek, 2010). There are few examples of good practice to meet the demand for aggregate. Reviews have found that controlling beach mining by communities is difficult, and that trying to regulate this practice in the absence of a suitable alternative is next to impossible.

The coral atoll of Tarawa, Republic of Kiribati, is heavily populated and located just south of the equator in the Pacific Ocean. South Tarawa is home to a number of major infrastructure investment programs financed by international donors, projects facing the challenge of finding a supply of suitable aggregate for construction. In 2012, examples of infrastructure projects included: (i) Kiribati Road Rehabilitation Project (KRRP) (World Bank/Asian Development Bank), rehabilitating over 32 km of main and feeder roads; (ii) Rehabilitation of the Bonriki Airport (World Bank) runway and ground facilities; (iii) Kiribati Climate Adaptation Project III (World Bank), providing coastal protection and other facilities; (iv) Betio Port Development (Japan), expanding the existing port; and (v) South Tarawa Sanitation Improvement Sector Project (Asian Development Bank), providing improved sanitation infrastructure.

Construction materials in South Tarawa have traditionally been supplied from two main sources: (i) extracted by excavators in the tidal zone at the north shore at the east end of the Betio, a port township at the extreme southwest of South Tarawa; or (ii) acquired through “beach mining” (i.e., the physical collection) of sand and aggregate materials, from beaches, reef flats or mud flats at the east of the atoll..

This paper reviews the challenges associated with meeting the demand for aggregates in Tarawa. It provides a summary of the issues at stake for the region and makes recommendations about what should be considered by donors in planning and implementing projects.

2. The growing demand for aggregates
In the coral reef and atoll environments of PICs, there is increasing demand for building materials. Demand is caused by the growing need for domestic housing, the construction building industry and increased demand for major transport facilities such as airports, roads and ports. This has in turn led to an increase in extraction of aggregates from coral reef ecosystems.

As is the case in many neighboring PICs, reef mining of aggregates is the common practice in South Tarawa. The population of Tarawa has more than doubled since the 1980s, with an overall average annual growth rate of 3.87%, reaching over 50,000 people and representing half of the Kiribati’s total population. This growth combined with ensuing development pressure resulted in significant increases in demand for construction aggregates (Government of the Republic of Kiribati (GoK), 2012). Intense and unsustainable rates of beach mining are now commonplace in many locations on the atoll, and the associated erosion and destruction of the natural protective beach profile is prevalent. The consequent degraded shoreline system leaves property, homes and infrastructure with a heightened risk of flooding which would have long-term negative impacts on the well-being of residents.

Traditionally, the main source of demand for aggregates in Tarawa came from households. Of the estimated 82,500 m³ annual demand for construction material, some 70,000 m³ is for household consumption. The 2012 estimated demand for aggregates in South Tarawa is summarized in Table 1. Mining is widespread. A 2006 socio-economic survey of 280 households actively engaged in mining revealed that “73 percent of households across South Tarawa were mining aggregate (sand, gravel, rock and shell) and of the households that were mining, a third mined more than once a week (Pelesikoti, 2007)”. Fifty-five to fifty-eight percent of those households that mine aggregate did so from their own village beaches or inland or inter-tidal flats. The materials are then used to meet household needs and for commercial use.

<table>
<thead>
<tr>
<th>Source of demand</th>
<th>Volume (m³)</th>
</tr>
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<tbody>
<tr>
<td>Household sector</td>
<td>70,000</td>
</tr>
<tr>
<td>Ministry of Public Works and Utilities</td>
<td>5,000</td>
</tr>
<tr>
<td>Maintenance/small projects</td>
<td></td>
</tr>
</tbody>
</table>
Imports 5,000
Commercial sector 2,500
Total 82,500

*Source:* Author’s elaboration.

For large scale infrastructure projects, materials are removed from the inter-tidal flats using large scale excavators. In 1986 the Ministry of Works and Public Utilities (MWPU) established a borrow area in Betio, and associated crushing yard. Materials from this site were used in the construction of the Dai-Nippon Causeway, as well as many other projects.

