BALI BEACH PROJECT

APPENDICES PROJECT MANAGEMENT PLAN AND EVALUATION

CIE4160 – Multidisciplinary Project 2015-2016 Q1
Faculty of Civil Engineering and Geosciences – Delft University of Technology

A COLLABORATION OF

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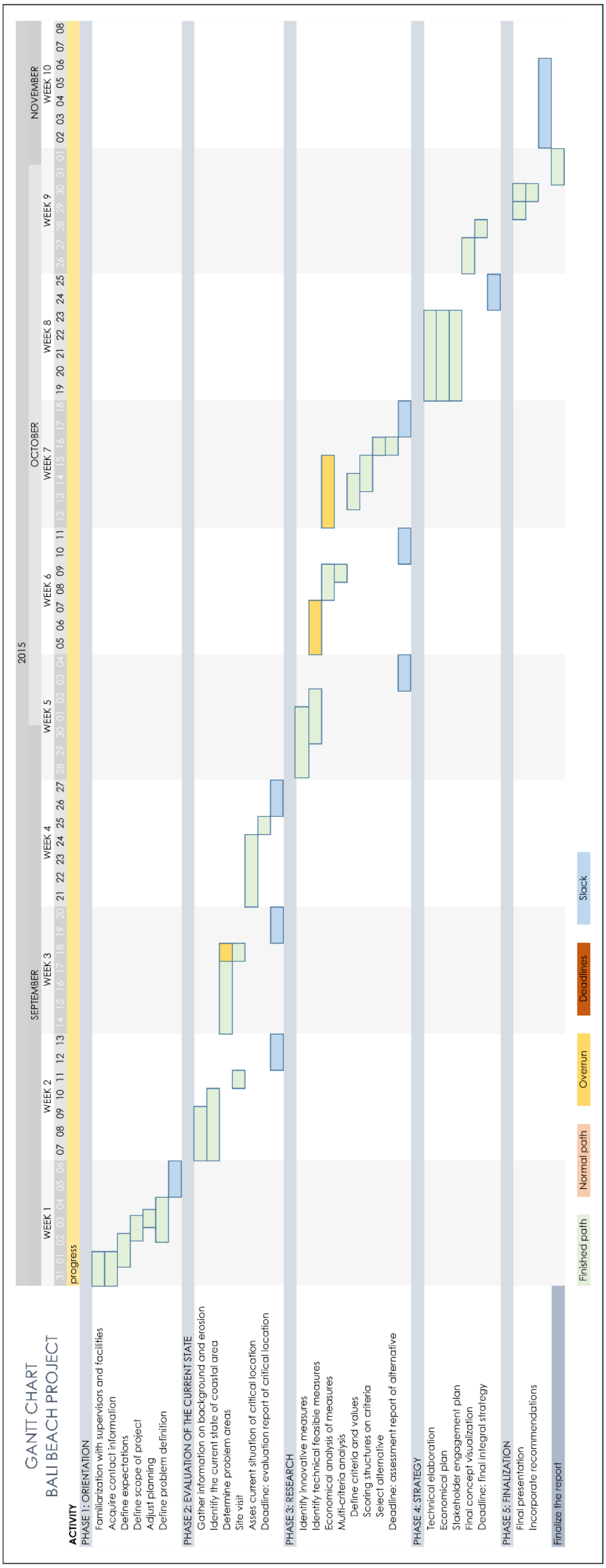
1 APPENDICES PROJECT MANAGEMENT PLAN

A: GANTT CHART



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C: Phase Breakdown Structure September 2015

Phase 1

Orientation

- Get in touch with PUSAIR supervisors
- Get to know the facilities
- Acquire contact information of (local) experts
- What are the expectations from PUSAIR
- Define final scope
- Adjust planning
- Define problem definition

Phase 2

Evaluation of current state

- Find relevant information about problem
- Adjust problem definition
- Determine problem areas using FMECA method
- Site visits
- Identify current state of coastal structures
- Identify impact of coastal erosion on ecology and economy
- Assess current strategy PUSAIR using RAMS
- Document findings in comprehensive overview (deadline)
- Brief update to supervisors (2x)

Phase 3

Research

- Investigate possible specific solutions
- Test solutions on safety and durability in lab
- Design and combine solutions in general alternatives
- Use Analysis of Alternatives to determine preferred alternative
- Document preferred alternative in comprehensive overview (deadline)
- Brief update to supervisors

Phase 4

Strategy

- Implementation time and duration
- Financial feasibility
- Engagement plan
- Visualization
- Document final strategy in comprehensive overview (deadline)
- Brief update to supervisors

Phase 5

Finalization

- Presentation
- Incorperate recommendations
- Finalize report
- Final meeting with PUSAIR supervisors

