

17. Future Development of Beach Nourishment Project

17.1 Overview

The Project is the first trial in applying the ecosystem-based and user-friendly type of coastal protection measure in the Pacific island countries, which is the beach nourishment using coral gravel and sand, to recover the original image of the natural beach. Thus, it is required to clarify the level of understanding and get opinion for this new type of coastal protection measure to the government of Tuvalu, community, and Funafuti people.

Even though the Government of Tuvalu and/or the public opinion of Tuvalu showed a positive request to apply the same type of protection measures, it is also required to clarify the feasibility for procurement of nourishment materials such as sand and gravel.

This chapter shows the feasibility for future development of same type of protection measures, beach nourishment in Tuvalu and other Pacific island countries.

17.2 Level of Understanding for Nourishment Based on Interview Survey

Interview survey was conducted to evaluate how a concept of beach nourishment had been well spread and made public through the Project. While comprehensive results of the survey are described in Chapter 14 in this report, results related to the level of understanding on the beach nourishment are summarized in this section.

Figure 17.2.1 shows the interview survey results on both “project purpose” and “project effect” for residents. With regard to “project purpose”, most of the respondents recognized that the Project was implemented for protection and did not put weight on the other benefits based on the Project purpose. On the other hand, in terms of Project effect, the respondents highly evaluated environment (85%) and beach use (56%) compared with protection (29%). Thus, it was confirmed that respondents well recognized the effect of the beach nourishment after implementation.

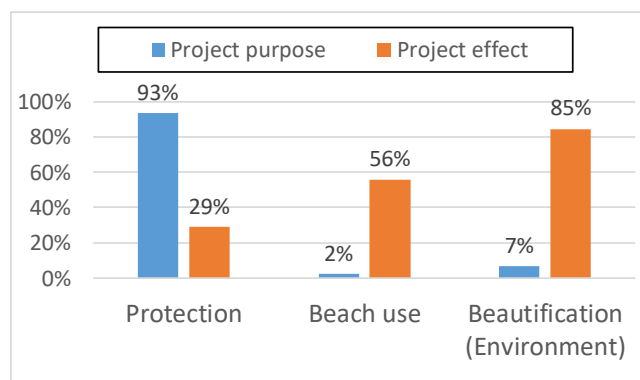


Figure 17.2.1 Interview Survey Results on Project Purpose and Project Effect

(Source: JICA Expert Team)

Table 17.2.1 shows the interview survey results on “desirable coastal conservation measure to be applied in Tuvalu” for both residents and government officials. It was confirmed that the beach nourishment was selected as desirable coastal conservation measure for both residents and government officials. And it should be noted that most of the respondents did not even know beach nourishment before the Project started. Reasons behind those who preferred seawall was due to its safeness against high waves and less maintenance, while those who preferred the beach nourishment was due to environment and beach use.

Table 17.2.1 Interview Survey Results on Desirable Coastal Conservation Measure

Target (Sample No.)	Beach nourishment	Seawall	Both	Not Sure
Residents (62)	73%	3%	19%	6%
Government officials (27)	44%	19%	33%	4%

(Source: JICA Expert Team)

Table 17.2.2 shows the interview survey results on “do you want to apply a beach nourishment to other coastal areas in Tuvalu?”. It is obvious that most of the respondents for both residents and government officials had positive opinion to apply beach nourishment in other areas in Tuvalu for coastal conservation.

Table 17.2.2 Interview Survey Results on Willingness to Apply Beach Nourishment

Target (Sample No.)	Yes	No	Not Sure
Residents (62)	93%	2%	5%
Government officials (27)	85%	4%	11%

(Source: JICA Expert Team)

From these results, it is concluded that the concept of the beach nourishment had been well recognized among the people in Funafuti and they understand the effect of the beach nourishment even this was quite a new coastal conservation measure applied in Tuvalu. As for the results, most of them have requested for the development of beach nourishment in other areas in Tuvalu as well.

17.3 Feasibility for Procurement of Nourishment Material

(1) Types of Nourishment and Required Materials

Several types of beach nourishment methods exist and the appropriate method shall be selected taking into account the different characteristics of wave and beach condition, possible procured materials, condition of beach use, etc. There are mainly two types of beach nourishment, i.e., “Dynamically stable beach” and “Statically stable beach”. “Dynamically stable beach” is basically just fill sand and/or gravel for nourishment and supplementary coastal structures to control the nourishment such as groin, headland, offshore breakwater, etc., are not employed. On the other hand, “Statically stable beach” is the nourishment with supplementary coastal structures to control filled material for nourishment. Also, there are

several options of employed material for nourishment. Sand beach is the most popular in nourishment. However, gravel or combined gravel and sand beach are also employed depending on each site condition. The reason why combined coral gravel and sand was employed in the Project was to consider the original formation of beach and land in Funafuti Atoll, people's request especially for beach use, and procurement condition of material as pilot-scale (not full-scale) project.

There are also several options for structure type of supplementary coastal structures such as rubble type, concrete block type, concrete type, flexible type (geo-bag, geo-tube, etc.). In the Project, rubble type of groin using armor rock was employed taking into account the durability, beach use, and landscape. Even though there are several options; and required material is variable depending on selected type of nourishment and structure type as mentioned above, the procurement for gravel, sand, and armor rock are discussed in this chapter as main representative materials for the future expansion of the same type of coastal adaptation measure in Tuvalu.

(2) Gravel

1) Possibility to obtain gravel from Funafuti Atoll

The Project is the pilot-scale project and the total required quantity of gravel was not so big at about 3,200 m³. In the planning and design stage (Phase-1), two options were compared, which were imported from Fiji and taking from sandspit in the nearby island in Funafuti Atoll. As a result of the comparison study for construction cost and environmental impact, it was decided to employ the accumulated gravel at the tip of sandspit in Funamanu and Papanalae islands, which was formed by wave action during Cyclone Bebe in 1972.

On the other hand, it was not allowed to extract significant quantity of gravel from land side for future full-scale projects considering the possibility of negative impact to the surrounding beach. However, it was found that certain amounts of gravel exist on the seabed at the channel, which is located on the west side of Funamanu Island (Figures 17.3.1 and 17.3.2), as a result of the diving survey in Phase-1 (refer to the supporting report-1 ITR1, pp.5-18 to 5-20). Because the coral gravel on the beach on the four islands (Fongafale, Fatato, Papanalae, and Funamanu) was provided mainly from the ocean side due to strong wave action on the ocean side. Accumulated gravel on the beach gradually transported to the west and dropped into the deep channel on the west side of Funamanu Island, based on the finding result in Phase-1. Even though further investigation is required, there is a possibility that this location will become one of potential borrow sites for gravel extraction to be utilized for future full-scale project.



Figure 17.3.1 Location Map for Gravel Mining Site

(Source: JICA Expert Team)



Figure 17.3.2 Seabed Condition on the West Side of Funamanu Island
(Inside the Lagoon)

(Source: JICA Expert Team)



Figure 17.3.3 Example for Crane Barge Attached with Clam Shell Bucket)

(Source: Website Alamy (<http://www.alamy.com/stock-photo/dredge-crane.html>))

The depth of the channel on the west side of Funamanu Island is too deep about more than 20 m. Furthermore, strong current occurs at this area due to tidal inlet. The construction method for taking gravel from the deep seabed might be using only a crane barge attached with a clam shell bucket (Figure 17.3.3). However, the production rate might be too limited due to limited bucket size, cycle time for one unloading, and wave and strong current condition. This will cause increase in construction cost. Further study for both checking the potential volume and the construction method is required for future expansion of the Project.

There is another possibility to obtain the gravel from Funafuti Atoll. The sand dredging activity from the seabed on the lagoon side was carried in 2015 for the borrow pit Project by New Zealand (NZ) Aid and following reclamation project by the government of Tuvalu. At that time, it was observed that some portion of gravel contained in dredged sand as shown in Figure 17.3.4. Figure 17.3.5 shows the beach condition at the retreat area of the reclamation area after filling the dredged sand. After the dredged sand was washed out by wave action, only the gravel was retained on the beach. From this observed phenomenon, certain rate for the contents of gravel in the seabed material is expected. Even though further investigation is necessary to identify the quantitative rate of contents of gravel, there is a possibility to obtain the gravel from the dredged sand.



Figure 17.3.4 Sand Dredged from the Seabed on the Lagoon Side

(Source: JICA Expert Team)



Figure 17.3.5 Retained Gravel after Filled Dredged Sand

(Source: JICA Expert Team)

The construction method is just dredging by using several types of dredger. The cutter suction dredger with direct pumping to the land was employed in the previous project. However, another option for selection of dredger and sand filling method is also feasible depending on the site condition.

2) Import from other country

In case that the possibility to procure the gravel in Tuvalu is low, another option is to import from other countries. Basically, it is difficult to obtain the natural produced coral gravel from other countries due to environmental issue as same as the Tuvalu case. Thus, the imported gravel will be a volcanic one or crushed rock from land quarry site. Considering the increase

in transportation cost, it is better to import nearby country from Tuvalu. Even so, the material cost will significantly become high. Based on the comparison study for material cost of gravel between imported and self-procured one (taking from Funamanu and Papaelise) in Phase-1 stage, the price for imported materials from Fiji was about double the price than the self-produced one (refer to the supporting report-1, ITR1, pp.5-21 to 5-25).

(3) Sand

The seabed of Funafuti Atoll consists of coral sand with some contents of coral gravel. Tuvalu country consists of five atolls and four islands. Basically, the seabed condition at the other atolls is also expected to be at the same situation as Funafuti Atoll. Thus, coral sand is only the material to be utilized as coastal protection measures.

However, the grain size of sand is very important for stability of nourished beach. In case that the grain size is fine, it is easily moved by wave action. The beach slope also becomes mild and easy to move to offshore. Based on the preliminary survey result of seabed material on Funafuti Atoll in Phase-1 Stage, several potential areas of sand borrow were identified at Fongafale-north, Fongafale-south, and Fualifeke. Based on the rough estimation as a result of Phase-1 Stage, about 300,000 m³ of potential sand with suitable characteristics as nourishment material was expected in Funafuti Atoll (refer to the supporting report-1 ITR, pp.5-27 to 5-32). However, this preliminary survey was just carried out at limited points. Further detailed investigation is required to identify the quantity and quality of sand with certain accuracy.

The construction method is only dredging using several types of dredger as mentioned before. Figure 17.3.6 shows the dredging activity during the Borrow Pit Project by NZ Aid as one of the examples. The cutter suction dredger was employed and the dredged sand was pumped and discharged into the borrow pit directly using a discharge pipe.



Figure 17.3.6 Sand Dredging Activity (Borrow Pit Project by NZ Aid)

(Source: JICA Expert Team)

In case that the dredging area is close to the beach and depth is shallow, the dredging activity may cause a negative impact to surrounding beach, namely, further beach erosion might be occurred. Thus, it is very important to select the dredging site taking into account the

presumed impact to the beach. In general, the depth of dredging is recommended to be set more than 15 to 20 m. Beach monitoring at the surrounding coast is also required to assess the impact after the dredging activity if the dredging area is close to the beach or shallow water area.

(4) Armor Rock

As Tuvalu Island was formed by accumulated coral gravel and sand, it is impossible to obtain armor rock with certain size and weight. Even if the construction site will be on the lagoon side, where the wave condition is calm and the design wave height ($H_{1/3}$ for 30-year return period) is about 1.6 m based on the design calculation in Phase-1 Stage, about 1 ton size of armor rock for rough shape is required to secure the stability of rubble type groin (refer to Progress Report). The only possibility to procure the armor rock is to import from outer countries. Considering the transportation and resulting material cost, the armor rock was imported from Taveuni Island in Fiji (Figure 17.3.7). The Government of Tuvalu also imported the armor rock from Nauru for the use of construction of revetment at the reclamation area (Elizabeth Park, Figure 17.3.8).

According to the design standard for armor type of structure, the required stability weight for armor is significantly different between rough shaped armor and rounded one. It is recommended to apply the armor rock with rough shape for economical design.

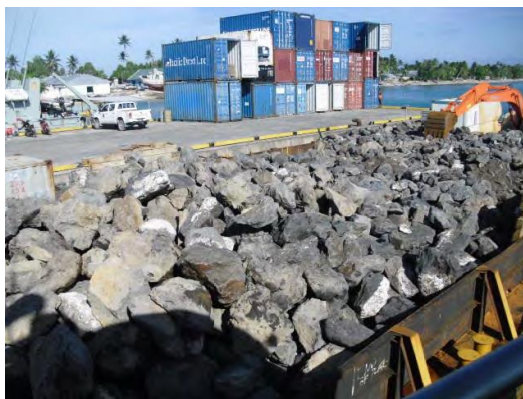


Figure 17.3.7 Armor Rock from Taveuni
(JICA Gravel Beach Project)

(Source: JICA Expert Team)



Figure 17.3.8 Armor Rock from Nauru
(The Government of Tuvalu Reclamation Project)

(Source: JICA Expert Team)

17.4 Possibility for Implementation of Beach Nourishment Project in Tuvalu

(1) Basic Idea for Potential Project Area

The basic ideas to examine the implementation plan for beach nourishment project are described as below, taking into account the necessity and possibility of beach nourishment measure in Tuvalu Island based on the obtained information through the Project.

- Main target island for the implementation of coastal adaptation measure using beach nourishment may be Fongafale Island, which has been threatened by the risk of coastal disaster due to coastal erosion by anthropogenic land alternation and increase of environmental load due to rapid population growth in the recent ten years.
- Other coastal issues have been also identified on other islands, Nulufetau, Nanumea and Nanumaga in Tuvalu. However, the United Nations Development Programme (UNDP) has already implemented the coastal protection in Nulufetau, while Nanumea and Nanumaga have also covered by the “Tuvalu Climate Adaptation Project (TCAP)” as implemented project site. For this moment, it seems that there are no other sites that urgent remedy is required.
- Beaches on the ocean side of Fongafale Island were covered by natural gravel and this condition has been maintained until now because of no anthropogenic land alternation on the ocean side. Furthermore, no sandy beach exists on the ocean side ever since. Thus, the required and potential area for applying the beach nourishment measure might be the coastal area on the lagoon side.
- Two coastal projects have been undertaken in the central part of Fongafale Island, which are the “Pilot Gravel Beach Nourishment by JICA” and the “Reclamation and Nourishment Project by the government of Tuvalu”, as shown in Figure 17.4.1. Furthermore, the coastal area from the Funafuti Wharf to the south with approximately 1 km alongshore distance will be covered by the TCAP. On the other hand, serious coastal erosion problems have been identified on both further north and south coasts on the lagoon side with roughly 3 km and 1.5 km, respectively, as shown in Figures 17.4.2 and 17.4.3. The hinterland on these coasts are also highly utilized as residential and public area. From this, the potential area for future coastal adaptation using beach nourishment is assumed in these two coasts.