The currently planned international donor financed projects will create large demands for materials. For example, it is estimated that the Kiribati Road Rehabilitation Project (KRRP) will require over 20,000 m³ of aggregate and sand. By comparison, the upgrading of Betio port wharf by Japan required a relatively modest 5,900 m³. While high quality aggregates, such as those used for road surfaces, will need to be imported, there will still be major demand for lower quality aggregates such as those available from local sources.

3. **Supplying aggregates to Tarawa**

There are three main sources of aggregates in Tarawa: (i) beach mining; (ii) mechanical extraction; and, (iii) imports. Each source presents its own logistical and regulatory challenges.

3.1 **Beach mining**

The 2006 socio-economic survey revealed that beach mining is an important source of income for the unemployed in South Tarawa (Pelesikoti, 2007). Of those that mine aggregate, some 120 households rely financially in some capacity on the sale of aggregate, with 15 households relying exclusively on mining and the sale of aggregates as their main source of income. Because of the desperate need for cash, mining is carried out in the foreshore and also on the land itself, as evident in the number of visible borrow pits in the area. These miners believe that they are acting within their rights as customary owners of the land.
The Government of the Republic of Kiribati (GoK) regulates beach mining by limiting aggregate extraction to designated areas. Sand mining is permitted from the Dai-Nippon causeway channel near Betio while gravel mining is permitted from the ocean beach at the eastern end of Temaiku and Bonriki. The picture in Figure 1 shows pilings of aggregates that have been mined on a beach in South Tarawa.

![Image of pilings of aggregates](image.jpg)

**Figure 1. Aggregates from beach mining practices in Tarawa**

*Source: Author’s photo.*

Extraction is regulated through a permit system based on licensing that is supervised by the Ministry of Environment, Land and Agriculture Development (MELAD). Each license, issued for three months does not stipulate a quota or volume of material that is allowed to be mined and costs about US$ 32, of which nearly US$ 23 goes to the Lands Department and US$ 9 goes to the Division of Environment for their development consent. Outsiders who are mining in designated areas for gravel have to get the consent of the local landowner as a precondition for getting a license. Miners are supposed to pay a royalty of US$ 1.82/m\(^3\) to the landowners adjacent to the resource.

A review of the regulatory framework for Kiribati has highlighted some of the weaknesses of the current system. It is estimated that only a small proportion of the households engaged in mining actually have a license. In addition, the amount of royalty that is payable is based on the miners reporting the volume of material they have mined, so the amount often tends to be under reported. There is also a lack of enforcement of the legal beach mining practices and no effective prosecution mechanisms in place to dissuade potential offenders.
Experiences from other countries suggest that it is difficult for communities to control beach sand mining, and that trying to regulate it in the absence of a suitable alternative is nearly impossible. Over twenty years of experience in attempting to tackle the problems of regulating the removal of sand from beaches in small islands in the Caribbean has revealed that to do so, at least four supporting factors must be in place: (i) political support to stop sand mining practices; (ii) existence of a good and affordable alternative source of aggregate; (iii) continued education campaigns; (iv) addressing special interests groups with sand mining interests (Cambers, 2007).

3.2 Mechanical extraction

As noted earlier, in Tarawa, the main source of construction materials for major projects has been a crushing yard on the north shore at the east end of the Betio, a city port at the extreme southwest of Tarawa. From there, materials are extracted using mechanical equipment from a borrow pit that has been owned and operated by the Ministry of Works and Public Utilities (MWPU) since 1986, when it was first established to construct the Betio-Bairiki causeway. Materials from this site were also used in the construction of the 3.2 km long Dai-Nippon Causeway, as well as many other projects.