2 APPENDICES EVALUATION OF COASTAL STRUCTURES

B: APPENDIX FUNDAMENTALS OF COASTAL EROSION

B.1 Factors leading to erosion

Event		Outcome/Result/effect	Consequence
NATURAL	HUMAN INTERVENTION		
Sea level rise	Coastal or nearshore land subsidence	Deepening of nearshore waters	Submergence and increased wave attack
1. Lower rainfall 2. Natural river outlet diversion	1. Dam construction leading to sand entrapment. 2. Successful revegetation and soil conservation works. 3. Artificial diversion of river outlet. 4. Removal of weathered mantle from slopes in river catchments.	Reduced runoff or sediment yield from river	Diminution of fluvial sand and shingle supply to the coast
1. Diminished runoff 2. Stabilisation of landslides 3. Decline in the strength and frequency of wave attack 4. Exposure to massive resistant rock or soft silts and clays	1. Building seawalls to halt cliff recession	Stop of erosion from cliffs or shore outcrops or the exposure by cliff recession of formations that do not yield beach-forming sediment	Reduction of sand and shingle supply to shore
1. Natural vegetation colonisation 2. Supply run out	1. Conservation works	stabilising of moving inland dunes	Reduction of sand supply to shore
1. Production of biogenic material reduced due to ecological changes 2. Transverse profile attained a concave or steeply declining from which no longer permits shoreward drifting. 3. Increased growth of seagrasses or marine vegetation impeded of shoreward drifting		Supply washed in by waves and current from seafloor declined	Diminution of fluvial sand and shingle supply to the coast
	1. Quarrying or the extraction of mineral deposits 2. Losses from intensively used recreational beaches like beach cleaning operations.	Removal of sand and shingle from beach	Change of beach profile and volume
1. Bar and shoal has drifted away 2. Seagrass vegetation has disappeared 3. Dredging 4. Seafloor has subsided		Deepening of nearshore water	Increased wave energy reaching the shore
Interruption by the growth of a fringing coral reef or some other depositional feature	1. Interceptions like groines and breakwaters	Change of supply by longshore sources	Reduction of sand supply to shore
1. Change in wind regime 2. Growth or removal of a shoal, reef, island or foreland	1. Breakwater construction 2. Growth or removal of a shoal, reef, island or foreland	Change in the angle of incidence of waves	Increased loss of sand and shingle alongshore

	1. Dredging 2. Scour due to wave reflection induced by a seawall 3. Boulder rampart construction 4. Beach mining	Lowering of the beach face on an adjacent sector	Intensification of obliquely incident wave attack
1. Loss of retaining vegetation cover and dunes are drifted inland 2. Onshore wind activities		Lowering area behind beach and thus reducing the volume of sand to be removed to achieve coastline recession	Increased losses of sand from the beach to the backshore and hinterland
1. Climate change		A higher frequency, duration, or severity of storms in coastal waters	Increased wave attack
1. Attrition by wave agitation		Diminution in the calibre of beach and nearshore material	Winnowing and losses of increasingly fine sediment from the beach, either landward or seaward
1. Weathering of material 2. Solution of material 3. Attrition of material 4. Impaction of material		Diminution of beach volume	Lowering of the beach face
	1. Seawalls 2. Boulder ramparts	Increased scour by waves reflected from backshore structures	Reduction of the beach in front of backshore structures
1. Longshore currents	1. Structures	Long shore drifting	Migration of beach forelands
1. Increase in rainfall	1. Local drainage modification	Rise in water table level	Rendering the beach wetter and therefore easier eroded
1. Increase in rainfall 2. Melting snow or ice 3. Natural modifications in the catchments	1. Artificial modifications, such as urbanisation, in the catchments	Outwashing by streams or from drains carrying a large discharge of water	Increased losses of beach material
1. Natural enclosement of bay or lagoon	2. Artificial enclosement of a bay or lagoon	Impeding tidal ventilation	Intensification of wave action where tide range has diminished

B.2 Time scale of erosion factors and human factors for erosion and their timescale

Factor	**Effects**	**Time scale**								
		Hours	Days	Months	Years	10 years	50 years	100 years	1000 years	10000 years
Short wave period	Erosion									
Waves of small steepness	Accretion									
Large wave height	Erosion									
Storm surge	Erosion									
Alongshore currents	Accretion, no change or erosion									
Rip currents	Erosion									
Underflow	Erosion									
Overwash	Erosion									
Wind	Erosion									
Sediment supply (source and sink)	Accretion or erosion									
Inlet presence	Net erosion; high instability									
Sea level rise	Erosion									
Land subsidence	Accretion or erosion									

Erosion		Accretion/Erosion		Accretion	

Factor	**Effects**	Time scale								
		Hours	Days	Months	Years	10 years	50 years	100 years	1000 years	10000 years
Dredging	Erosion or accretion									
Coastal defence	Erosion or accretion									
Vegetation cleaning	Erosion									
Harbour development	Erosion or accretion									
River damming	Erosion									
Land reclamation	Erosion									

C: Appendix Coastal Area Analysis Data (JICA, 2013, pp. 190-212)

C.1 Criteria for scoring of Tourism Area

Score	Criteria
5	International tourism area (highest tourism area in Bali)
4	International tourism area (2nd highest tourism area in Bali)
3	Domestic tourism area (with future tourism development plan)
2	Domestic tourism area
1	Others

C.2 Evaluation of Tourist Area

Area	No	Subjected Beaches	Description	Score
South East Coast	E1	Candidasa	Highest international tourism area at east coast area	4
	E2	Kusamba	Out of tourism area	1
	E3	Klotok	Out of tourism area	1
	E4	Tegal Besar	Out of tourism area	1
	E5	Siyut	Out of tourism area	1
	E6	Lebih	Domestic tourism area but there is future tourism development plan	3
	E7	Masceti	Out of tourism area	1
	E8	Saba, Purnama	Out of tourism area	1
	E9	Pabean	Out of tourism area	1
	E10	Sanur North ~ Padang Galak	Domestic tourism area, but foreign tourist also sometimes visit	3
South West Coast	W1	North Kuta ~ Legian	Highest international tourism area in Bali	5
	W2	Seminyak	Highest international tourism area in Bali	5
	W3	Canggu	Developing international tourism area	4