Figure 17.4.1 Existing and Potential Area for Beach Nourishment Project

(Source: Google Earth Pro arranged by the JICA Expert Team)



Figure 17.4.2 Beach Condition in the North Area of Fongafale Island

(Source: JICA Expert Team)



Figure 17.4.3 Beach Condition in the South Area of Fongafale Island

(Source: JICA Expert Team)

(2) Expected Implementation Schedule

One ideal implementation schedule for the future potential project of beach nourishment in the next ten years is shown in Table 17.4.1, taking into account the tentative schedule for the TCAP, which was presented in the inception meeting in August 2017. Even if it is difficult to say the expected funding body for this moment, it is suggested to consider the future image of coastal adaptation in Tuvalu to ensure to mitigate the coast against future risk on coastal disaster.

Table 17.4.1 Ideal Implementation Schedule for Beach Nourishment Project

Project	Location	Planned Area	Activity	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	
TCAP (by GCF)	From the Funafuti Wharf to the south	about 1 km	Coastal Assessment	■											
			Construction		■	■	■	■	■						
			Maintenance & Management						■	■	■	■	■	■	■
(Project A)	From the Funafuti Wharf to the north	about 3 km (assumed)	Planning & Design					■	■						
			Construction						■	■	■				
			Maintenance & Management								■	■	■	■	■
(Project B)	South of Fongafale	about 1.5 km (assumed)	Planning & Design					■	■						
			Construction								■	■			
			Maintenance & Management										■	■	■

(Source: JICA Expert Team)

17.5 Subject and Consideration Points

Based on the results of Section 17.2 and 17.3, the subject and consideration points for maintenance and management of the Project beach and future expansion of full-scale project for beach nourishment are summarized in this section.

(1) Maintenance and Management for Pilot Gravel Beach

Subject

- 1) Concrete adaptive measure for abnormal condition (possibility for drastic change of beach condition due to abnormal wave condition)

Almost two-year beach monitoring was conducted and characteristics of beach behavior for seasonal change and high wave condition have become clear. On the other hand, even though several high wave conditions were experienced, e.g., during Cyclone “Ula” in January 2016, Cyclone “Winston” in February 2016, extreme condition under combined abnormal wave and tide conditions has not been experienced. The maintenance work and procedure of the Project beach as adaptive measure was also recommended and executed in the Project. However, the

recommended maintenance was based on the limited monitoring period and not for abnormal external condition. Therefore, there is a possibility to require the different adaptive measures for abnormal external condition.

2) **Maintaining basic understanding, procedure and taking realistic action of Kaupule and Funafuti communities on beach maintenance and management**

Continuous beach maintenance and management has been undertaken for two years after the construction mainly by Funafuti Kaupule and the community, and successive results for community-based beach maintenance and management have been obtained. However, even though the action on beach maintenance and management has been undertaken by Tuvaluan side through the Project, and they have committed to take action continuously after the Project, it is uncertain that they surely carried out or not. Especially, it is uncertain in case of after retirement of present members of Kaupule who have been related to the maintenance and management work in the Project. Because, the replaced new members might not be so familiar and capable to maintain the beach due to less experience on beach maintenance and management work.

3) **Maintaining the required equipment for maintenance in Kaupule**

Special equipment is not required for the beach maintenance work of the pilot gravel beach. Based on the experience of undertaking beach maintenance in the Project, it was realized that excavator and wheel loader were contributed mainly to the beach maintenance work. Kaupule has owned such two equipment, which were procured from the contractor after the completion of construction. However, several parts have already been damaged and it is not sure in securing of durability of the equipment. It is necessary to consider securing the equipment for continuous beach maintenance after the completion of the Project.

4) **Securing sand for maintenance of the Project beach**

As the monitoring result, total volume of filled sand has been decreased a little by continuous wave action, even though the beach could be maintained in stable condition. Stocked sand with roughly 80 m³ was employed for adaptive measure in September 2017 with acceptance of the Government of Tuvalu. According to the information from the government of Tuvalu, the stocked sand will be mostly utilized in the maintenance of reclamation area (Elizabeth Park) and material for planned building construction. At this moment, there is no sufficient sand to be used for other purpose. From such current condition, it might be difficult to obtain the acceptance of the Government of Tuvalu for the use of stocked sand in the next time for maintenance of the Project beach.

Consideration Point

- 1) Necessity of continuous monitoring by the Tuvaluan side and sharing of information of beach condition to related parties

The necessity to execute the adaptive measure after acting the abnormal external condition will be judged based on actual beach condition. Thus, the continuous beach monitoring carried out by the Tuvaluan side is strongly requested to know the relation between acting wave and tide condition and resulting beach change. Further, it is important to share such information to the related stakeholders in Tuvalu and other parties who are interested in the same coastal issue.

- 2) Necessity to establish the “interactive activation structure” on beach maintenance and management between beach users and management side

It is necessary to establish the “interactive activation structure” on beach maintenance and management among related stakeholders both beach users (Funafuti people) and management side (Funafuti Kaupule and the government of Tuvalu) in order to achieve the community-based beach maintenance and management. In the Phase-3 stage of the Project, the set of “organizing of community participated beach sports events” and “implementation of adaptive measure” was conducted for the purpose of achieving such structure on beach maintenance and management. Continuing such events based on strong request from the community is expected to lead the driving force to ensure the realization of community-based beach maintenance and management by Funafuti Kaupule sustainably maintaining their passion and motivation, even if the present members will be changed.

- 3) Consideration for procurement of required equipment for beach maintenance

It is hard to do such adaptive measure proposed in the Phase-3 stage of the Project without the excavator. Also, the condition of present excavator is getting worse due to damage of several parts. It is requested to consider the possibility of procurement of new excavator for maintenance work in the future.

- 4) Securing of sustainable sand stock through the planned coastal project

Sand for maintenance about the order of 100 m³/year is recommended to maintain the Project beach in good condition. This required quantity is very small from the existing volume of stocked sand. It is requested to the government of Tuvalu the use of small amount of sand for the maintenance of the Project beach in the future.

On the other hand, the big-scale coastal protection project, which is the “Tuvalu Coastal Adaptation Project (TCAP)” using the Green Climate Fund (GCF) will commence in 2018. The provision of new sand stock into the TCAP is recommended to secure the sand for beach

maintenance not only for the Project beach, but also for future full-scale project for beach nourishment.

(2) Expansion of Full-scale Project for Beach Nourishment

Subject

1) Uncertain for provision of large amount of coral gravel as full-scale project

As presented in Section 17.3, there are two possibilities to obtain gravel in Tuvalu, which are obtaining from the deep channel on the west side of Funamanu Island (Case-1) and obtaining from the seabed on the lagoon (Case-2). However, there is the difficulty for the construction method in Case-1 for taking gravel from the deep seabed under existence of swell wave and strong tidal current. Also, there is no sufficient information about the potential volume of gravel for both cases at this moment.

2) Economical method to secure sand stock for maintenance

If the sand for maintenance will be procured in different timing from the initial construction in Tuvalu, the newly mobilized dredger is required and it causes high construction cost. Basically, it is required to stock sand, which will be utilized as future maintenance for nourishment during the initial construction.

3) Declaration for intention of public opinion for demand of nourishment as coastal protection measures

The Funafuti people and the government of Tuvalu have realized the effect and advantage of beach nourishment method through the Project. However, it seems that the common opinion of desirable coastal protection measure in Tuvalu is still “hard structure measures”, such as revetment, seawall, breakwater, etc. One of the reasons might be that; this was based on their long-term understanding in Tuvalu. On the other hand, the beach nourishment method was just newly applied in the Project, and Tuvalu people have no experience of this until now. Even though it has been tried to share and expand the knowledge for ecosystem-based and user-friendly type of coastal protection measure, it seems that it is still not sufficient to change their mind. As a result, there is a possibility to apply the hard structure measures without sufficient consideration for the use of coastal area and hinterland, difference of wave condition between the lagoon and ocean side, environmental impact to surrounding beach, etc.

4) Reality of sustainable beach management and maintenance in Tuvalu for full scale project

Ongoing community-based beach maintenance and management is for the limited Project area with 180 m alongshore distance. On the other hand, the required area of beach maintenance

and management for full-scale project will increase drastically. The expansion of project area might induce the difficulty of community-based beach maintenance work.

Consideration Point

- 1) **Necessity of further study for potential volume, construction method, and cost for gravel**

Further study is required to identify the potential volume of gravel for two possibilities, which are obtaining from the deep channel on the west side of Funamanu Island (Case-1) and obtaining from the seabed on the lagoon (Case-2). Also, the construction method especially for Case-1 is required taking into account the wave and current condition on site. Finally, the cost shall be compared for both imported and procured case in Tuvalu.

- 2) **Implementation of sand stock and establishment of management system for sand stock**

It is important to consider securing sand stock while the big dredger stay in Tuvalu for large-scale coastal protection project, such as TCAP. Also, appropriate management of stocked sand is required taking into account the future plan for the use of sand not only for the beach protection project but also for other purpose.

- 3) **Necessity of continuous knowledge transfer and PR activity**

The understanding and knowledge for beach nourishment is still not enough to Tuvalu people. Continuous knowledge transfer in Tuvalu is requested to be considered, for example, holding the seminar, site visit to beach nourishment project in other countries, etc. PR activity to show the difference of function from other hard structure type protection is also requested to be considered to expand the information. Conducting beach sports event annually is one of the effective PR activities.

18. Conclusion and Suggestion

18.1 Conclusion

(1) Effectivity and validity of beach nourishment using coral gravel and sand were proved

The beach nourishment using coral gravel and sand was proposed as the first trial of ecosystem-based and user-friendly type of coastal protection measure in Tuvalu, and applied to the central area on the lagoon side (Tausoalima) in Fongafale Island. Based on a two-year monitoring result, it was proven that the required three functions, which are “protection function”, “beach use”, and “coastal environment”, as ecosystem-based and user-friendly type of coastal protection measure could be fulfilled. There are no other protection measures to fulfill such three functions except for the beach nourishment.

(2) No adverse impact on the surrounding coasts at both the gravel borrow site and the Project site was identified based on the monitoring result

The influence on surrounding beach due to construction activities at the gravel borrow site (Funamanu and Papaelise islands) and the Project site was monitored for two years by visual checking, comparison of beach profile, and aerial photo. The result showed that no adverse impact on the surrounding coasts at both sites was identified.

(3) Community-based beach management was successfully established

It was realized that the initial constructed beach was flexible due to wave action. Thus, beach maintenance and management is important in order to maintain a comfortable condition especially on “beach use”. As the Project beach is utilized as public beach for Funafuti people, who are the main beach users, they have frequent opportunities to identify the beach condition on a timely manner. From this, it was realized that “community-based beach management” not the “government-based beach management” is necessary to maintain its sustainability. To achieve this, beach management consists of “beach cleaning”, “self-control for beach use”, and “executing adaptive measure for beach maintenance”, was carried out by Funafuti Kaupule with public participation. The result showed that the community-based beach management was effective and realistic for sustainable beach management with Tuvalu ownership.

(4) Adaptive management based on monitoring result was implemented

It was proven that conducting appropriate adaptive measures after initial construction was both effective in the improvement of the beach condition for beach use and enhancement of

the life period of the beach. To ensure action by the community in Tuvalu will be sustainably done, the proposed adaptive measure shall be “simple and easy with low technology only”. Furthermore, the “integrated inevitable system”, which consists of “execution of adaptive measure”, “active use for events using improved beach” and “educational activity” as one set activity, will be required to accelerate public participation in beach maintenance and awareness of responsibility on beach maintenance and management by the local government (Funafuti Kaupule), and finally to ensure the sustainable execution of future community-based beach management by the Tuvaluan side.

(5) Public awareness on beach conservation was significantly improved

Improving public awareness on beach environment is one of the urgent issues to be accomplished in terms of beach management because it was directly related to people’s behavior on the beach such as dumping rubbish, illegal activities, and so on. Several public relation (PR) and education activities were applied through the Project for this purpose. As presented in Chapter 14 from the interview survey results, it was confirmed that public awareness on the beach, especially for beach environment and beach use, was significantly improved due to PR and educational activities and these contributed to maintain the beach area in good condition for almost two years after the implementation.

(6) Capacity of stakeholders on beach nourishment was developed through the Project

Since the Project goes through a whole process on coastal conservation, which are investigation, planning, design, construction, monitoring, and adaptive management, knowledge on coastal conservation of the counterpart (C/P) had been developed with the Project progress. In addition, several programs such as technical exchange in Mauritius and training in Japan contributed in the improvement of stakeholders’ understanding on beach nourishment through the lessons learned from other countries.

18.2 Suggestion

For Beach Maintenance and Management

(1) “Interactive Activation Structure” is requested to establish a sustainable community-based beach management by the Tuvaluan side

As mentioned above, continuous execution based on the “interactive activation structure”, consists of “execution of adaptive measure”, “active use for events using improved beach”, and “educational activity” was requested to ensure a sustainable execution of community-based beach management by the Tuvaluan side. Beach sports event was one of

the effective approaches to enhance both people's awareness on beach environment and maintenance and the responsibility of Funafuti Kaupule on beach maintenance and management. It is expected that Funafuti people and primary schools continue to organize such event using the beach annually, and coordinate with Funafuti Kaupule and the Government of Tuvalu. This will be a driving force to ensure the sustainability and realization of community-based beach maintenance and management by Funafuti Kaupule maintaining their passion and motivation, even if the present members of Funafuti Kaupule will be changed.

(2) Procurement of the equipment for beach maintenance will be considered

It is also necessary to consider maintaining the equipment for beach maintenance. It was proven that the excavator was useful in implementing the proposed adaptive measure to take gravel from the foreshore area and return to the original backshore area. It is recommended to consider the procurement of equipment for beach maintenance in the near future by the Japan International Cooperation Agency (JICA) or other donors.

(3) Securing of sand provision for maintenance is requested by the Tuvaluan government for the first two to three years.