3.3 Imports

One challenge faced by all users is the suitability of materials. Research in the Federated States of Micronesia (FSM) has shown that construction aggregates from coral rubble with a high calcium carbonate, as found in the area, generally tend to have poor engineering properties; such aggregates have low unit weight and have low crushing/compressive strength (Maharaj, 2001). This is because construction aggregates from Pacific islands are almost entirely made up of reef carbonates, with more than 50-70 % coral gravel, skeletal sands and sea salts. As a result, these aggregates are angular — with high aspect ratios, void ratios, and porosity — and of low densities that can give them poor engineering properties (Maharaj, 2011). Although these types of aggregates have often been used in many previous infrastructure works, the presence of chloride ions from the salts can cause chemical reactions with cement and steel if they go unwashed and are used in concrete and steel-reinforced concrete (Maharaj, 2001). To remove salt and improve the desired engineering application, these aggregates require additives to improve its strength depending on the desired engineering application and may need to be washed. Not washing the aggregates may lead to further corrosion and cracks, with implications for safety and maintenance costs (Maharaj, 2001). Since many islands suffer water shortages, washing is
often not done. In Tarawa, the best aggregate comes from the ocean side, with the lagoon having weaker materials. This material quality issue often contributes to poorly performing infrastructure, otherwise projects have to import high quality aggregate from sources in countries like Fiji, some 2,200 km away.

The materials extracted in South Tarawa will not meet the technical requirements of hardness and wear of most ongoing and future road construction projects. The aggregates may be suitable for other roles such as fill, but it will always be necessary to import high quality aggregates to South Tarawa for pavement surfacing and for use in high strength concrete. For example, the recent Betio port wharf development funded by Japan imported some 550 20-foot containers with aggregate and sand from Fiji, each containing some 10 m$^3$ of aggregate. The KRRP road project envisaged importing 12,500 m$^3$ of base material, and sufficient aggregate for some 85,000 m$^3$ of asphaltic concrete surfacing.

Importing aggregates poses environmental challenges as well. One risk is the importation of foreign organisms to the ecosystem of the imported country. The approach used by Japan, which involves fumigating the construction materials imported in containers, can help prevent bio-contamination and represents a good safeguard from an environmental perspective. Such an approach, on a larger scale, will be done for importing surfacing materials for the road and aviation projects. However, importing by barge significant volumes of aggregate for major infrastructure projects to Pacific island countries is not economically viable, although it is the practice in other parts of the world, such as in the Cape Verde islands, the Gambia, Senegal, India or Sri Lanka.

Another practice can include modifying the infrastructure design and construction practices in order to reduce reliance on imported or locally-mined aggregate. Pre-cast building panels and beams could be imported instead of casting these aggregates in situ. This also gets around the problem of water shortages. Concrete, brick or stone paving blocks or setts, which are placed directly on a sand base, could replace asphalt or concrete pavements that require aggregate base courses, as is the case in the Maldives. Similarly, stone and brick masonry could replace cement concrete in buildings and other structures, with rock and bricks imported by barge. The need for aggregate can also be reduced by using lime- or cement-stabilized soil/sand blocks that can be manufactured at household and community level with simple manually-operated extruding machines. This technology has been used in Kiribati for building schools.
4. **The Environmentally Safe Aggregates Tarawa project**

Beach mining is extremely environmentally damaging. Materials are manually collected from the beach areas, screened and bagged for sale. Studies in Tarawa and elsewhere have highlighted the causal link between the coastal mining of aggregate and the increased threat of erosion and flooding in coastal communities (Webb, 2005; Webb, 2006; Worliczek, 2010). The removal of aggregate material from the foreshore reduces the buffering effect and exposes the coastline to increased wave energy. Additionally, given the well understood vulnerability of atolls to the effects of climate change-induced stresses such as sea level rise and coral bleaching, shoreline resilience is a critically important priority. Those resource use pressures which can be better managed (such as beach mining for construction materials) must be addressed (See Box 1).