C.3 Beach area ranked by number of rooms of hotels

Rank	Regency/City	Representative Resort Beach Area	Classified Hotel		Non-classified Hotel		Total	
			Num. of Hotel	Num. of Room	Num. of Hotel	Num. of Room	Num. of Hotel	Num. of Room
1	BADUNG	*Kuta(Phase-1 Project)*	18	3,253	120	3,315	138	6,568
2	BADUNG	*Nusa Dua Beach (Phase-1 Project)*	22	5,170	11	250	33	5,420
3	BADUNG	Seminyak - Petitenget (Kerobokan) - Batu Mejan (Canggu)	17	1,941	100	2,269	134	4,846
4	BADUNG	Kuta North - Legian	17	2,275	110	2,568	127	4,843
5	DENPASAR	*Sanur Beach (Phase-1Project)*	20	2,882	49	1,014	69	3,896
6	BULELENG	Lovina Beach	6	295	51	802	57	1,097
7	BADUNG	Jimbaran	7	896	7	155	14	1,051
8	KARANGASEM	Candidasa	5	208	43	792	48	1,000
9	KLUNGKUNG	Nusa Lembongan Area	2	36	26	269	28	305
10	TABANAN	Tanah Lot Area (Phase I)	1	278	3	21	4	299
11	DENPASAR	Sanur North - Padang Galak	1	100	2	41	3	141
12	KARANGASEM	Tulamben Beach	0	0	7	114	7	114
13	JEMBRANA	Menjangan (West Bali National Forest)	2	71	0	0	2	71
14	KLUNGKUNG	Tegal Besar - Klotok	0	0	1	5	1	5
-	KARANGASEM	Ujung Beach	0	0	0	0	0	0
-	KLUNGKUNG	Kusamba - Pesinggahan	0	0	0	0	0	0
-	KLUNGKUNG	Klotok - Kusamba	0	0	0	0	0	0
-	GIANYAR	Lebih - Siyut	0	0	0	0	0	0
-	GIANYAR	Saba - Masceti	0	0	0	0	0	0
-	GIANYAR	Gumicik - Pabean - Purnama	0	0	0	0	0	0
	TABANAN	Soka Beach	0	0	0	0	0	0

C.4 Beach area ranked by number of seating capacity and restaurants

Rank	Regency/City	Representative Resort Beach Area	Number of Restaurant	Number of Seat
1	BADUNG	*Kuta (Phase-1 Project)*	203	12,048
2	BADUNG	Kuta North - Legian	131	8,650
3	BADUNG	Seminyak - Petitenget (Kerobokan) - Batu Mejan (Canggu)	133	7,359
4	DENPASAR	*Sanur Beach (Phase I Project)*	91	4,602
5	BADUNG	*Nusa Dua Beach (Phase-1 Project)*	*53*	*3,580*
6	BULELENG	Lovina Beach	23	1,263
7	KARANGASEM	Candidasa	35	1,112
8	BADUNG	Jimbaran	24	998
9	KLUNGKUNG	Nusa Lembongan Area	21	725
10	GIANYAR	Lebih - Siyut	21	657
11	KLUNGKUNG	Kusamba - Pesinggahan	4	176
12	KARANGASEM	Tulamben Beach	4	78
13	TABANAN	Tanah Lot Area (Phase I)	6	-
-	KARANGASEM	Ujung Beach	0	0
-	KLUNGKUNG	Klotok - Kusamba	0	0
-	KLUNGKUNG	Tegal Besar - Klotok	0	0
-	GIANYAR	Saba - Masceti	0	0
-	GIANYAR	Gumicik - Pabean - Purnama	0	0
-	DENPASAR	Sanur North - Padang Galak	0	0
-	TABANAN	Soka Beach	0	0
	JEMBRANA	Menjangan (West Bali National Forest)	0	0

C.5 Criteria for scoring of Land Use

Score	Criteria
5	within top 5 for both
4	within top 10 for both
3	within top 15 for both
2	within top 15 for either
1	out of rank

C.6 Evaluation of Land Use

Study Area	No	Subjected Beaches	Description	Score
South East Coast	E1	Candidasa	Hotel (rank 8), Restaurant (rank 7)	4
	E2	Kusamba	Hotel (out of rank), Restaurant (rank 11)	2
	E3	Klotok	Hotel (out of rank), Restaurant (out of rank)	1
	E4	Tegal Besar	Hotel (rank 14), Restaurant (out of rank)	2
	E5	Siyut	Hotel (out of rank), Restaurant (rank 10)	2
	E6	Lebih	Hotel (out of rank), Restaurant (rank 10)	2
	E7	Masceti	out of ranking	1
	E8	Saba, Purnama	out of ranking	1
	E9	Pabean	out of ranking	1
	E10	Sanur North ~ Padang Galak	Hotel (rank 11), Restaurant (out of rank)	2
South West Coast	W1	North Kuta ~ Legian	Hotel (rank 1), Restaurant (rank 1)	5
	W2	Seminyak	Hotel (rank 3), Restaurant (rank 3)	5
	W3	Canggu	Hotel (rank 3), Restaurant (rank 3)	5