In the monitoring result, the filled sand moved to the south; and the total volume of sand has been decreased a little by continuous wave action, even though the beach could be maintained in stable condition. It is preferable to re-fill of the sand as one of the adaptive measures as an undertaking in the Phase 3 of the Project. As the required volume is very small about the order of 100 m³/year based on these monitoring result, it is requested to the Tuvaluan government for the use of such small amount of sand in the maintenance of the Project beach for the first two to three years until the next opportunity comes to stock sand.

(4) Taking photo continuously from fix point after the Project is requested

Continuous monitoring of the beach is important to know the beach behavior for both normal and extreme wave conditions and to plan for suitable adaptation measure as required. Beach profile monitoring was carried out throughout the Project as well as taking photos from the fix point to know the beach behavior in detail. However, it might be difficult to enforce such complicated monitoring on the Tuvaluan side from now. Taking into account the possibility and sustainability for implementation of beach monitoring by the Tuvaluan side, taking photo from the fix point will be feasible. And if possible, checking the backshore width at several representative lines is also recommended to be carried out together with taking photo.

(5) Continuous wave observation is effective for beach monitoring and other purpose

Accumulation of continuous wave and tide observation data will become very useful not only for beach monitoring but also for planning of future coastal and marine projects and other meteorological purpose. The bottom-mount type wave-current meter (Wave Hunter) was handed over to the Tuvalu Meteorological Service. It is strongly recommended to carry out the wave observation continuously by Tuvalu Met Office.

For Future Expansion of Beach Nourishment

(1) It is recommended to apply ecosystem-based and user-friendly type of protection measure on the lagoon side

It is important to keep the concept of “selection of right protection measure at the right place” in coastal adaptation. In case that the targeted project area is located at the residence or public area where people commonly gather, it shall be considered three functions on the selection of coastal protection measures, which are “protection function”, “beach use”, and “coastal environment”. The request to consider such three points was also shown in the result of the interview survey with Tuvalu people. From this point of view, it is basically recommended to adopt the same type of ecosystem-based and user-friendly type of protection measure, “beach nourishment” on the lagoon side, where coastal area is highly utilized as the residence and public area. The Tuvalu Coastal Adaptation Project (TCAP) is planned to implement at the area of lagoon side from the north of the Project site to Funafuti wharf with approximately 1.0 km. It is expected to select the ecosystem-based and user-friendly type of protection measure at the Project area.

(2) Holding of beach sports event as annual event is strongly recommended

Even though the understanding of beach nourishment for Tuvalu people could be enhanced by implementation of the Project, the present situation is just to stand in the same field as other coastal protection measures. Continuous PR and promotion activity to enhance the knowledge and experience for this ecosystem-based and user-friendly type of coastal protection measure are requested. As the result of the Project, it was realized that the conducted beach sports event greatly contributed on public relation (PR) effect as well as in enriching the understanding for beach nourishment through the actual activity on the beach. Thus, it is strongly recommended to hold the same beach sports event as an annual school event.

(3) Implementation of future sand stock is requested to consider in full-scale coastal project and establishment of a management plan for sand stock is requested

To consider the future expansion of beach nourishment measure in Tuvalu, there are mainly two subjects for implementation, that is “securing of gravel for full-scale project” and “securing of sand for future maintenance”. Even though a further study is required to ensure the potential volume of gravel as mentioned in Chapter 17, there is another option to use only sand. However, as sand is easier to move due to wave action, appropriate design including supplementary coastal structures is requested based on the detailed study for drift of sand. Securing of sand for future maintenance is requested to maintain the nourished beach sustainably. Preparing of management plan for sand stock is required taking into account the future plan for the use of sand not only for the beach protection project but also for other purpose. It is also necessary to consider the appropriate timing for the implementation of sand stock taking into account the cost efficiency. At least, sand stock is recommended to implement during the full-scale coastal project such as Tuvalu Climate Adaptive Project (TCAP). However, attention will be on the selection of the location of sand mining area so as not to cause new coastal erosion problems.

(4) Technical guideline is expected as reference for the appropriate selection of coastal adaptation measures and its implementation

The technical guideline for beach nourishment was prepared as one of the results of the Project. This guideline shows the basic idea for consideration on the selection of coastal adaptation measure and for planning and design of beach nourishment. It is expected to refer this guideline to the persons who are related to planning, design, and implementation of the coastal project in Tuvalu and other Pacific Island countries.

(5) It is recommended to take opportunities to learn about coastal conservation from other countries.

To learn from case examples in other countries, such as technical exchange in Mauritius and training in Japan implemented in the Project, it is very useful to improve the understanding on planning and design of coastal conservation measures. Therefore, it is recommended, especially for key personnel who will be in charge of coastal conservation in the government and Kaupule, to keep taking opportunities to learn from other countries as much as possible. One opportunity can be the JICA’s knowledge co-creation program (group and region) on coastal conservation, which will be implemented this coming two years, 2018 and 2019 respectively.

<Appendix>

Technical Guideline

1) Outline of Technical Guideline



Essential Points for Application of Beach Nourishment (Digest Version)



- A Case-based Know-how based on Coastal Conservation Projects Implemented by JICA -

The Government of Tuvalu / Japan International Cooperation Agency (JICA)

About this Leaflet

- ◆ This leaflet is the digest version for the booklet of "Essential Points for Application of Beach Nourishment" which was published in April 2018.
- ◆ The booklet is expected to be utilized as a reference for user- and nature-friendly coastal conservation/protection to government officials and community members who will tackle coastal conservation in Pacific Island Countries.
- ◆ The booklet introduces standardized know-how for beach nourishment in a simple way for planning, design, construction and monitoring and maintenance learned from actual coastal conservation projects implemented by JICA including that of Tuvalu.

Concept of Ecosystem-based & Use-friendly Coastal Protection in the Pacific

1. Coastal Problems at the Pacific Island Countries

Coastal problems, which are coastal erosion, wave overtopping, coral degradation, etc., become serious in the Pacific Island Countries. Furthermore, the risk for coastal disaster due to climate change will be increased. Strong support and undertaking of remedy for such coastal problems are strongly requested from each country.

Coastal Erosion



Wave Over-topping, Flood



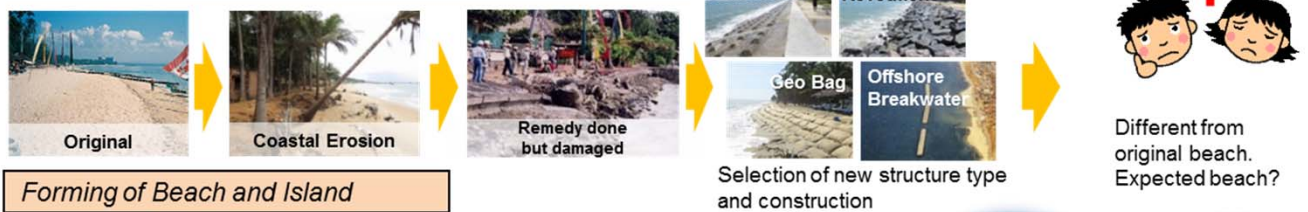
Degradation of Coastal/ Marine Environment



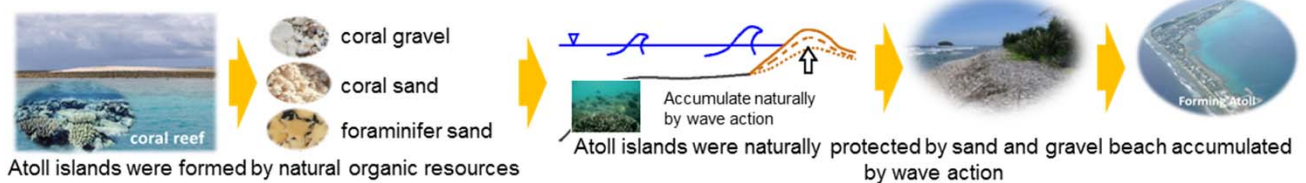
2. Importance for Understanding of Long-term Historical Forming of Island and Original Own Function of Beach

Most of the implemented coastal protection projects had a tendency to focus just only the "hard point", which is "selection and construction of hard measures", based on engineering point of view. Understanding of the "soft point" that is, long-term historical forming of islands, original own multi-function of beach, "protection", "usage of beach for people's dairy life, recreation, culture, etc." and "environment", was not so deeply considered.

Common Case for Process of Coastal Protection Project



Forming of Beach and Island



Original Own Function of Beach



3. Principle for Process of Coastal Protection/Conservation Planning

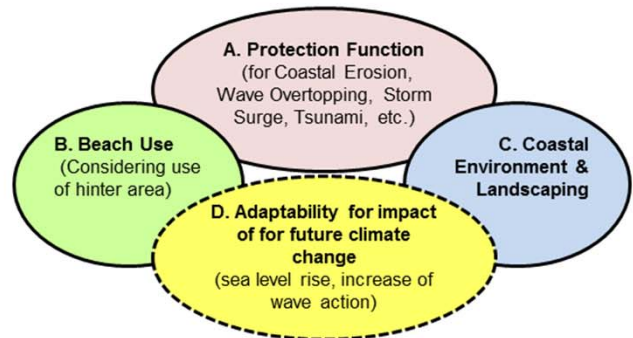
Coastal area is closely associated with the life of local residents and it provides a variety of benefits to them and a habitat to plants and animals. These basic functions that a coastal area originally had should be preserved when we implement coastal conservation. We also have to remember a primary way of interaction between human and beach, which is that *community/residents maintained beach area by themselves to receive a benefit from it.*

Step 1: What is coastal problem
(Clarification on coastal problem)

Step 2: What are the causes of coastal problems?
(Clarification on the cause of problems)

Step 3: What do you want to do for such coastal problem taking into account the use of coastal and hinter area ?
(Clarification for the purpose of coastal protection / conservation)

Important 4 Considerations on Planning of Coastal Conservation



4. Case Based Learning from Implemented Project for Beach Nourishment

With considerations on primary interaction between human and beach, the basic policy of the projects was set to establish *human- and nature- friendly coastal conservation and maintain it sustainably.* Thus, beach nourishment was applied to restore the conservation function that a natural healthy beach used to have and a community based beach management had been developed through the Project. Both are the first trial applied in Tuvalu, a Pacific Island country.

Before the construction



After the construction 1



After the construction 2



- Fongafale Island, Tuvalu -

Statically Stable Beach
(using accumulated coral gravels and seabed sand at lagoon)

- Mauritius Island -

Dynamically Stable Beach
(using crushed volcanic rock taken from land)

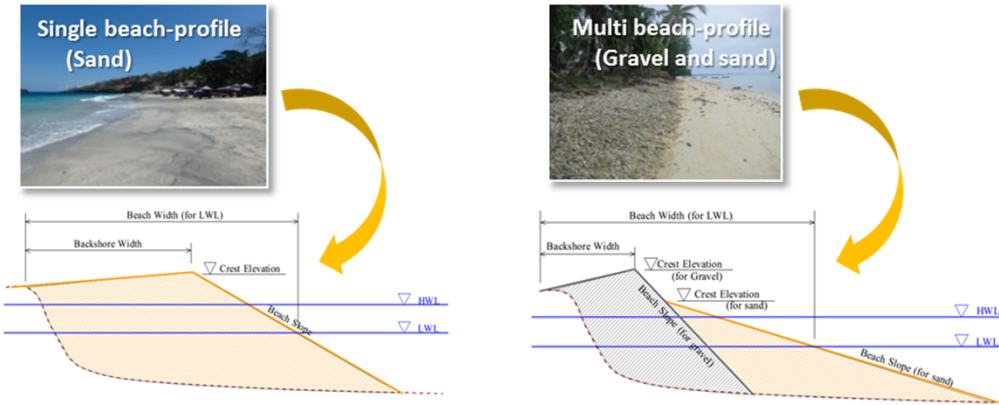
- Bali Island, Indonesia -

(Statically Stable Beach
using coral sand taken from offshore seabed)

Case Based Learning from the Pilot Project for Beach Nourishment in Tuvalu

1. Design of Beach Nourishment

POINT Learn a basic design from nature and develop it by applying a scientific data.



Learn a design either through past or existing nearby healthy because these are formed by experiencing a long period of wave action and become the most stable profile.

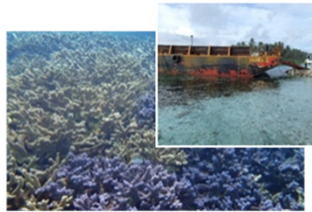
2. Construction

Safety



Since located at near residential area, careful restriction is required.

Environment



Since corals are one the most precious resources, access route and type of vessels needs to be carefully selected.

Consensus Building



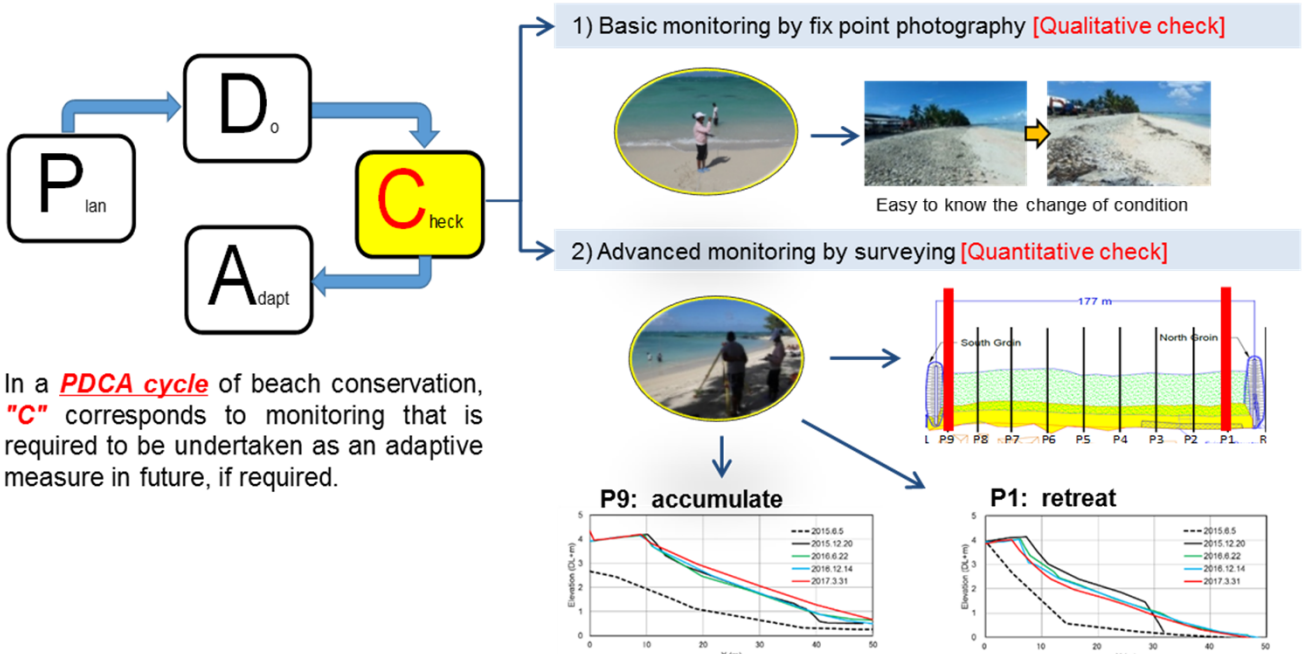
It is essentially required for, where beach conservation is not so familiar to local villagers.