**Box 1, Examples of negative effects of climate change on atolls due to global warming**

- Sea level rise leads to loss of habitat through coastal inundation, saline fouling of fresh groundwater resources, and drowning of coral reefs;
- Change in frequency of El Niño-La Niña weather cycles with intensifying of weather conditions either through drought or rain periods. This promotes coastal erosion from enhanced runoff, as well as wind and wave storm damage;
- Periods of high ambient temperature causing coral bleaching;
- Potential change in the ocean currents;
- Ocean acidification which inhibits calcification of corals, coralline algae and shelled organisms

*Source: Mimura et al. (2007); Lovell (2012).*

In Tarawa, concerns about coastal erosion linked to unmet demand for aggregates grew in the mid-1990s. A field study conducted by the Secretariat of the Pacific Community Applied Geosciences and Technology Division (SOPAC) in 1995 identified the need for an economical source of aggregate materials to replenish eroding beaches and provide materials for construction, leading the GoK to review the usefulness of offshore materials in meeting demand (Cruickshank, 1998).

SOPAC developed the Environmentally Safe Aggregates Tarawa (ESAT) project with financial support from the European Union. The financing includes the construction of a dredging barge to extract materials from the lagoon area north of Betio where it will be possible to undertake progressive extraction of aggregates to meet the needs of Tarawa for more than 50 years at the present rate of consumption (Lovell, 2011) The scale of extraction within the lagoon and relative to the atoll is shown by the small colored area north of Betio (See Figure 2).
4.1 Aggregate dredging and its environmental impacts

Mechanical extraction of aggregate will be done using a dredge equipped with two clamshells, one heavy duty (capacity 2.6 m$^3$) with teeth for loading the coarse aggregates and rock and a standard duty one (capacity 3.5 m$^3$) with knives for loading sandy aggregates and unloading all the aggregates. The operation, from dredging the material to on-site sales to the public and other users, will be carried out by the Government-owned company, Atinimarawa Co. Ltd (ACL) (See Figure 3). The aggregates will generally not need to be cleaned, except for those targeted for high stress applications or premium activities such as when used for reinforced concrete. Where washing is required, the ESAT project will use a desalination unit located directly opposite the proposed processing yard, rather than using the limited available local water supplies.

Figure 2. The location of the extraction site

Whereas it has a positive environmental impact by reducing beach mining, the project also has potential negative environmental consequences. There will be a need to monitor and better assess the potential impacts of sediment plumes and habitat loss in areas used by artisanal fishers in North Tarawa. Monitoring key ecological indicators will help alert project managers to the rate of change and whether thresholds had been exceeded. In cases where these thresholds are exceeded, the project will need to cease operations in that area and resume in another suitable site while the initial site recovers. It may also be advisable to decide a priori to rotate dredging sites so as to allow borrow pits to recover. The project should also prohibit dredging during seasons of heavy monsoons were currents would carry sediment plumes over living reef.

Dredging could have negative impacts on the fish population, even though most fish are caught outside the lagoon, some distance from Tarawa. Limited amount of reef fish are available daily and most of these are fished from different areas of the lagoon. Most fishermen avoid fishing for different types of reef fish on lines on the ocean-side of Betio because it is generally believed that there is a high probability of ciguatera fish poisoning from fish caught from this side of the island.

There could also be a negative impact on fish from the noise caused by the dredging operations. The dredging vessel’s engine noise during transit and at mooring and the mechanical din of the clamshell grab during the removal of the substrate (1hour/day) could be a harmful disturbance to fish. The issue is a concern based on experience with the fishing method called “te ororo” whereby a crowbar is used...
underwater and the noise from the banging of the metal against rock and rubble on the lagoon floor has the effect of forcing the fish to the gill nets.

There are concerns that noise from the grab as it hits the lagoon floor may be heard some distance away from the dredging site and scare away fish in nearby fishing grounds, having both environmental and socio-economic repercussions. There is also some concern about the impact of dredging operations on the seasonal spawning runs of species like te maebo (goat fish) and bone fish. Depending on the severity of the impacts, dredging operations and fishing should cease during the spawning season of reef fish that are commercially valuable.