C.7 Evaluation of contribution of tourism development plan

Study Area	No	Subjected Beaches	Infrastructure Development					Tourism area	Score
			Toll Road		Sea Transport Access				
			Sanur to Padangbai	Kuta to Soka	International cruise port	Ferry (Amed to Lember)	Ferry (Gunaksa to Nusa Penida)		
South East Coast	E1	Candidasa	1		1	1		1	4
	E2	Kusamba	1						1
	E3	Klotok	1				1		2
	E4	Tegal Besar	1						1
	E5	Siyut	1					1	2
	E6	Lebih	1					1	2
	E7	Masceti	1					1	2
	E8	Saba, Purnama	1					1	2
	E9	Pabean	1					1	2
	E10	Sanur North ~ Padang Galak	1					1	2
South West Coast	W1	North Kuta ~ Legian		1				1	2
	W2	Seminyak		1				1	2
	W3	Canggu		1				1	2

C.8 Criteria for scoring of degree of beach erosion

Score	Criteria
5	Beach retreat more than 50m for 30 years
4	Beach retreat from 20m to 50m for 30 years
3	Beach retreat from 10m to 20m for 30 years
2	Beach retreat from 0m to 10m for 30 years
1	No beach retreat

C.9 Evaluation of degree of beach erosion

Study Area	No	Subjected Beaches	Description	Score
South East Coast	E1	Candidasa	20 to 30m retreat at east side, 40 to 60m at west side	5
	E2	Kusamba	No retreat	1
	E3	Klotok	150 to 200m retreat	5
	E4	Tegal Besar	100 to 150m retreat	5
	E5	Siyut	100 to 150m retreat	5
	E6	Lebih	100m retreat	5
	E7	Masceti	5 to 10m retreat	2
	E8	Saba, Purnama	10 to 20m retreat	3
	E9	Pabean	50 to 80m retreat	5
	E10	Sanur North ~ Padang Galak	70 to 100m retreat	5
West Coast	W1	North Kuta ~ Legian	5 to 12m retreat	3
	W2	Seminyak	5 to 15m retreat	3
	W3	Canggu	0 to 10m retreat	2

C.10 Evaluation of obstruction on beach use and land facilities

Study Area	No	Subjected Beaches	Main Purpose of Beach Use	Obstruction on beach activities and utilization	Obstruction on land facilities	Score
South East Coast	E1	Candidasa	Tourism area for foreigner and domestic	- Difficulty to beach access - Difficulty of walking along the beach - No space for beach activities	- Wave over topping into hotel property - Loss of property	5
	E2	Kusamba	Fishery and sea transport	no problem	no problem	0
	E3	Klotok	Religious area		Wave intrusion into temple	1
	E4	Tegal Besar			Wave intrusion into property	1
	E5	Siyut			Wave intrusion into property	1
	E6	Lebih	Religious and recreation area	Insufficient space for beach activities	-Wave run up in front of some facilities -Possibility for damage of facility	3
	E7	Masceti	Religious and recreation area		Wave intrusion into temple	1
	E8	Saba, Purnama	Religious and recreation area		Wave intrusion into property	1
	E9	Pabean	Recreation area		Wave intrusion into property	1
	E10	Sanur North ~ Padang Galak	Tourism recreation area for domestic, religious and recreation area		Wave intrusion into property	1
South West Coast	W1	North Kuta ~ Legian	Tourism area for foreigner and domestic	- Insufficient of beach space for activities during high tide	-Wave run up in front of some facilities -Possibility for damage of facility	3
	W2	Seminyak	Tourism area for foreigner	- Insufficient of beach space for activities during high tide	-Wave run up in front of some facilities -Possibility for damage of facility	3
	W3	Canggu	Tourism and residential area for foreigner, religious area		-Wave run up in front of some facilities -Possibility for damage of facility	2

C.11 Interview of necessity for coastal protection

Priority	No	Selected Beach	Interviewer	Request for Beach Conservation	Evaluation
1st	E1	Candidasa	The Head of Samuh Traditional Sub-Village	Immediately	High
			The Head of Sengkidu Traditional Village	Immediately	
			The Head of Hotel Association	Immediately	
			Candidasa Fisherman Group	Immediately	
			Subagan Traditional Village Teacher	Immediately	
	W1	North Kuta ~ Legian	The Head of Traditional village	Immediately	High
			The Head of Legian beach management	Immediately	
			Hotel Bali Mandira	It might be necessary in future	
	W2	Seminyak	The Head of Seminyak Traditional village	Immediately	High
			The Head of Seminyak Beach Management	Immediately	
2nd	W3	Canggu	The Head of Traditional village	Immediately	High
			The Head of Fisherman Association	It might be neceesary in future	
			The Head of Hotel and Restaurant Executive Club	Case to case	
			The Head of Traditional village (Brawa)	Immediately	
			The Head of Fisherman Association (Brawa)	Immediately	
	E6	Lebih	The Head of Lebih Fisherman Groups	Immediately	High
			The Head of Lebih Traditional Village	Immediately	
3rd	E10	North Sanur ~ Padang Galak	The Head of Kesiman Traditional Village	It might be neceesary in future	Medium
			The Head of Padanggalak Fisherman Group	It might be necessary in future	

C.12 Relation between hotels and community

Priority	No	Selected Beach	Present Condition	Evaluation
1st	E1	Candidasa	Community and Hotels do the beach cleaning together	No problem
			Coordination meeting is sometimes held between village and hotels as required	
	W1	North Kuta ~ Legian	Community and Hotels do the beach cleaning in cooperation with private sector and NGO	No problem
	W2	Seminyak	Community and Hotels coordinate for beach cleaning	
2nd	W3	Canggu	Coordination meeting is sometimes held between village and hotels as required	No problem
			Hotels pay local authority to clean the beach	
	E6	Lebih	No coordination (due to no hotel exists)	-
3rd	E10	North Sanur~ Padang Galak	No coordination (due to no hotel exists)	-