Public Relations and Education



Construction site can be utilized as a field for PR and education to improve people's awareness on beach environment.

3. Monitoring



In a **PDCA cycle** of beach conservation, **"C"** corresponds to monitoring that is required to be undertaken as an adaptive measure in future, if required.

4. Establishment of Community Based Beach Management

POINT

A beach management can never be realized without improvements on public understanding and participation.

Approaches through a sequence of public relations and educational activities in order to raise public awareness

Step-1: Learn



Environmental Education

To learn the importance of beach environment

Step-2: Role play



Beach Cleaning Event

To learn their roles in using the beach safely and pleasantly

Step-3: Enjoy the beach

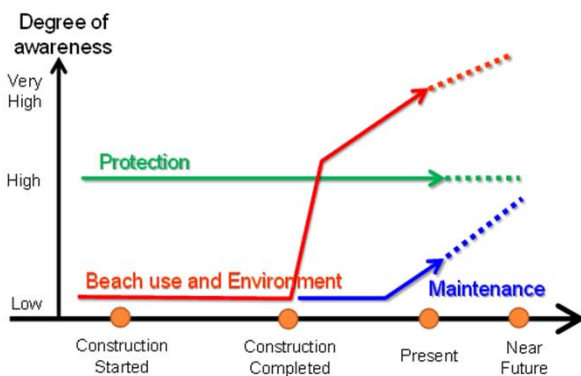


Beach Sports Festival

To understand the value of the beach by enjoying it.

Outcome-1

Public awareness on beach use, environment, and maintenance were much improved through the Project



Changes on public awareness on beach conservation through the Project

Outcome-2

The community started continuous beach management by involving its residents. Furthermore, the beach has been maintained in good condition through their efforts.



Maintenance activity initiated by city council



Signboard for beach use installed by the community



Beach cleaning of community involving residents once in every two weeks



NIPPON KOEI

Please contact us as below if you need further information:

Takashi Oba JICA Global Environment Department, DRR Team
 E-mail: Oba.Takashi@jica.go.jp
 Susumu Onaka Nippon Koei CO.,LTD. Engineering Consultants
 E-mail: onaka-ss@n-koei.jp.

2) Technical Guideline:

Essential Points for Application of Beach Nourishment



Technical Guideline



Essential Points for Application of Beach Nourishment

*~ A Case-based Know-how based on Coastal
Conservation Projects Implementd by JICA ~*



April 2018

Japan International Cooperation Agency



- Preface -

The pilot scale project of beach nourishment using coral gravel and sand was implemented in Tuvalu Country as the first trial of ecosystem-based and user-friendly type of coastal protection.

A lot of know-how and information as outcome of the Project were obtained through the Project, and such know-how and information are expected to serve as a useful reference not only to the related stakeholders in Tuvalu but also to other Pacific Island countries who are facing the similar coastal problem.

Further, JICA has implemented several coastal conservation projects applying beach nourishment in other countries.

From the above background, the obtained know-how and information through this Project and some information from other similar Projects were summarized as the technical guideline on titled “Essential Points for Application of Beach Nourishment in Pacific Island Countries”

The main objective of this technical guideline is as follows.

- To understand the concept of ecosystem-based and user-friendly coastal conservation measure applied in Pacific Island countries
- To introduce the basic procedure and consideration for beach nourishment project as case based learning through the Project in Tuvalu

Basic policy of this technical guideline is as follows.

- This guideline is not only to the engineers who are engaged in the coastal work, but to wider stakeholders who are related and/or interested in the coastal problems (e.g. government officers, NGO members, donor officers, community members, etc.) in both Tuvalu and other Pacific Island Countries.
- This guideline focuses not only “hard point” as “coastal engineering”, “implementation of coastal measure” etc., but also “soft point” as “maintenance and management”, “consensus building”, “public relation and education”, etc.
- To achieve an effective expansion of knowledge, it was paid attention to keep “easy”, “simple” and “visibility”. From this policy, one topic was described in one page and not to put too much information for each topic.

We hope this guideline contributes on planning, design and implementation of beach nourishment as useful reference to Tuvalu and other Pacific Island Countries.

Table of Contents

Section 1: Concept of Beach Conservation, Basic Information of Beach Nourishment

- 1.1 Coastal Problems in Pacific Island Countries
- 1.2 Importance for Understanding of Long-term Historical Forming of Island and Original Own Function of Beach
- 1.3 Principle for Planning of Coastal Conservation Measure
- 1.4 Characteristics of Beach Nourishment
- 1.5 Example of Beach Nourishment (Based on JICA Project)
- 1.6 Chronology of Shore Protection Measure in Developed Countries
- 1.7 Stability of Beach Nourishment after Construction
- 1.8 Cost and Benefit of Beach Nourishment

Section 2: Planning and Design of Beach Nourishment

- 2.1 Essential for Layout Planning
- 2.2 Essential for Beach Profile Design
- 2.3 Supplementary Coastal Structures to Maintain Nourishment Material
- 2.4 Identification of Boundary Between Nourishment Area and Existing Property
- 2.5 Importance of Public Consultation on Planning and Design

Section 3: Construction

- 3.1 Considerations on Construction Planning for Beach Nourishment
- 3.2 Environment Monitoring during Construction
- 3.3 Points to Note on Construction Works

Section 4: Monitoring, Maintenance and Management

- 4.1 Purpose of Beach Monitoring
- 4.2 Basic Monitoring by Community and Residents
- 4.3 Advanced Monitoring by the Government
- 4.4 Beach Maintenance by Beach Cleaning
- 4.5 Rules on Beach Use
- 4.6 Adaptive Measure and Proposed Beach Management Structure
- 4.7 Importance of Public Relations and Educational Activities
- 4.8 PR & Educational Activities Implemented in the Project
- 4.9 Changes in Public Awareness on Beach through the Project

- Section 1 -

Concept of Beach Conservation, Basic Information
of Beach Nourishment

1.1 Coastal Problems at Small Island Countries

Summary: Coastal problems, which are coastal erosion, wave overtopping, inundation, degradation of coral, etc., become serious in the small island countries. Furthermore, the risk for coastal disaster due to climate change will be increased.

Coastal Erosion



Wave Overtopping, Inundation



Degradation of Coastal/Marine Environment

Rubbish dumping on beach



Degradation of coral habitat



1. Loss of land (public and private property)
2. Increase risk for coastal disasters
3. Loss of space for beach use (for recreation, fishing activity, etc.)
4. Loss of coastal and marine nature
5. Loss of traditional culture of the community/residents

Point !

Risk on coastal disaster due to climate change will increase and impact of coastal disaster in the Pacific Island countries becomes more serious than in other countries.

1.2 (1) Importance for Understanding of Long-term Historical Forming of Island and Original Own Function of Beach

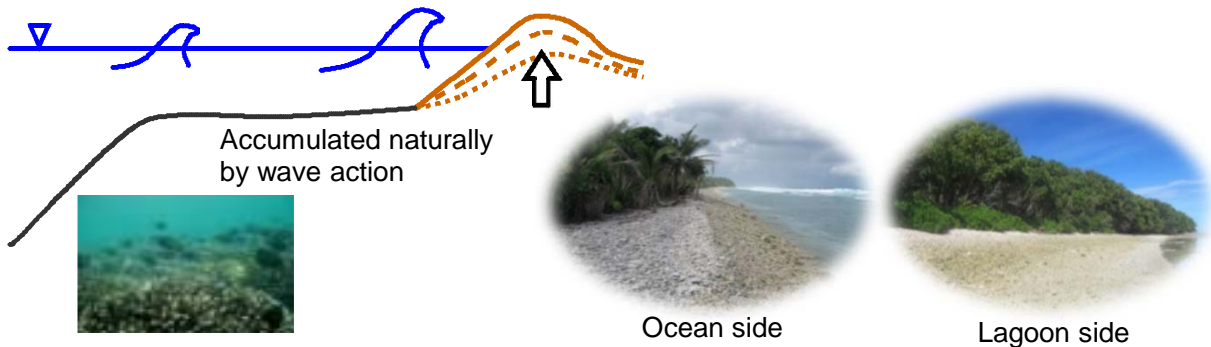
Summary: Most of the implemented coastal protection projects had a tendency to focus just only the "**hard point**", which is "selection and construction of hard measures", based on engineering point of view. Understanding of the "**soft point**" that is, long-term historical forming of islands, original own multi-function of beach, "protection", "usage of beach for people's dairy life, recreation, culture, etc." and "environment", was not so deeply considered.

Forming of Beach and Island

1) Coral reef is producing natural organic resources



2) Beach and atoll island were formed by coral gravels and sand for coral and foraminifer naturally accumulated by wave action



3) Also, atoll islands were naturally protected by coral sand and gravel beach



Point !

- Important to know the original condition of the beach before the occurrence of beach degradation.
- Important to understand well the long-term historical formation of beach and island when the beach conservation measure is planned.
- Basically, maintaining the original natural beach is the most stable and safety protection measure, because the coastal area was protected by the existence of beach for a long period.

1.2 (2) Importance of Understanding the Long-term Historical Formation of Island and Original Own Function of Beach

Common Process for the Implementation of Coastal Protection



Point !

Do not just focus on the engineering point of view, which is "selection and construction of hard measures". "Beach" and "human life and activity" were originally in very close relation. High consideration taking into account planned usage of both shore area and hinterland is important for selection of coastal conservation measure.

1.2 (3) Importance of Understanding the Long-term Historical Formation of Island and Original Own Function of Beach (3/3)

Original Own Three - Functions of Natural Beach

Protection



Out of the project area
(Tuvalu, Nov. 2015)



Project area
(Tuvalu, Nov. 2015)

Usage



Recreation
(Tuvalu, 2016)



Culture
(Indonesia Bali, 2008)



Event
(Tuvalu, Jul. 2016)

Environment



Coral farm
(Indonesia Bali, 2008)



Habitat for baby fish
(Tuvalu, Apr. 2017)



Natural landscape
(Tuvalu, Jan. 2016)

Point !

Originally, the natural beach had a multi-function not only for "protection", but also "usage" and "coastal and marine environment". People are in close relation to the beach for their daily activities and fun.

The target of beach nourishment is to recover such original natural beach artificially as much as possible.

Remark (Difference between the definition of "*Coastal Protection*" and "*Coastal Conservation*")

The word "Coastal Protection/Coastal Protection Measure" was commonly used in previous, however, it is recommended to consider three view points (protection, usage, and environment) on coastal measure in this guideline. Thus, the word "coastal conservation/ coastal conservation measure" is adopted in this guideline.

1.3 Principle for Planning of Coastal Conservation Measure

Summary: Coastal area is closely associated with the life of local residents and it provides a variety of benefits to them and a habitat to plants and animals. These basic functions that a coastal area originally had should be preserved when we implement coastal conservation. We also have to remember a primary way of interaction between human and beach, which is *community/residents maintained beach area by themselves to receive a benefit from it.*

1. What is coastal problem? (*Clarification on coastal problem*)



2. What are the causes of coastal problems? (*Clarification for cause of problems*)



3. What do you want to do for such coastal problem taking into account the use of shore area and hinterland ?

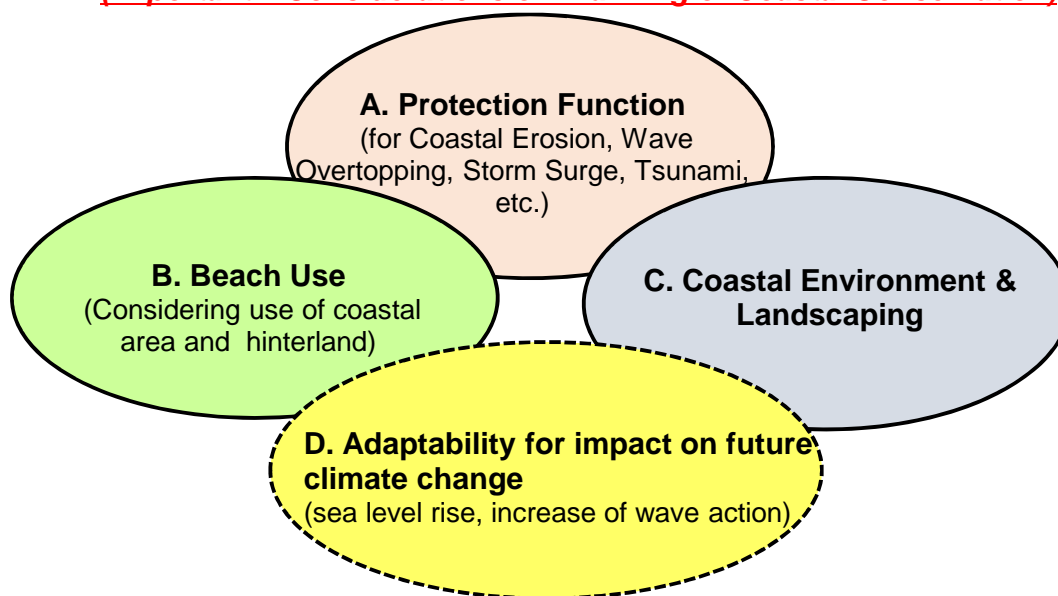
(*Clarification for the purpose of coastal conservation*)

To protect hinterland or /and facilities,

To restore beach space for use, or

To restore coastal / marine environment , or Combined?

(Important 4 Considerations on Planning of Coastal Conservation)



4. What is your expected effect ?

(*Clarification for expected targeted achievement, requirement*)



Selection of coastal conservation measure

Point !

Clarification to identify the fundamental coastal problem and its cause is very important on planning of coastal conservation measure.

It is also important to clarify the purpose of beach conservation taking into account the use of coastal area and hinterland on selection of coastal conservation measure.