Unfortunately, very little research has been carried out on the effects of noise produced by dredging activities on marine life. Information is sparse and no study provides a clear assessment of the direct behavioral responses of fishes to dredging-produced noise (Hawkins and Popper, 2012; Rich, 2011). A number of studies infer from findings of behavioral responses of fish to noise generated by non-dredging activities, such as the noises of fishing vessels and gear. The inference for the fish response to typical dredging activities is that fish will likely respond behaviorally to perturbations such as suspended sediment plumes, noise (sound) and entrainment (Rich, 2011). Depending on the proximity of the fish to the impact area, the nature of soil, and the dredging tools used, the likely fish behavioral responses to these environmental perturbations will include avoidance/attraction/alarm reactions as well as changes in migration, habitat preference, and foraging and predatory behavior, resulting in changes in fish presence, distribution and abundance (Hawkins and Popper, 2012; Rich, 2011).

5. **Social considerations arising from ESAT dredging**

Fish is essential to the daily diet in Tarawa. During consultations for the ESAT project, concerns were raised about the impact of the dredging on fishing and the consequent social impacts. This is because dredging activities can impact the livelihoods of people who fish to sell their products, who fish for their food, or who buy fish for food. Changes in fishing practices could also in turn impact local diets. Residents of Tarawa have a preference for reef fish, which are believed to be tastier, and there are more ways of preparing them so that the taste is varied. If the fish population were to be reduced as a result
of dredging, people could resort to less healthy canned foods to break the monotony of having to increasingly eat different tuna species to compensate for the reduction of the reef fish population. This could force people to eat less nutritious diets with higher fat-content and alternative proteins such as canned fish and corned beef.

Dredging could also have consequences for the welfare of Kiribati’s residents who are either sellers or users of aggregates. Sellers of aggregates rely on beach mining for their livelihoods. A 2006 household survey found that 206 out of 280 households surveyed were involved in some form of beach mining. These miners believe that they are acting within their rights as customary owners of the land, and they will likely lose economic opportunities when the ACL operations commence. Out of the 280 households, 147 females (52.5 %) and 133 males (47.5 %) were interviewed. Of the households that are known to mine any amount of aggregate, almost an equal number of females (70.1 %) and males (78.2 %) confirmed that members of their household do mine aggregate. However, actual aggregate mining is a task carried out mostly by men only (51.9 %) rather than women only (5.3 %) and some (42.1 %) where both males and females did the mining (Pelesikoti, 2007).

For users of aggregates on the island, a main interest is to avoid the curtailment of their long standing customary rights to mine aggregates and sand from their own beaches or from their relatives through some kind of mutual agreement. It is argued that these customary rights have been strengthened by the Foreshore Amendment Act of 2006. The Amendment provides for certain rights to landowners with respect to the granting of licenses for the extraction of materials from the foreshore. This includes their rights to be compensated for the gravel or sand or other like substances removed from their land pursuant to a license issued under the Act. This group includes households which mine aggregates, gravel or sand for their own use — either for the construction of homes and other buildings, the building of seawalls, or for landscaping. This group currently mines aggregates from the beaches of their own lands, from those of their relatives and friends, or from designated extraction sites. Usually, their mining is a one-off activity to meet a specific need, and once that need is met, mining ceases. Such mining activity (i.e., mining from one’s own beach or that of a relative) has been going on for a long period of time and it is customary practice. This group will likely purchase aggregate from the ACL as long as it priced appropriately (i.e., equal to or below the current price of US$ 2/bag).

6. Implications of dredging in Tarawa
There are clear potential negative social and environmental impacts associated with dredging. These impacts need to be assessed against the current alternative methods of aggregate sourcing: (i) the continued use of beach mining materials; (ii) mechanical extraction from the intertidal zone; and (iii) importing aggregate materials from overseas.

The ESAT project is both environmentally and economically the most cost efficient option, considering that importing materials is associated with long distance transportation costs and that it would not be possible to determine the environmental impact of imported dredged materials on the areas outside the project.