C.13 Summary impact coastal environment

Priority	No	Selected Beach	Type of Beach	Coral Habitat	Sea Grasses	Water Quality	Target fish species for fishery	Restriction on Environmental Regulation	Evaluation
1st	E1	Candidasa	Coral Reef Beach	Exiting	Exiting	Good	Mackerel, Snapper, Grouper, Albacore Tuna	No	Necessity of careful attention
	W1	North Kuta ~ Legian	Sandy Beach	-	-	Moderate	Lobster	No	Not impacted
	W2	Seminyak	Sandy Beach	-	-	Moderate	Lobster	No	Not impacted
2nd	W3	Canggu	Sandy Beach	-	-	Moderate	Lobster	No	Not impacted
	E6	Lebih	Sandy Beach	-	-	Moderate	Mackerel, Snapper, Grouper, Albacore Tuna, Lobster	No	Not impacted
3rd	E10	North Sanur~ Padang Galak	Sandy Beach	-	-	Moderate	-	No	Not impacted

C.14 Commercial fishing areas

Priority	No	Selected Beach	Target fish species for fishery	Fishing area (Distance from coast)
1st	E1	Candidasa	Mackerel, Snapper, Grouper, Albacore Tuna	5 - 25 km
	W1	North Kuta ~ Legian	Lobster	1 - 10 km
	W2	Seminyak	Lobster	1 - 10 km
2nd	W3	Canggu	Lobster	1 - 10 km
	E6	Lebih	Mackerel, Snapper, Grouper, Albacore Tuna, Lobster	25 km area
3rd	E10	North Sanur~ Padang Galak	-	-

C.15 Occurrence of degradation of water quality

Priority	No	Beach	Present Condition	Physical Characteristics of the Shore	Impact for Nourishment	Impact for Offshore Sand Mining
1st	E1	Candi Dasa	Good	-Inside the coral reef -Partial stagnation of water due to existing groins and breakwaters	Some impact is expected due to turbidity and decrease of water exchange	Some impact is expected to corals due to turbidity during mining
	W1	North Kuta ~ Legian	Moderate	Open shore	No impact is expected	No impact is expected
	W2	Seminyak	Moderate	Open shore	No impact is expected	No impact is expected
2nd	W3	Canggu	Moderate	Open shore with partial rock cliff	No impact is expected	No impact is expected
	E6	Lebih	Moderate	Open shore	No impact is expected	No impact is expected
3rd	E10	Sanur North ~ Padanggalak	Moderate	Open shore	No impact is expected	No impact is expected