1.4 Characteristics of Beach Nourishment

Main Characteristics

1. Performing ecosystem-based and user-friendly coastal conservation as same image as natural beach (Fig.1)
2. Flexibility for shape of beach profile and coast line due to changeable wave action (Fig.2)

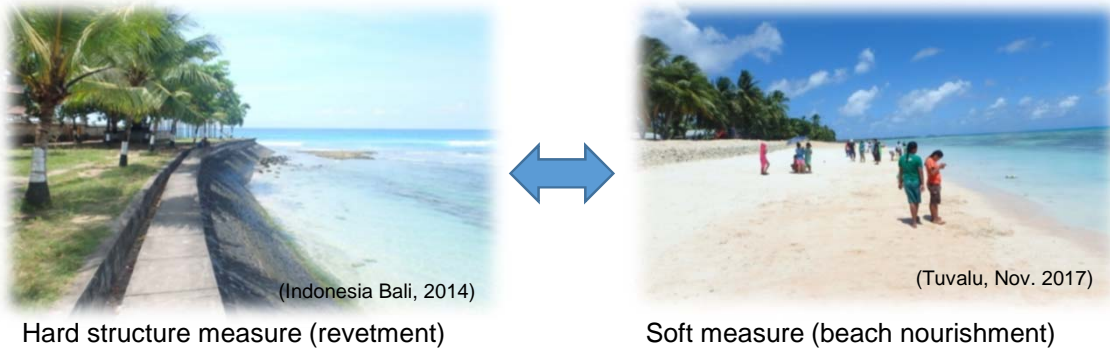


Fig.1 Difference of Hard and Soft Measures

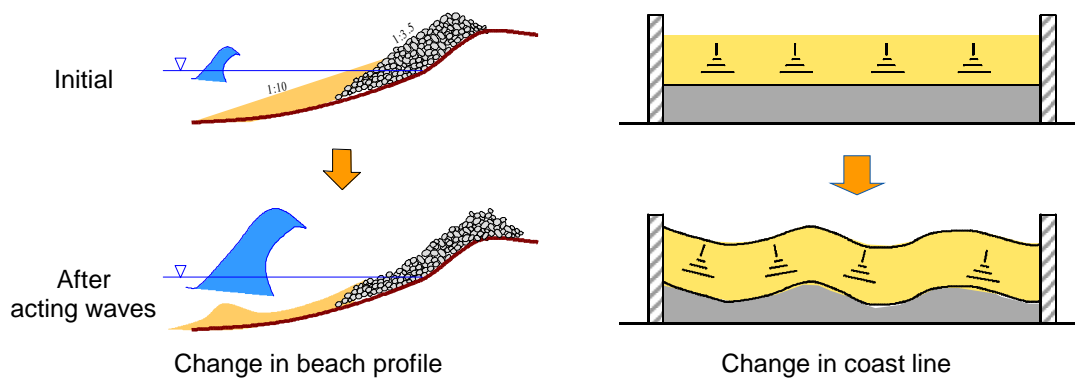


Fig.2 Flexibility of Beach Shape

Advantages

1. Multi purpose (not only "protection function" but also enhancement of "beach use" and "coastal environment") can be secured.
2. Adverse effect to surrounding coast area is expected to be low compared with other hard structure measures.
3. High adjustability depends on the actual condition and unexpected future risk for climate change due to characteristics of flexibility of shape.
4. Simple and easy for maintenance work

Point !

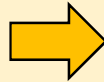
- The most different characteristics of "beach nourishment" from "hard structure measures" is to consider the functions of "beach use" and "environment" as well as "protection".
- Beach shape is always changeable due to waves. What is important is to identify the tendency of beach change for certain period.

1.5 Example of Beach Nourishment (Based on JICA Project)

Summary: Sand and gravels are main materials for beach nourishment and several considerations are required for selection for type of nourishment.

Beach Nourishment (Sand)

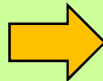
- Bali Island, Indonesia -



Nourishment using coral sand
taken from offshore seabed

Beach Nourishment (Gravel)

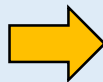
- Mauritius Island -



Nourishment using crushed volcanic rock
taken from land quarry site

Beach Nourishment (Gravel and Sand)

- Fongafale Island, Tuvalu -



Nourishment using accumulated coral
gravel and seabed sand at the lagoon side

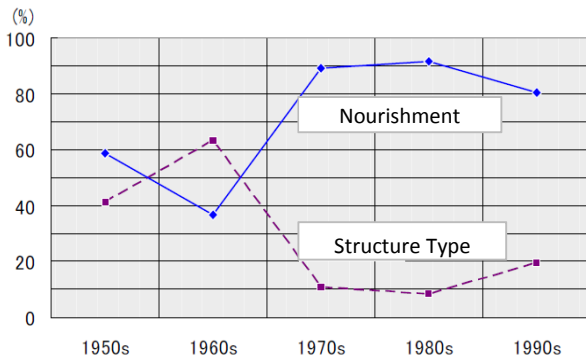
Point !

- Selection for Type of Nourishment -

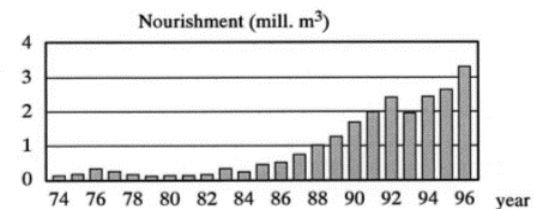
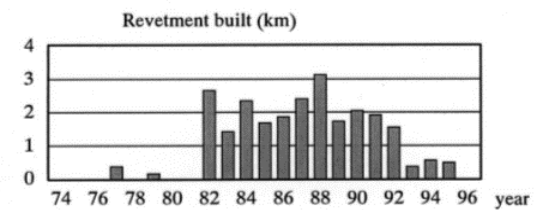
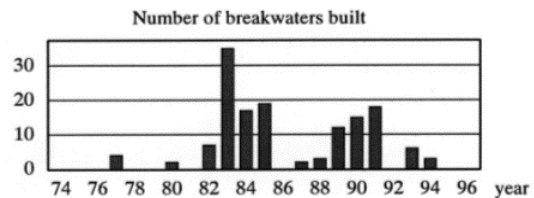
1. Proposed material for nourishment is sustainable on productivity and cost?
2. Proposed type of nourishment is expected to maintain stable condition?
3. Proposed type of nourishment is be expected desirable beach use, view and environment?
4. No negative impact on coastal and marine environment is expected for taking materials for nourishment?
5. Easy for maintenance and repairing works (easy for procurement of material and for maintenance and repairing work) ?

1.6 Chronology of Shore Protection Measures in Developed Countries

Summary: In developed countries, the shore protection was shifted from "hard structure measures" to "beach nourishment" based on lessons learned from the experience in implementing coastal protection works.



(1) In case of USA ⁷⁾



(2) In case of Denmark ⁸⁾

Developed Country (USA, Europe)

In USA, structure measures, which were previously common methods such as coastal protection, have been replaced to beach nourishment since 1970. In Denmark, only beach nourishment has been applied as coastal protection measure since 1996, and no concrete type structure measures were applied.

Developing Country

Hard structure measures are still common as coastal protection measures

Reasons

- Limited experience in implementing beach nourishment
- Concerns on the possibility of future periodical maintenance (refilling of sand)
- Concerns on the possibility of high cost both initial and maintenance work

Point !

- Trend in the implementation of beach nourishment increases due to increase of people's demand on user- and nature-friendly type of coastal measure.
- But still necessary to learn the implementation and management of beach nourishment based on actual experience in both Pacific and other countries

1.7 Stability of Beach Nourishment after Construction

Summary: High stability of beach can be secured based on actual implemented project for beach nourishment even though additional filling was not undertaken

Case-1: Gravel + Sand Nourishment (with groins) - Tuvalu -



Just after the Construction (Dec. 2015)



About 1.5 years later (Apr. 2017)

Case-2: Gravel Nourishment (only gravel filling) - Mauritius -

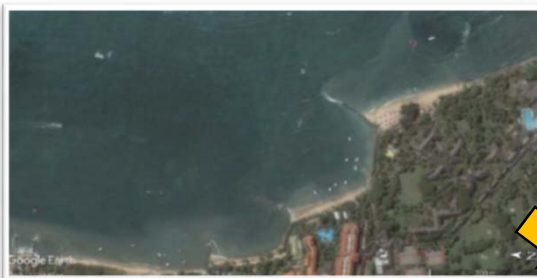


Just after the Construction (Dec. 2013)



About 3.5 years later (Mar. 2017)

Case-3: Sand Nourishment (with groins, headlands) - Bali, Indonesia -



Just before Construction
(May 2002)



7 years later after the
construction (Oct. 2009)



15 years later after the
construction (Apr. 2017)

Point !

Appropriate design (layout design) and proper site selection are important to secure high stability of the beach

1.8 Cost and Benefit of Beach Nourishment

Summary

- Project cost of beach nourishment is significantly influenced by its procurement cost of nourishment materials. Procurement from nearby location is generally more desirable in view of economic aspect.
- Beach nourishment has more kinds of benefits than that of other structural measures. Thus, a beach nourishment is often evaluated as the most desirable coastal conservation measure in cost and benefit aspect.

● Variation of Procurement Cost

▼ Reference for Procurement Cost of Nourishment Materials (sand)

Case	Location for Procurement of Materials	Unit Cost (USD/m ³)
1	Land area in the same island	5~10
2	Seabed close to the site (<10 km)	8~20
3	Seabed close to the site (<50 km)	20~50
4	Import from other country	100~200

● Comparison of Benefit and Cost

In case of beach nourishment, benefits generated from restoration of sandy beach can be added in the project evaluation, which mainly are improvement of beach use and environment.

▼ Benefits Expected for Coastal Conservation Project

Category of Benefit		Hard Structure	Beach Nourishment
Protection	Wave overtopping protection	○	○
	Beach erosion protection	○	○
Beach use	Seaside recreation	—	○
	Fishery use	—	○
	Tourism activation	—	○
	Promotion of local culture	—	○
Environment	Landscape conservation	—	○
	Ecosystem conservation	—	○
	Seawater purification	—	○

A study (The Preparatory Survey on Bali Beach Conservation Project Phase-II, 2013 JICA) indicated that beach nourishment is preferable as more benefits would be expected than that of hard structure even if the project cost was a bit expensive.

▼ Study Result on Benefit and Cost for Different Coastal Conservation Measures

	Hard Structure (Revetment)	Beach Nourishment
Ratio of Benefit	1 (Protection, reference value)	2~10* (Protection, beach use, and environment)
Ratio of Project Cost	1 (reference value)	1.5

* benefit on beach use varies depending on tourist potential

Point!

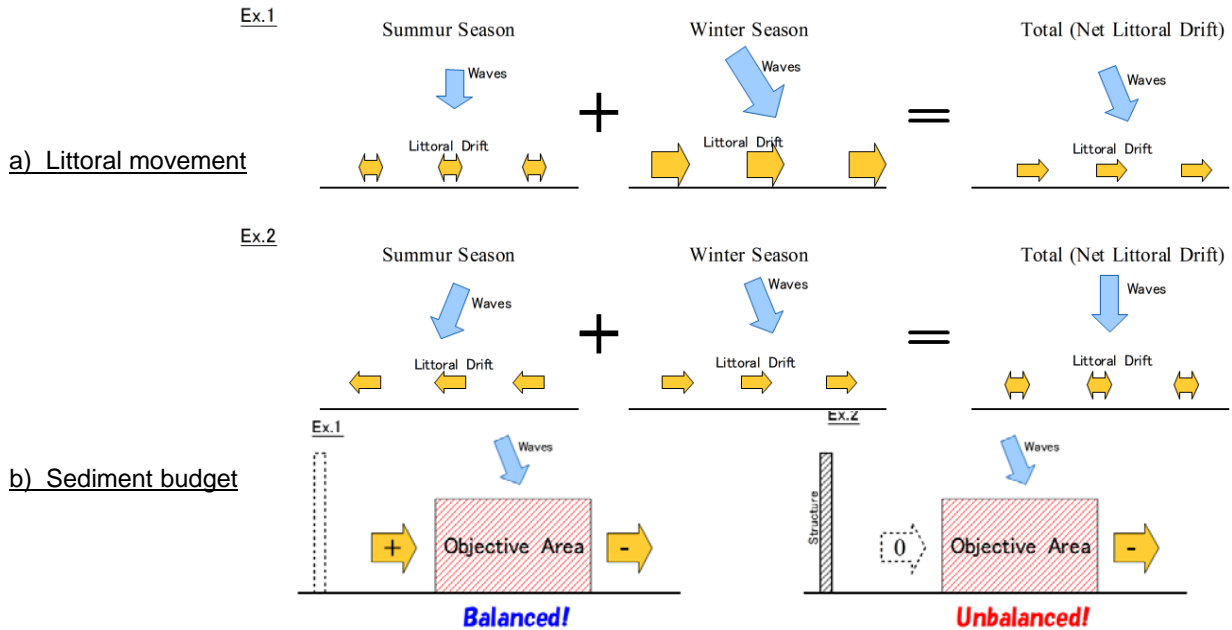
In project evaluation, it is important to evaluate not only the project cost but also the benefit to be generated by the implementation.

- Section 2 -

Planning and Design of Beach Nourishment

2.1 Essential for Layout Planning

1. Important to understand well the condition of littoral movement and sediment budget



Point !

Important to know the net (total) littoral transport and sediment budget for objective area

2. Selection for type of nourishment ("Dynamically Stable Beach" with only nourishment or "Statically Stable Beach" with supplementary coastal structures)



ex.1 Dynamically Stable Beach (Only sand filling)
- Legian Beach in Bali Island -



ex.2 Statically Stable Beach (with headlands)
- Nusa Dua Beach in Bali Island -



ex.3 Dynamically Stable Beach Method (Only gravel filling)
- Mauritius -



ex.4 Statically Stable Beach Method (with groins)
- Tuvalu -

Point !

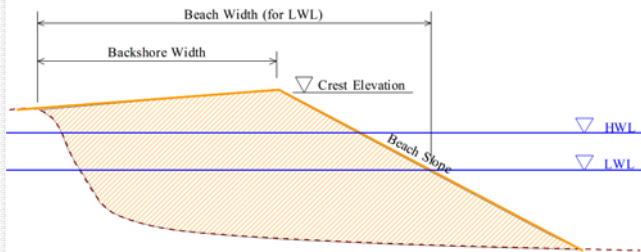
Which type of beach nourishment method will be applied, depends on total project cost for both initial and maintenance period, and feasibility for implementation.