Research undertaken in the context of due diligence for the World Bank financed KRRP project confirmed that there is a general agreement that extraction of sand and gravel from a confined area of the Tarawa lagoon will be greatly beneficial in lieu of the current practice of taking it from the coastal beaches. Environmental damage from such extraction should also be minimal. However, there are important potential social impacts associated with the program that cannot be underestimated. Two of the recurring questions from the attendees at public consultations reflected these aspects: (i) how would the dredging affect the fish stock in the areas to be dredged; and, (ii) what will happen to those people who currently mine aggregates and depend on them for their main source of income. Neither of these questions was adequately addressed during the original design of the ESAT project.

To ensure that fish stocks are protected, the World Bank recommended that dredging plans include proper, regular monitoring and better assessment of the potential impacts of sediment plumes and habitat loss in areas used by artisanal fishers. The cost of monitoring and assessment should be internalized as part of the operating cost of dredging. The monitoring of key ecological indicators would alert project managers to the rate of change and whether thresholds had been exceeded. If so, the project would need to cease operations in that area and resume in another suitable site within the designated boundary, allowing the initial site to recover. This work should include monitoring the impact of sediments and turbidity on the biota, monitoring the impact of noise on fish stocks and if the link between fish stock and noise level is established, to then cease dredging operation during spawning and other times to allow for fish stock recovery.

It is important to ensure that dredging is not conducted during seasons of inclement weather, king tides, heavy monsoons, etc., when currents would carry sediment plumes over living reef. Dredging operations
should not interfere with the seasonal spawning activity of important reef fish. Time limited closures of dredging activity may be required during the height of spawning activity if dredging is observed to have negative effects.

The World Bank also recommended ensuring that clear livelihood restoration plans, prepared with impacted people’s inputs, are put in place before dredging begins. For example, it will be important to create jobs for those currently involved in beach mining. Alternatively, they could be provided access to dredged material at a competitive price so as to create incentives for them to switch to obtaining and selling sand and gravel from the ESAT project. Failure to properly consider livelihood restoration will lead to severe economic hardship on the affected households. These economic incentives, along with stricter regulations and environmental education on the serious impacts of beach mining in low lying coral islands, should help communities to eventually stop beach mining altogether. People whose diet or income would be affected by the dredging should be consulted and their views considered when preparing the livelihood restoration programs so as to ensure that any impacts are well mitigated.

7. Conclusions and recommendations

The current threats posed by climate change, combined with the current practice of beach mining, increase the likelihood of damages and disasters associated with rising sea levels. The growing demand for construction materials in South Tarawa provides an example of the environmental and social challenges of ensuring sustainable use of non-renewable resources and of dealing with the vulnerability of small islands to climate change.

Donors of large investment programs have an important role to play in ensuring that materials used on their projects have been obtained in an environmentally and socially sustainable manner. These projects often place significant demand for aggregate, and failure to consider the manner in which it is sourced may lead to unintended negative consequences. Japan’s approach for the Betio wharf improvement project — importing all materials from overseas — is not viable for large projects such as roads where moderate quantities of lower standard materials are required for fill. Ideally, these should be locally sourced in a sustainable manner.
Experiences from other island countries suggest that controlling beach sand mining by communities is extremely difficult without suitable and complementary approaches. More than twenty years of experience in attempting to manage the problems of regulating the removal of sand from beaches in small islands in the Caribbean has revealed that a number of supporting factors must be in place, such as: political support to stop sand mining practices; the existence of a good and affordable alternative source of aggregate; continued education campaigns; and confronting special interests groups with sand mining interests (Ramsay et al., 2000).

In South Tarawa, unless appropriate sources of aggregate supply are found, continued beach mining and other inappropriate coastal developments are likely to continue. To compensate for the lack of natural coastal protection, the atoll may ultimately require the building of artificial defense structures. Three main options for starting to control mining that should be considered include: (i) banning household extraction along the coastline; (ii) identifying and developing an alternative supply of aggregate for domestic use; and, (iii) establishing a commercial aggregate company to undertake dredging in the lagoon and relocate all extraction from South Tarawa to a more sustainable alternative source of aggregates.