C.16 Evaluation results of realization of beach management

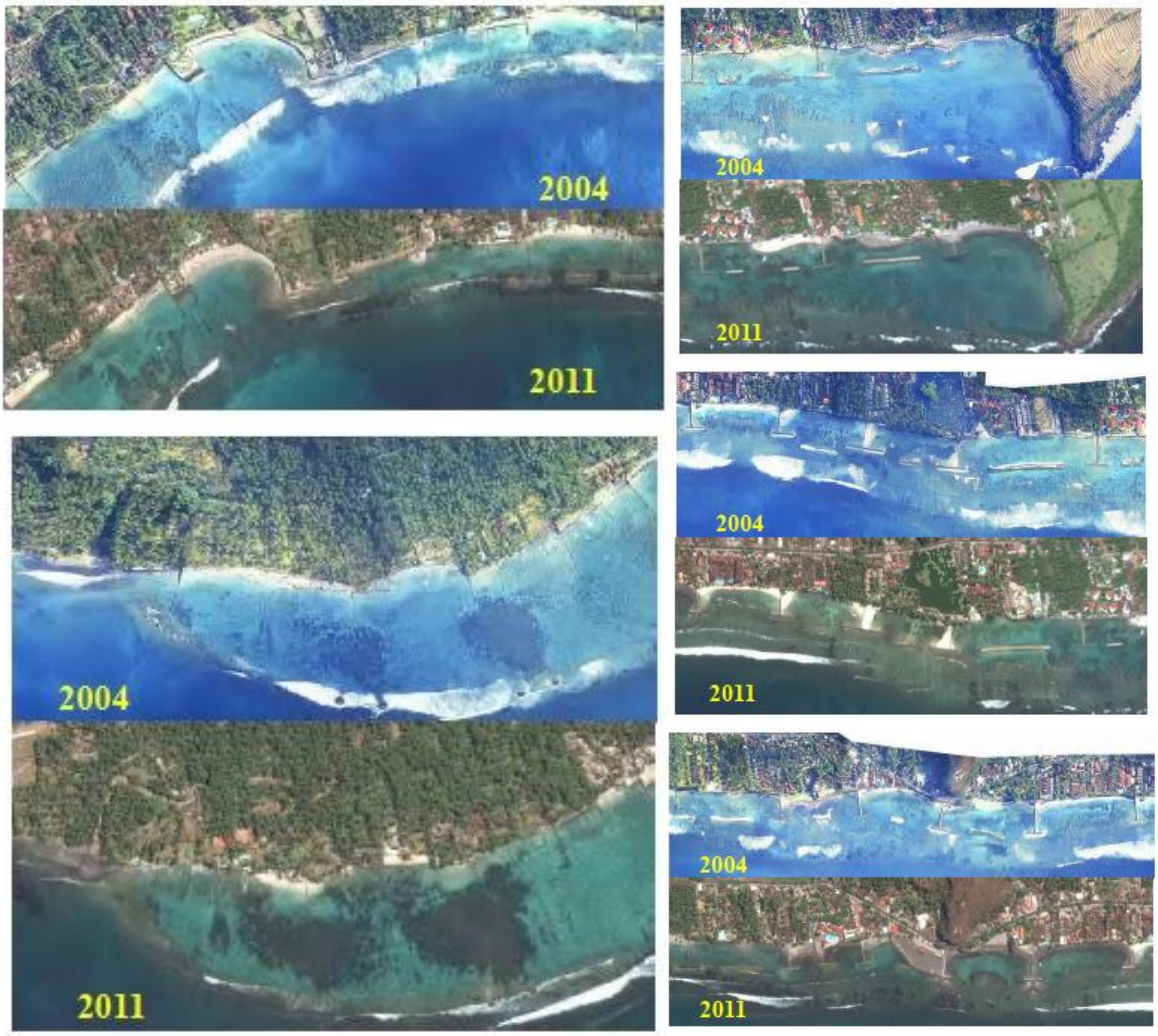
<table>
<tr><th>Priority</th><th>No</th><th>Selected Beach</th><th>Regency</th><th>Present Conditions, Future Possibility</th><th>Evaluation (Possibility for Realization)</th></tr>
<tr><td rowspan="3">1st</td><td>E1</td><td>Candidasa</td><td>Karangasem</td><td>-Candidasa is one of the world tourist beaches in Bali. The Karangasem Regency is receptive to learn about beach maintenance works for the Phase-1 Project Beaches. With this, the common information on beach maintenance and management can be shared and maintained between BWS-BP and Karangasem Regency.
-Karangasem Regency is an observer of the working group of this study. Meeting are held to discuss the establishment of beach management in Bali. After the establishment of the Team Coordination for Beach Management System (TKMPP) and if Candidasa become the project site, Karangasem Regency will become one of the main players.
-BWS-BP and Karangasem Regency have experiences on the maintenance and implementation for beach conservation and coastal protection in Candidasa Beach. Karangasem Regency understand the importance and difficulty of beach conservation and maintenance based on its past experience. However, they have never conducted any beach monitoring due to lack of engineering skills and survey equipment. A capacity building will be required through OJT during project implementation in Candidasa Beach.</td><td>Ready</td></tr>
<tr><td>W1</td><td>North Kuta ~ Legian</td><td rowspan="3">Badung</td><td rowspan="3">-Most of the world tourism beaches (e.g. Kuta and Nusa Dua in Phase-1 Project, Legian,Seminyak, Canggu, etc.) belong to Badung Regency, and their income is extremely high compared to other regencies.
-Based on the above condition, Badung Regency has already well understood the importance and necessity of beach maintenance and management
-Badung Regency is a member of Working Group Meeting in this study to discuss the establishment of beach management in Bali. After the establishment of the Team Coordination for Beach Management System (TKMPP), they will become a leading players among other related local government.
- BWS-BP has an experience on the maintenance and implementation for coastal protection in Canggu area. Badung Regency also get interested coastal protection and conservation through requirements from stakeholders.</td><td rowspan="3">Ready</td></tr>
<tr><td>W2</td><td>Seminyak</td></tr>
<tr><td rowspan="2">2nd</td><td>W3</td><td>Canggu</td></tr>
<tr><td>E6</td><td>Lebih</td><td>Gianyar</td><td>-The beaches in Gianyar Regency are basically only local beaches and there was no world tourism beaches.
- BWSBP has experience of maintenance and implementation for coastal protection at Lebih area. However, Gianyar regency has never conducted monitoring and maintenance for coastal protection and conservation due to lack of human resources and equipment.</td><td>Low</td></tr>
<tr><td>3rd</td><td>E10</td><td>Sanur North ~ Padang Galak</td><td>Denpasar City</td><td>-Sanur, which is one of world tourism beaches, belongs to the territory of Denpasar City. On the other hand, some of illegal use on projected sandy beach were observed.
'-BWSBP has experience of maintenance and implementation for coastal protection at Sanur North.</td><td>Medium</td></tr>
</table>