2.2 Essential for Beach Profile Design

How to design beach profile?

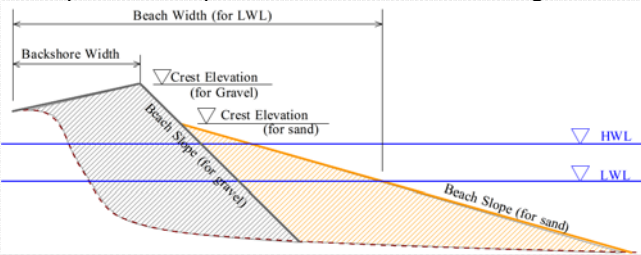
Case-1:

Single beach profile - only sand (gravel) -



Case-2:

Composit beach profile - combined sand and gravels -



Point !

Learn from the previous original healthy beach and/or existing similar healthy beaches nearby. Because...

Existing (or previous) beach was formed as a result is subject to long period wave action. The formed shape is expected to have the most stable shape and profile.



Healthy Sand and Gravel Beach

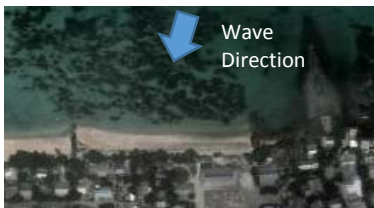
Healthy Sandy Beach

It is important to see and check surrounding beach condition on site, and to know the previous healthy beach condition by data collection (old beach photo, aerial photos, information from residents, etc.)

2. Change in Beach Profile and Shoreline due to Wave Action



Wave Direction



Wave Direction

Beach Profile Monitoring

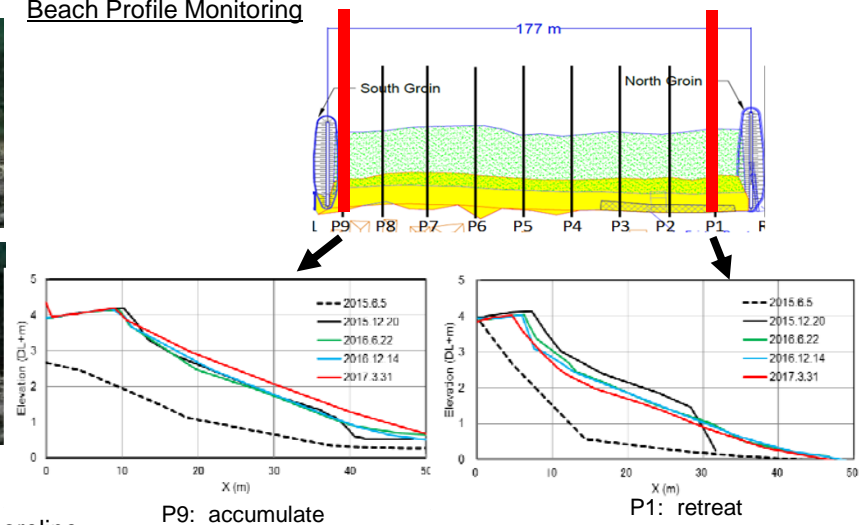
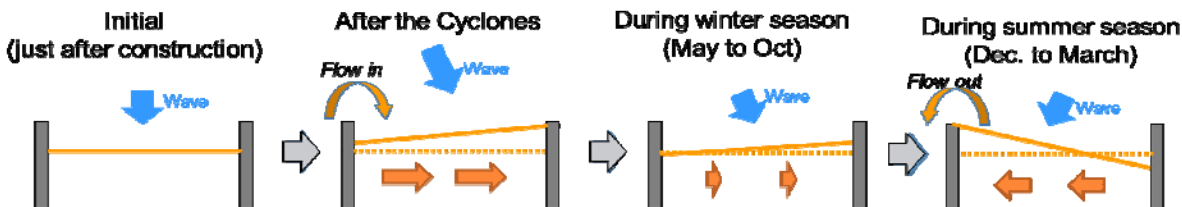


Image of Seasonal Change of Shoreline



Point !

- 1) Beach shape is changeable due to wave action and tends to form stable shape and profile.
- 2) Such flexibility of shape due to wave action has no other characteristics for beach nourishment compared with other hard structure measures (e.g., revetment, seawall).

2.3 Supplementary Coastal Structures to Maintain Nourishment Material

Summary:

In case that filled sand (or gravel) has a possibility to discharge to outer area, for example;

- 1) Significant littoral drift exists and discharge of sand to outer area is expected.
- 2) Beach width after the nourishment becomes wider than the beach width at surrounding area.
- 3) Beach after the nourishment is getting retreat and expected to continue.

Supplementary coastal structures (groins, headlands, etc.) will be necessary to consider.

Example to Apply Supplementary Coastal Structures with Nourishment



(e.g. 1) Nourishment with groins, headlands (Bali) (e.g. 2) Nourishment with offshore breakwaters (Bali)



(e.g. 3) Nourishment with groins (Tuvalu) (e.g. 4) Nourishment with backshore revetment (Bali)

Considerations on Planning and Design

Compatibility to fulfill two conflict functions, which are "function to minimize discharge of sand (gravel)" and "beach use, environment"

(e.g., In design of groins, increase of crown height will induce inconvenience on beach use, access across to beach.).

Point !

- 1) Important to determine whether supplementary coastal structures are employed or not, adequately.
- 2) Important to design adequate layout and specification of structures, not to cause the conflict between "function" and "beach use, environment".

2.4 Identification of Boundary between the Nourishment Area and Existing Property

Summary:

- It is important to identify the boundary between the newly formed nourishment area and existing property at the back side (In case that the existing coastal area is under the private property such as private residential area, the residents sometimes misunderstood that the new beach area in front of their property belongs to them)
- Installation of walkway, concrete wall, parapet, and stone is used to identify the boundary.



(2008)



(2004)

(1) Walkway (Bali)



(Dec. 2015)



(Feb. 2016)

(2) Backshore stone (Tuvalu)

Other Facilities



Gazebo and Plantation (Bali)



Garbage Bin (Tuvalu)



Information Board (Tuvalu)

Point !

Facility to identify the boundary is required to consider additional function especially on beach use. (e.g., backshore stone for identification facility is utilized as rest seat on the beach as shown in above photo, walkway is highly utilized as walking and cycling road at the sea side)

2.5 Importance of Public Consultation on Planning and Design

Summary

Since direct beneficiaries of the coastal conservation project are residents and local communities, it is essential to involve them into planning and design, and obtain consensus on coastal conservation measure through public consultation. In addition, public consultation can be utilized as an opportunity to provide basic concept and knowledge on coastal conservation to relative stakeholders.

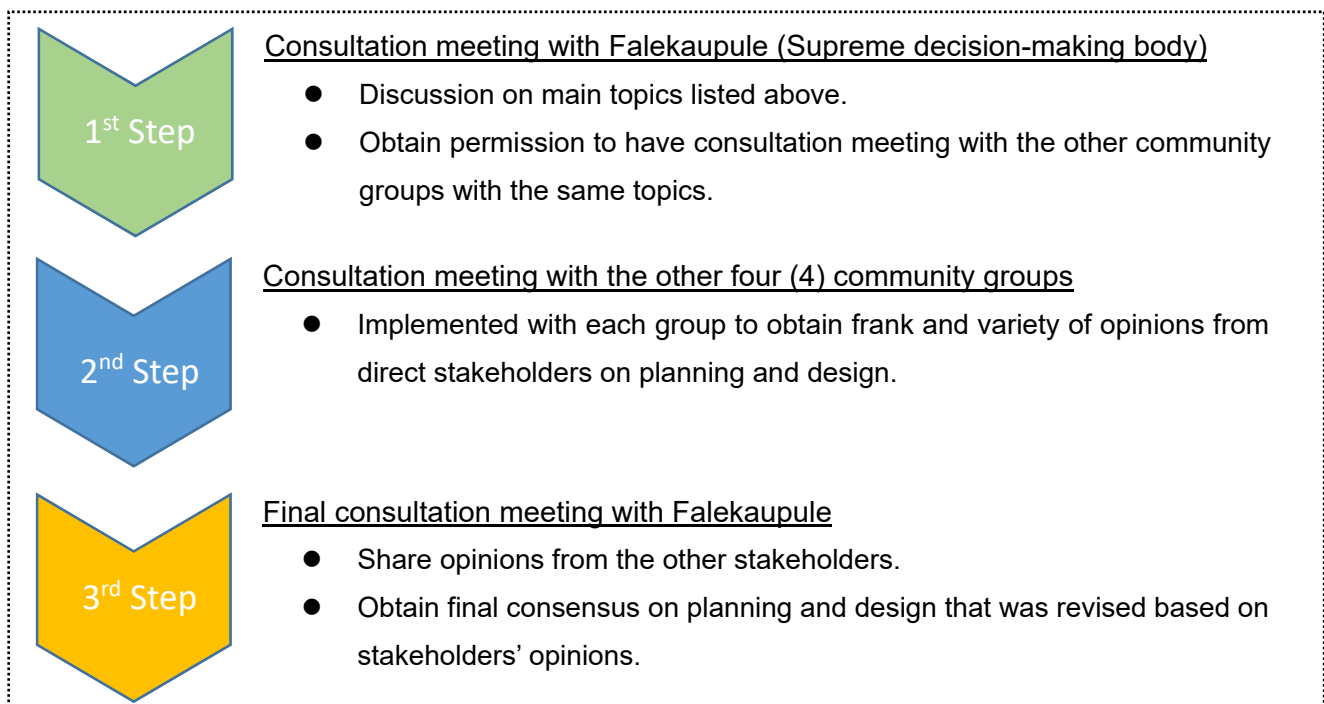
● Main topics that need consensus from stakeholders in public consultation meeting

- Objective and concept of the Project
- Advantage and disadvantage of proposed measure
- Project area and its boundary (layout plan)
- Basic design of the measure (cross section)
- Construction plan including material procurement plan and restriction during construction
- Possible environment impact and its mitigation measure
- Necessity of beach maintenance and management

● Case example:

Approaches to public consultation considering regional and social structure in Tuvalu

There are mainly five (5) community groups in Fongafale Island, where the Project was implemented, and one of the communities, namely Falekaupule, which consists of island elders is the supreme decision-making body of all matters in the island that are of public interest or political importance. The other community members such as women group and young group are not fully able to voice out their concerns with the presence of Falekaupule. Thus, public consultation meetings were implemented with the following procedures to obtain diverse opinions.



▲ Approaches to public consultation applied in Tuvalu

Point!

Planning and design of coastal conservation measure requires opinions and consensus from direct stakeholders, mainly residents and local communities, on an equal footing.

- Section 3 -

Construction

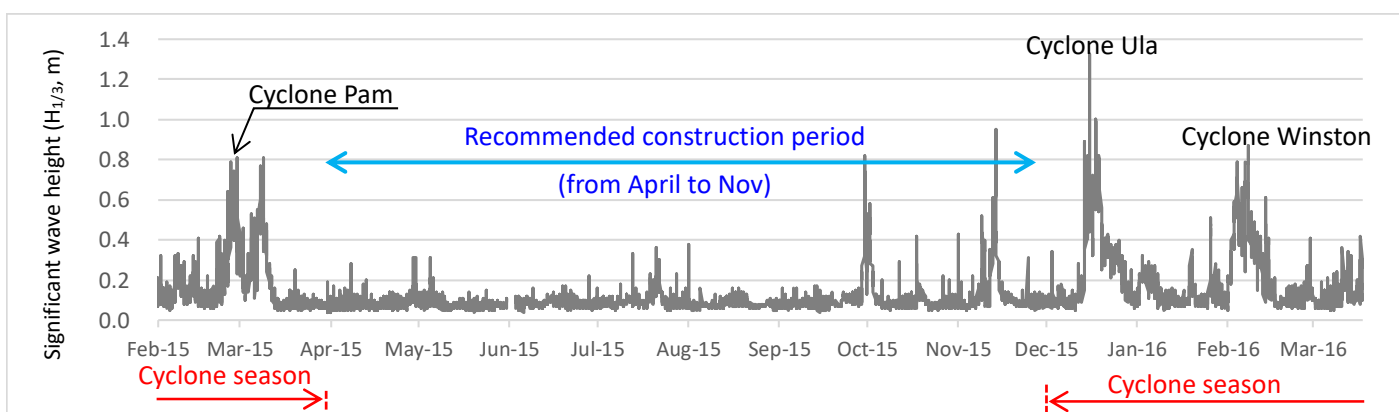
3.1 Considerations on Construction Planning for Beach

Summary

Since implementation of beach nourishment generally requires work at sea, it is desirable to set construction period during calm-wave season. Construction procedures are also important for beach nourishment to avoid extra loss of nourishment materials.

● Setting of Construction Period

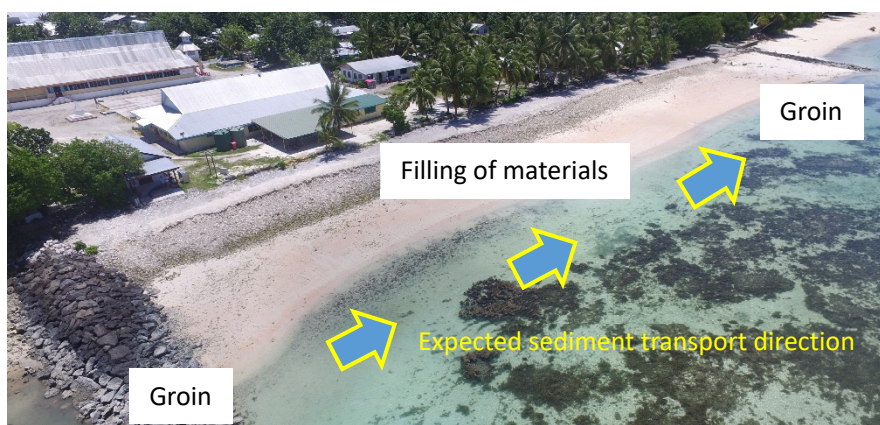
Point-1: It is desirable to set construction period to avoid cyclone season (see figure below for example). If it is inevitable, some allowance in schedule is required for construction planning.



▲ Observed significant wave height near the construction site in Tuvalu, 2015 and 2016

● Consideration on Construction Procedure

Beach nourishment has to be implemented with special care on construction procedure as nourishment material can be transported by wave action (i.e., sediment transport) even during construction period, which usually results in extra loss of nourishment materials.