In this context, the ESAT project should support the achievement of the overarching goal of providing an affordable, sustainable and reliable supply of construction sand and gravel as an alternative to beach sand mining. The project could also help achieve the long-term objectives of job creation and access to dredge material at a competitive price to those involved in beach sand mining, thereby creating incentives for them to switch to obtaining and selling sand and gravel from the ESAT source.

The ESAT project could help formalize a market for legally supplying aggregates. It could facilitate the setting up of prices that would achieve the dual objective of allowing subsistence users to access aggregates at affordable prices while at the same time making sure that prices remain high enough to control for greater volumes of demand. Making the dredged material slightly cheaper would reduce the incentives for beach mining, whereas the dredging related operations, such as the sorting of dredge material into different categories of aggregate for sale, could foster employment opportunities to individuals currently selling beach materials. This, along with an education and communications campaign on the environmental consequences of beach sand mining, could help wean the local population off of these destructive practices.
Considering aggregate removal’s influence on fish stock, a recent Environmental Impact Assessment reported that the ESAT project dredging area is relatively small, and monitoring will help assess the nature of the operation. Should the impacts be at an unacceptable level, adaptive management alternatives will be used. It is recommended that the dredging schedule not disturb more than 10% of the dredging area in any one year, leaving 90% untouched. The operation should be subject to strict monitoring guidelines regarding sediment loads, turbidity, and its potential impact on the benthic community. In addition, there should be an operational plan to minimize the impact of the barge, which should include a 2-year monitoring program. For the mined area, a rehabilitation project should be developed. If negative impacts are observed, strategic decisions should be made to ensure environmental sustainability in obtaining aggregate supply.

There are also social costs associated with eliminating beach mining, particularly in a poor country such as Kiribati where many people rely on the practice as a source of income. Projects need to carefully consider livelihood restoration opportunities for possible future economic losses to current beach miners. To support the ESAT project in minimizing social costs, a Community Participation Programme (CPP) was prepared, guided by a Communications Strategy developed in early 2011.

In cases where miners have interacted with the ESAT project, three main options are being considered with a distinction being made between large operators, and small, often family based “illegal” operators (Leney, 2012). In this context, the latter group is of particular relevance as they are likely to be most exposed to loss of livelihood following the start of off-shore dredging. For miners who wish to continue in the aggregate supply business, the CPP will provide a direct link between the ACL and the miners, so that the existing miners may be employed at the crushing yard or as aggregates processors and sorters who take raw materials from the dredge by the unsorted truckload and process them. Unsorted aggregates would be brought to the small operators where they would be able to buy them at a reduced rate, sort them and sell them directly to customers at the going market rate. For miners whose mining businesses are small, the forming of a cooperative society was discussed with the miners and suggested by the study. This option will need to be further explored and will require identifying community leaders among the miners who could play an active role in establishing such a cooperative. For miners who may not wish to join a cooperative, the ESAT project can, for those who have participated in the CPP survey, facilitate their entry into the formal labor market via the Ministry of Labour employment register. This register is where jobs for large infrastructure construction work are obtained.
As part of a Livelihood Restoration Plan, members of households who have been totally dependent upon mining will likely get preference in employment; establishing simple, transparent and easily monitorable selection criteria with adjustments made after the first two years, as experience is gathered, is recommended. As it is general practice in Tarawa to employ workers from the village where a project is being implemented, using a certain percentage of previous miners as laborers for each project to facilitate better coverage should also be considered.

Although the project is in its early stages of implementation, careful review of the social and environmental challenges and risks posed by the need for aggregates in infrastructure projects has shed light on South Tarawa’s increased coastal erosion and the associated degradation of the shoreline caused by unsustainable rates of beach mining. A review of current and projected infrastructure needs of both the public and private sectors should be undertaken to better understand the supply needs and the demand for dredge material going forward. This would assist in the development of policies to limit new construction in an effort to curb the demand.
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