C.17 Self-management by stakeholders

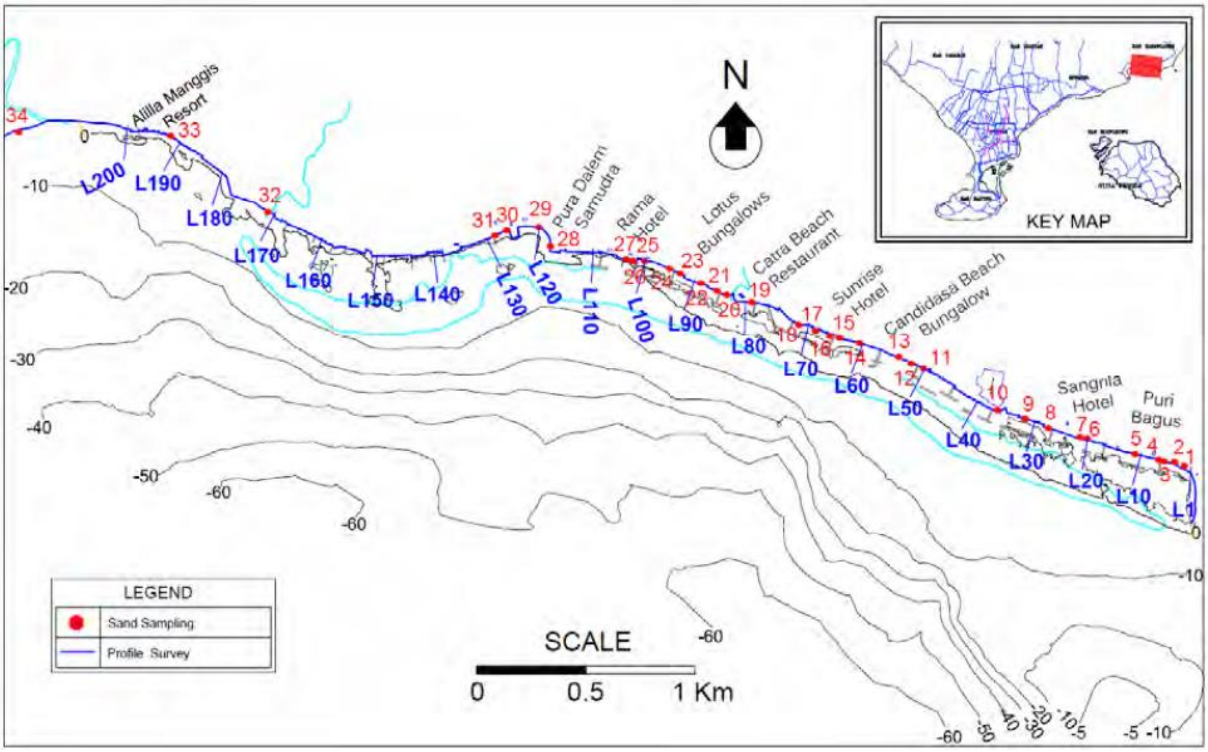
<table>
<tr><th>Priority</th><th>No</th><th>Beach</th><th>Management Item</th><th>Present Condition</th><th>Evaluation (Possibility)</th></tr>
<tr><td rowspan="5">1st</td><td>E1</td><td>Candidasa</td><td>Beach Cleaning</td><td>Communities and hotel associations managed well their responsible territories.</td><td>Medium</td></tr>
<tr><td rowspan="2">W1</td><td rowspan="2">North Kuta ~ Legian</td><td>Beach Cleaning</td><td>Communities and hotel and restaurant executive clubs managed the beach area in cooperation with the private sector and NGOs</td><td rowspan="2">High</td></tr>
<tr><td>Maintenance of Public Facilities</td><td>Some of public facilities (e.g., public toilet, bay watch set in Phase-1 Project) are maintained by communities after the Phase-1 Project.</td></tr>
<tr><td rowspan="2">W2</td><td rowspan="2">Seminyak</td><td>Beach cleaning</td><td>Communities and Hotel Association are well managed at their territory by their responsibility.</td><td rowspan="2">High</td></tr>
<tr><td>Maintenance of Public Facilities</td><td>Some of public facilitied (e.g. Public Toilet, Bay watch, which were set in Phase-1 Project) was maintained by communities after Phase-1 Project</td></tr>
<tr><td rowspan="2">2nd</td><td>W3</td><td>Canggu</td><td>Beach cleaning</td><td>Communities and Hotels are well managed at their territory by their responsibility</td><td>Medium</td></tr>
<tr><td>E6</td><td>Lebih</td><td>Beach cleaning</td><td>Fisherman groups managed the limited area (around fish market and restaurant on the beach)</td><td>Medium</td></tr>
<tr><td>3rd</td><td>E10</td><td>Sanur North ~ Padanggalak</td><td>Beach cleaning</td><td>Communities managed their territories.</td><td>Medium</td></tr>
</table>