▲ Project site condition and dominant sediment transport direction

Point-2

- Groins must be constructed sufficiently before nourishment to avoid extra/unexpected loss of filling materials.
- Location of sand filling must be carefully selected with consideration of sediment transport direction.

3.2 Environment Monitoring during Construction

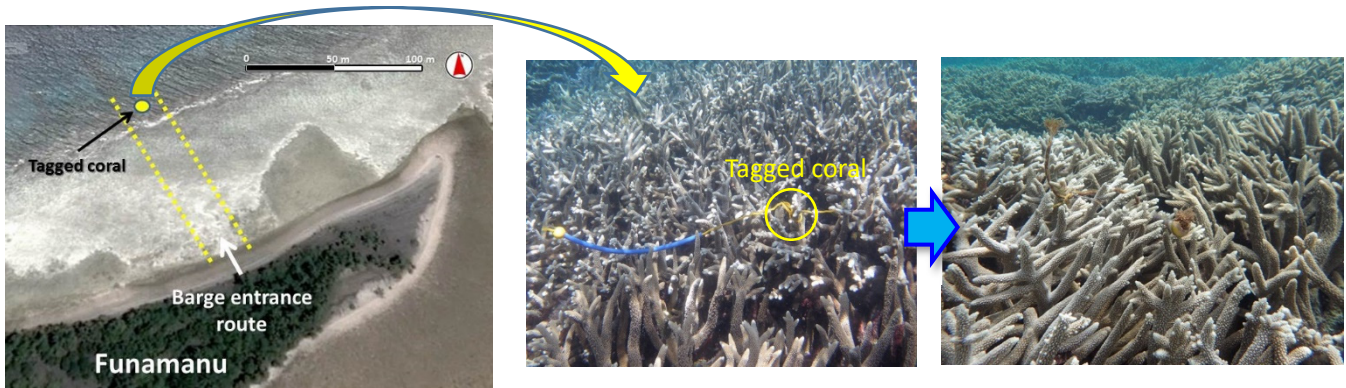
Summary

Environment monitoring is required during the construction to examine if any impacts would occur on surrounding environment. If serious impact occurs, construction must be aborted until mitigation measures are prepared. This monitoring has to be done not by contractor but by consultant or government to secure equality.

Practical Example: Environment monitoring implemented during the construction in Tuvalu

1. Coral (most critical issue)

To monitor whether the corals, especially for those that exist at a shallower depth distributed inside the barge entrance route, are not damaged through gravel-transporting activities.



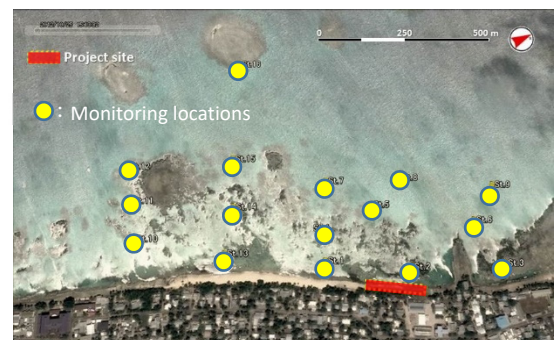
Notes:

Barge entrance route should be decided considering the draft of barge and water depth so as not to hit the lowest point



2. Water quality

To monitor the impacts of sand-placement works on water quality using turbidity as an indicator. Portable turbidity meter can be used for monitoring.



3. Marine life

To monitor the impacts of the nourishment works on the marine life adjacent to the project site.

- Many young fishes were observed along the groin in the post-construction stage.



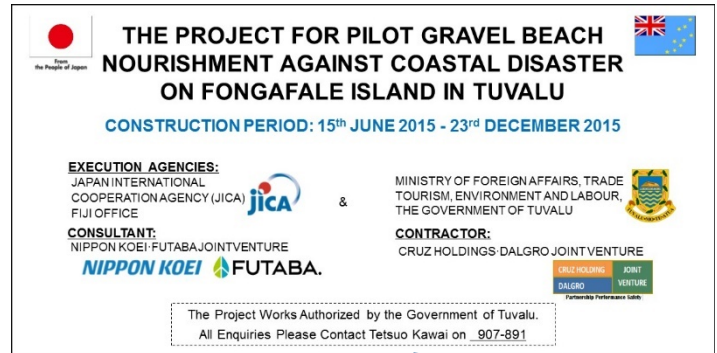
3.3 Points to Note on Construction Works

Summary

Construction works of beach conservation projects have some common points to note: 1) safety for residents, 2) consensus building with residents, and 3) preservation of natural environment (coral) are the main issues to be considered during construction.

Point to Note: 1

Safety comes first. Since beach is a public area that everyone can easily enter, adequate notification and limitations for entrance are required to secure public safety.

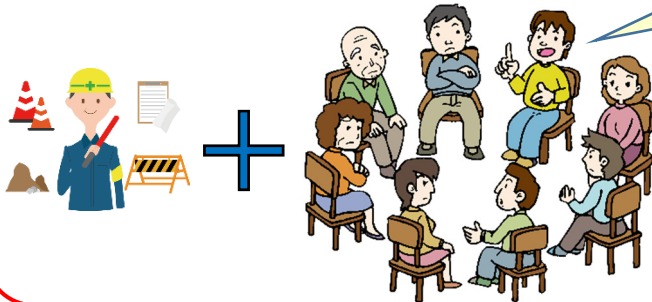


Limitations for entrance by building fences and deploying a watchman during construction

Signboard to inform construction information including emergency contact number

Point to Note: 2

Supervisor is required not only for construction but also for consensus building



Especially required where beach conservation project is not familiar and local village have strong voice on administrative matters

Construction must be planned and implemented very carefully to minimize the impact on the surrounding environment

Construction site can be utilized as a field of environmental education to improve their awareness on beach conservation



Point to Note: 3

Since coral is the most precious resource, no project is justified if it will



Point to Note: 4

Touring the construction site can be utilized as an opportunity to public relations (PR) the beach conservation project if safety is secured.

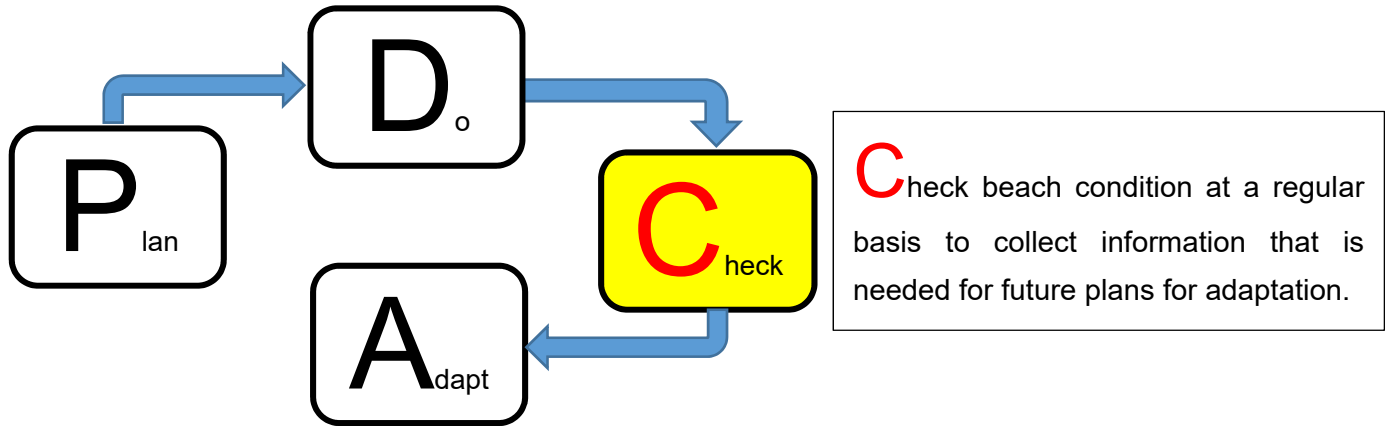
- Section 4 -

Monitoring, Maintenance and Management

4.1 Purpose of Beach Monitoring




Summary

For any beach conservation project, “adaptive measure” is essential as beach is always changing by current and waves and sometimes largely changed by cyclones and human activities. Thus, “Check” in the PDCA cycle, which is being used in beach monitoring, is firstly required to gather basic information required for adaptive measures.



▲ PDCA Cycle for Beach Conservation Project

Practical Examples in Tuvalu: Contents of Beach Monitoring and Implementation Bodies

Types	Basic Monitoring	Advanced Monitoring	
Content	Photography of beach	Beach profile survey	Photography by drone
Objective	Evaluate beach change <u>qualitatively</u> by comparing beach photos	Evaluate beach change <u>quantitatively</u> by comparing the beach profile data	Evaluate beach change with broad range.
Implementation body	Residents and local government members	Central government officers (Surveying Department)	Central government officers (Environment Department)
Frequency	<ul style="list-style-type: none"> Once a week Before and after bad weather 	<ul style="list-style-type: none"> Every three to six months Before and after bad weather 	
Equipment	Digital camera or mobile phone with camera 	Auto level, staff, tape-measure 	Drone (commercial one) 
See more details	Section 4.2	Section 4.3	

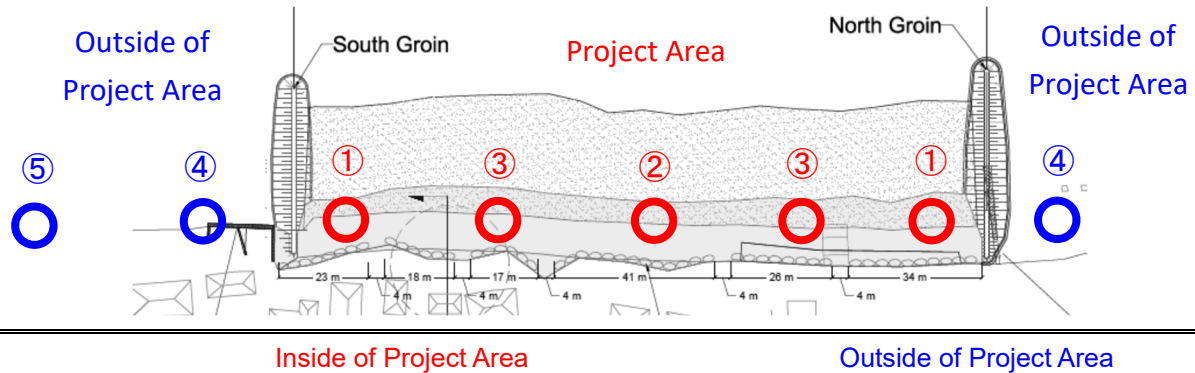
Note: Data for both basic and advanced monitoring must be stored at specific personal computer (PC) or shared server so that a coastal planner can refer to them at one time for review.

4.2 Basic Monitoring by Community and Residents

Basic Monitoring: Photography of Beach

- ✓ Method : Take photos from fixed position and angle to understand the beach change
- ✓ Equipment : Mobile phone with camera function or digital camera
- ✓ Frequency : Once a week and before and after the bad weather conditions

1) Locations of photography (practical example in Tuvalu)



Location	① Both ends of the project area	② Center of the project area	③ Supplementary locations between ① and ② (every 50 m for example)	④ Both ends of outside of the project area to evaluate the impact of the Project	⑤ Supplementary locations at the outside (50 m away from ④ for example)
----------	---------------------------------	------------------------------	--	--	---

2) Photography Example

First photo	Second photo (after one month from the first photo)
-------------	---

- Photos parallel to the shoreline from same location and angle



- Photos normal to shoreline across the structure from same location and angle

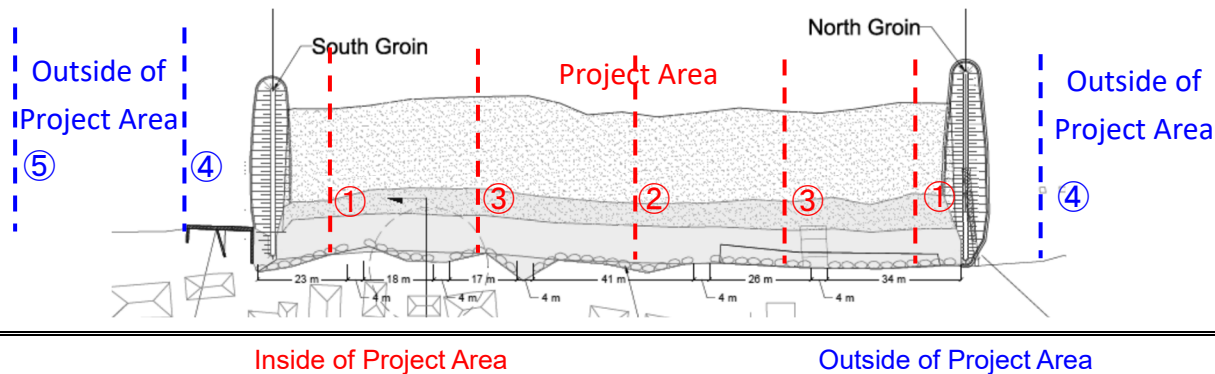


4.3 Advanced Monitoring by the Government

Advanced Monitoring-1: Beach Profile Survey

- ✓ Method : Survey beach profile using equipment to evaluate beach change quantitatively
- ✓ Equipment : Auto level, staffs, and tape measure
- ✓ Frequency : Every three to six months and before and after bad weather conditions

● Locations of survey lines

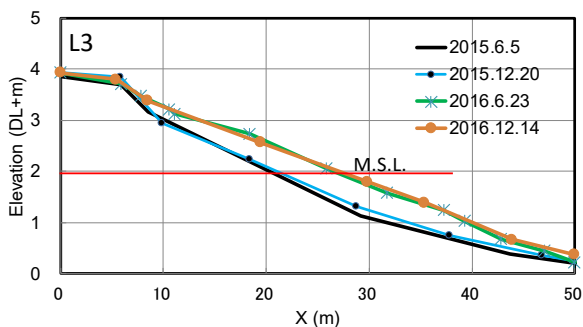


Survey lines	① Both ends of the project area	④ Both ends of outside of the project area to evaluate the impact of the Project
	② Center of the project area	⑤ Supplementary locations at the outside (50 m away from ④ for example)
	③ Supplementary locations between ① and ② (every 50 m for example)	

Advanced Monitoring-2: Photography done by Drone

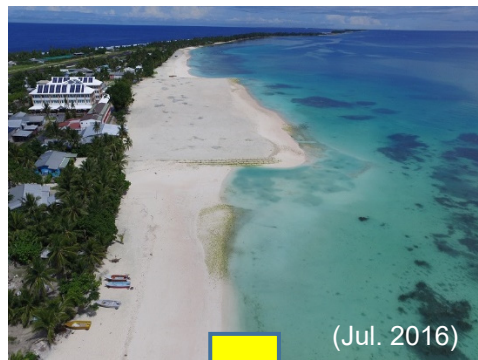
- ✓ Method : Take photos from bird's eye view to evaluate beach changes in broad view
- ✓ Equipment : Drone (commercial one)
- ✓ Frequency : Every three to six months and before and after the bad weather condition

(1) Beach Profile Survey



Comparison of Beach Profile

(2) Photography by Drone



(Jul. 2016)



six months later

(Dec. 2016)

4.4 Beach Maintenance by Beach Cleaning

Summary

Beach cleaning is the most common and effective activity of beach maintenance. Active participation from community and residents is necessary to make beach cleaning a sustainable activity. Thus, it is the government's chance to show their skills on how to make the community and residents be involved into beach cleaning activities.

Practical Examples in Tuvalu

1) What to collect/ Where to bring

- Rubbish (cans, plastic) ⇒ Designated dumping site
- Seaweed ⇒ Garden as a fertilizer or designated dumping site
- Obstacles for beach use (e.g., gravels scattered on sand) ⇒ Original location

2) Equipment needed for beach cleaning

- Cleaning items: folks, plastic bags, gloves (*Not so expensive if local government could prepare!!*)
- Machines (backhoe to pick up rubbish and trucks for transport to dumping site)

3) Beach cleaning structure that was established in the Project

Main Implementation
Body

Local
Government

<Approaches to residents>

- *Do beach cleaning ahead of them*
- *Provide some cleaning items*
- *Hold beach cleaning event regularly*
- *Help gather large amount of rubbish by machines*

Local Community
and Residents

Present Situation



Point!

Government's effort to encourage communities to join in the beach cleaning is essential to establish a sustainable beach cleaning structure.

4.5 Rules on Beach Use

Summary

Inadequate activities on beach can spoil healthy beach and make a bad influence on any aspects: protection, beach use, and environment. Setting rules on beach use and applying them into practice are one of the most important tasks of beach management.

<Typical Issues on Beach Use>

1. Steal of gravels/ sands for construction materials
2. Dumping and littering by beach users and residents that live behind the beach
3. Private construction such as private seawall or boat landing space (illegal occupation of public beach area)

Dumping, littering



Steal of gravel and sand



Private construction

Countermeasures applied in Tuvalu by the local government



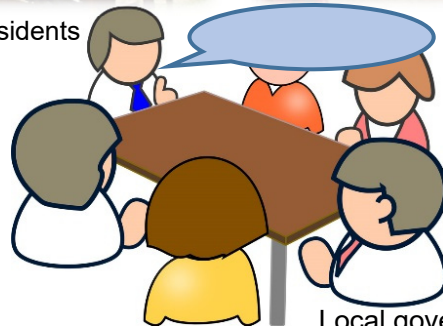
- Installation of signboard at the beach to inform public on the rules of beach use



Residents



- Preparation of by-laws on beach use



Local government

- Contact system of illegal activities from residents to local government



- Patrol by local government

Point!

Making efforts in various ways to prevent illegal activities on beach are important to expand rules and manners on beach use to public.

4.6 Adaptive Measure and Proposed Beach Management Structure

Summary

Adaptive measure was successfully implemented to improve beach use and beach management structure, including this adaptive measure, was proposed and practiced involving the local community from a sustainability standpoint.

Practical Example of Adaptive Measure in the Project

Step-1: Evaluate necessity of maintenance

- Any problems/inconvenience in functions: protection, beach use, and environment?
- Quantitative evaluation of beach profile change by monitoring

In Tuvalu case, maintenance was required to improve beach use

relocation from foreshore to backshore

Step-2: Relocation of gravel from foreshore to backshore

Step-3: Refilling and leveling of stockpiled sand

refilling of sand

Implementation of adaptive measure

Before implementation



- Relocation of gravel



- Filling and leveling of sand



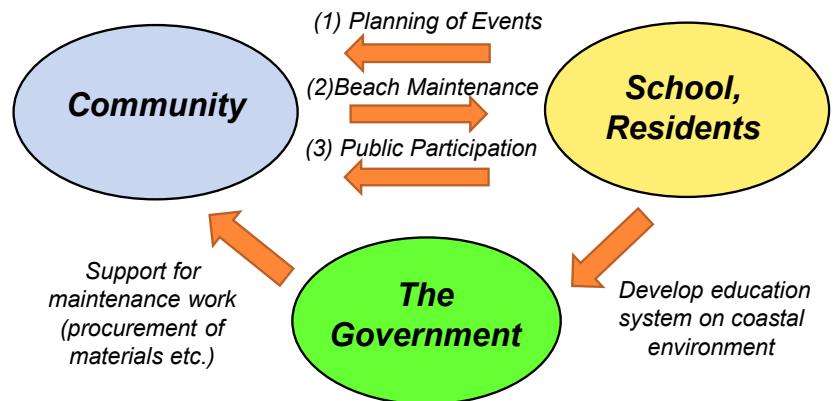
After implementation



Proposed Beach Management Structure

Beach management structure as shown in the right figure was proposed and practiced through the Project. This aims an “interactive activation between stakeholders” to make beach management activities more sustainable.

(For example, “event” in the figure was beach sports event that was implemented in the Project.)



▲ Concept of sustainable beach management structure

Point!

A beach management structure, including adaptive measure, has to be designed so that stakeholders can continue effortlessly by their ownership.

4.7 Importance of Public Relations and Educational Activities

Summary

A beach with full of rubbish indicates lack of people's interest on beach environment. In that case, beach condition would go back, sooner or later, even after the beach was improved by the Project. To raise public awareness on beach environment and maintain it at a high level is required for sustainable beach management.

[Before the Project] → [Just After the Project] → [Future]



Rubbish scattered on the beach



Beach nourishment completed



A branching point

Which future of beach do you expect?

Practical Example: A Sequence of PR and Educational Activities to Raise Awareness

To learn about the importance of beach environment.

Environmental Education



Step-1: Learn

To learn their roles to use the beach safely and pleasantly.

Beach Cleaning Event



Step-2: Play a role

To know the value of the beach by playing on it.

Beach Sport Festival



Step-3: Enjoy the beach

Point!

Beach management will never be realized without public understanding and participation.

4.8 PR and Educational Activities Implemented in the Project

Summary

It generally takes time to improve public awareness on beach conservation. Thus, it is recommended to implement PR and educational activities from the early stage of the Project. In actual, there are many types of PR and educational activities at each stage of the Project.

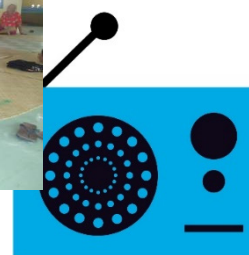
Stage-1: Planning and Design (Before Construction)



▲ Beach cleaning at the existing beach



▼ Workshop on beach maintenance



▲ Radio announcement

Stage-2: During Construction



▲ Construction site tour



▲ Beach song competition



▲ Drawing competition

Stage-3: Management and Monitoring (Post Construction)



▲ Environmental lessons



▲ Beach cleaning event



▲ Beach sport festival

Point!

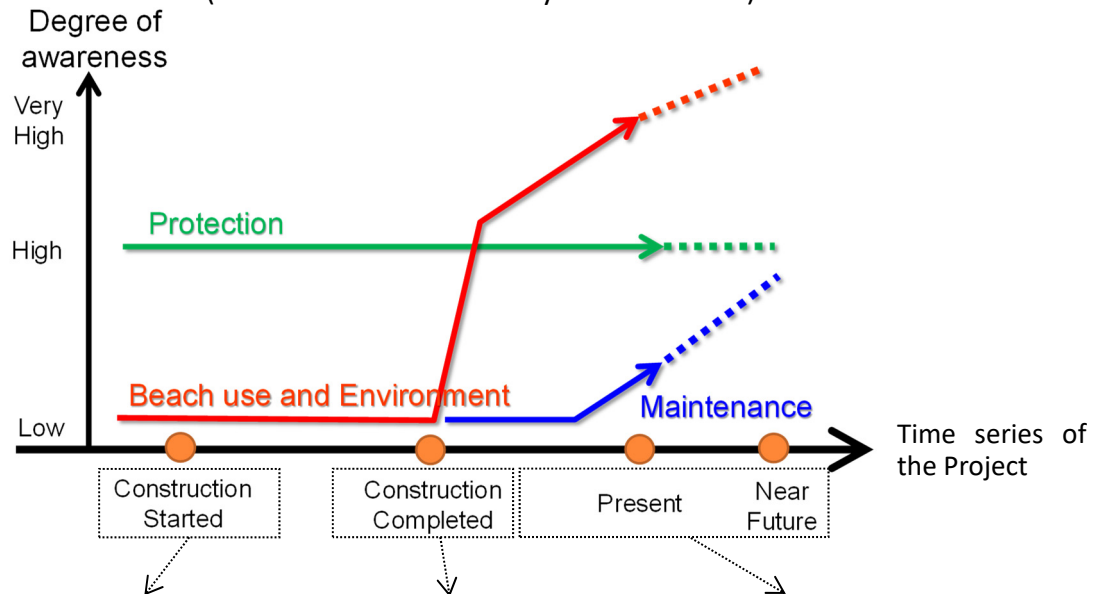
A variety of approaches by PR and educational activities for a certain period of time is required to improve public awareness on beach conservation.

4.9 Changes in Public Awareness on Beach through the Project

Summary

People's awareness on beach, especially for beach use and environment, can be much improved by combination of construction and PR and educational activities. Coastal planner must take this into consideration to realize a sustainable beach management involving the public.

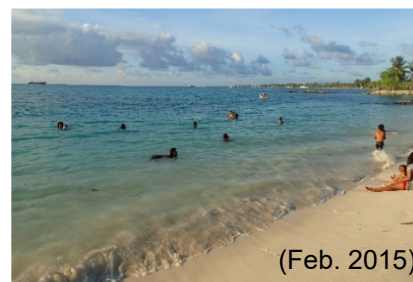
▼ Changes in People's Awareness on Beach through the Project in Tuvalu (based on interview survey with residents)



1) Construction started

2) Construction completed

3) Post construction



- High demand for protection
- The public is not familiar with beach nourishment and most of them preferred seawall than nourishment

- Natural beach was restored by gravel beach nourishment
- People firstly become aware of other benefits, i.e.: beach use and natural environment

- PR and educational activities were done to make people more familiar with the beach.

Point!

Public awareness on beach can be much improved through the Project and this improvement is essential to keep the beach in good condition for the future.

Example for Reference of Beach Nourishment

- 1) CUR (1987): Manual on Artificial Beach Nourishment, Centre for Civil Engineering Research, Codes, and Specifications, Rijkswaterstaat and Delft Hydraulics, Report 130, The Netherlands.
- 2) Bird, E.C.F. (1990): Artificial beach nourishment on shores of Port Phillip Bay, Australia, JCR Special Issue No.6, pp. 55-68.
- 3) NRC/ National Research Council (1995): Beach Nourishment and Protection, Committee on Beach Nourishment and Protection. National Academic Press, Washington, DC, USA
- 4) Sudar R.A., J. Pope, T. Hillyer, and J. Crumm (1995) Shore protection projects of the U.S. Army Corps of Engineers, Journal of Shore and Beach, pp.3-16.
- 5) IWR (1996): An Analysis of U.S. Army Corps of Engineers Shore Protection Program, Institute of Water Resources, IWR Report 96-PS-I, U. S. Army, Fort Belvoir, VA.
- 6) CUR (1997): Beach Nourishment and Rock Revetment, Center for Civil Engineering Research, Codes, and Specifications, The Netherlands.
- 7) T. Yamashita, Y. Tsuchiya, D.R.Basco, M. Larson (1997): Manual Evaluation of Beach Preservation Method in JAPAN, USA and EU(1), Proceedings of Coastal Engineering, JSCE, Vol.44, pp. 691-695.
- 8) Christian Lastrup and Holger Toxvig Madsen (1998): Evaluation of the effect of 20 years of nourishment, Danish Coastal Authority
- 9) Luc Hamm, H. Hanson, M.Capobianco, H.H. Dette, A. Lechuga and R. Spanhoff (1998): Beach fills in European projects, practices and objectives, Proc. of ICCE 1998, pp. 3060-3073.
- 10) Luc Hamm, M. Capobianco, H. H. Dette, A. Lechuga, R. Spanhoff, M.J.F. Stive (2002): A summary of European experience with shore nourishment, Coastal Engineering, Vol. 47, PP. 237-264
- 11) Stive, M.j.j., Aarninkhof, S.J.C., Hamm, L., H. Larson, M., Winjberg, K., Nicholls, R.J., Capobianco, M. (2002): Variability of shore and shoreline evolution, Coastal Engineering, vol.47, pp. 211-235.
- 12) Uda, T (2017): Japan's beach erosion -Reality and future measures, 2nd ed., World Scientific, 530p.

Reference of Beach Nourishment Projects by JICA

- 13) Onaka, S., S. Endo, I Yoshii and T. Uda (2008): Planning and Design of Beach Nourishment and Beach Change after Nourishment on Coral Reef Coast in Bali, Proceedings of the Seventh International Conference on Coastal and Port Engineering in Developing Countries (PIANC-COPEDEC VII)
- 14) Onaka, S., S. Endo and T. Uda (2010): Beach Nourishment on Coral Reef Coast and Resulting Beach Changes, Proceedings of the Fifth Civil Engineering Conference in Asian Region (5th CECAR)
- 15) Onaka, S., H. Hashimoto, S.R. Nashreen Banu Soogun, Amit Jheengut (2015): Coastal Erosion and Demonstration Project as Coastal Adaptation Measures in Mauritius, Handbook of Coastal Disaster Mitigation for Engineers and Planners, pp. 561-577.
- 16) Onaka, S., S. Ichikawa, M. Izumi, T. Uda, J. Hirano and H. Sawada (2017): Effectiveness of Gravel Beach Nourishment on Pacific Island, Asian and Pacific Coasts 2017, World Scientific, pp. 651-662.
- 17) Ichikawa, S. and S. Onaka (2015): Approach to Establish a Community-based Beach Management in Pacific Island Country, Asian and Pacific Coasts 2017, World Scientific, pp. 663-674.