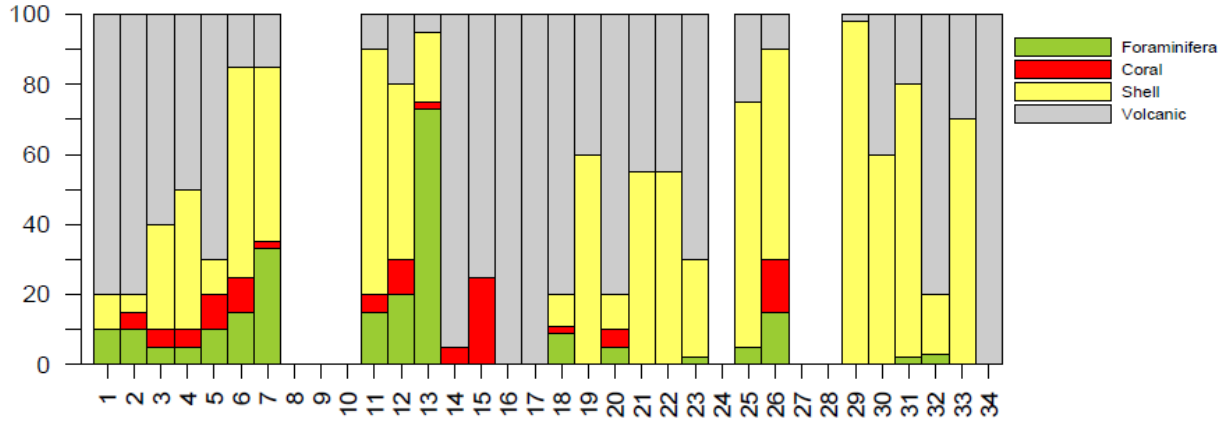
D: Appendix Evaluation of Candidasa

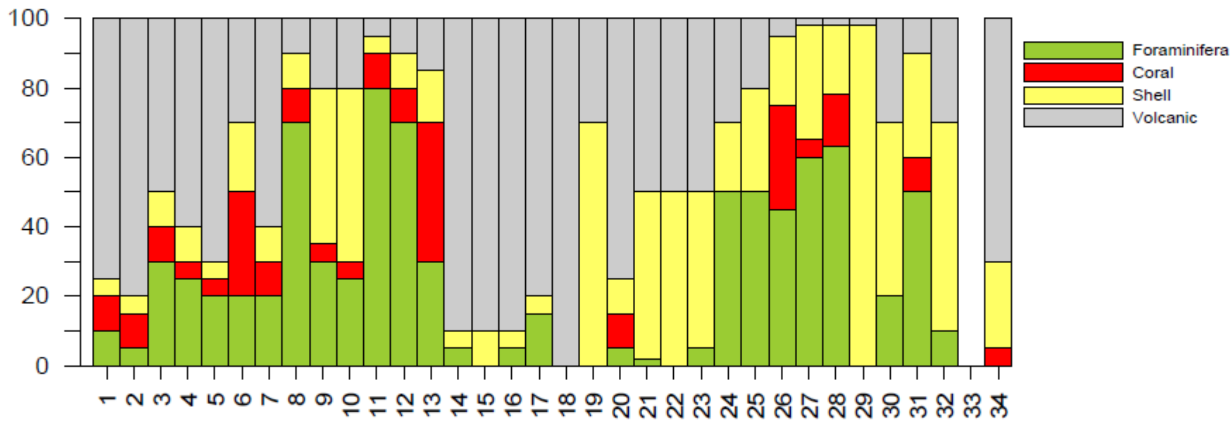
D.1 Comparison on the beach condition between 2004 and 2011 (JICA, 2013)



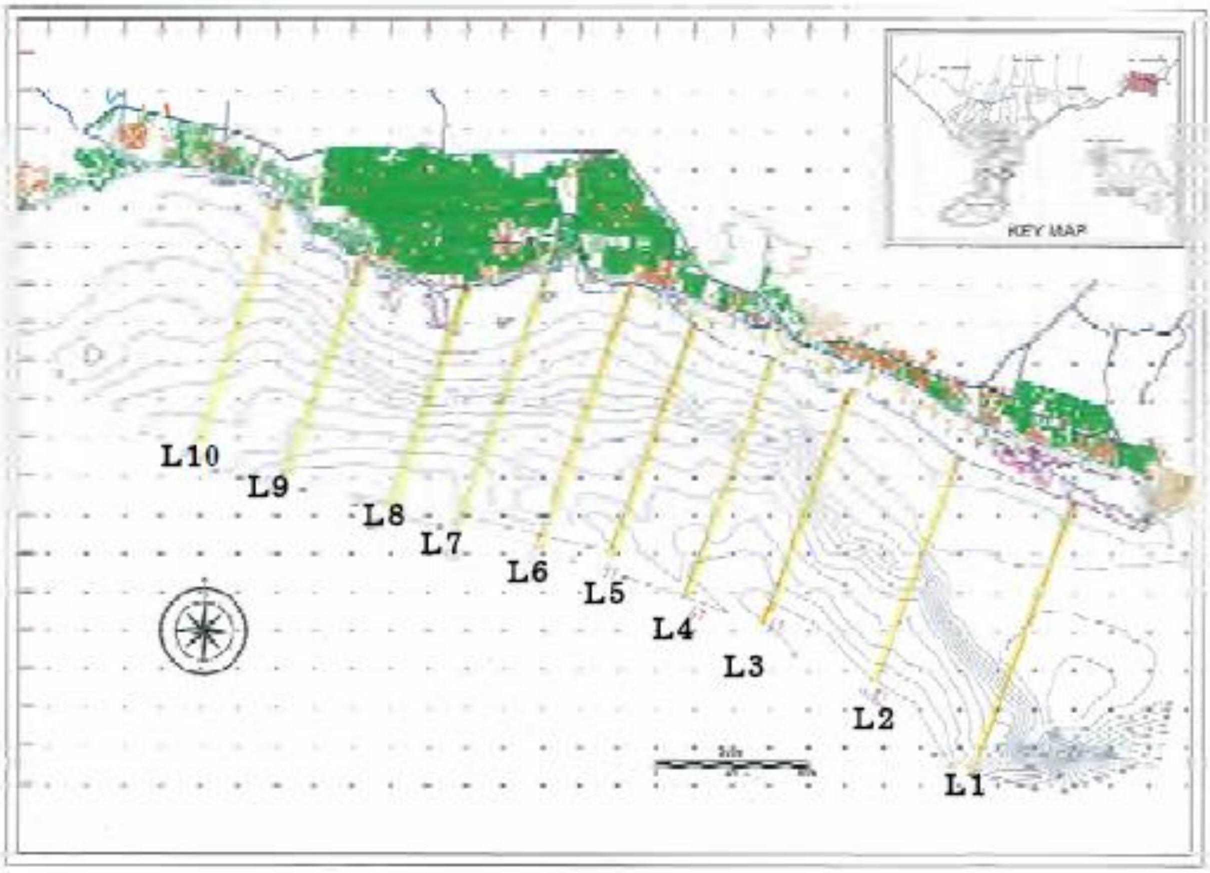
D.2 Sampling areas and Composition of the sand (JICA, 2013)

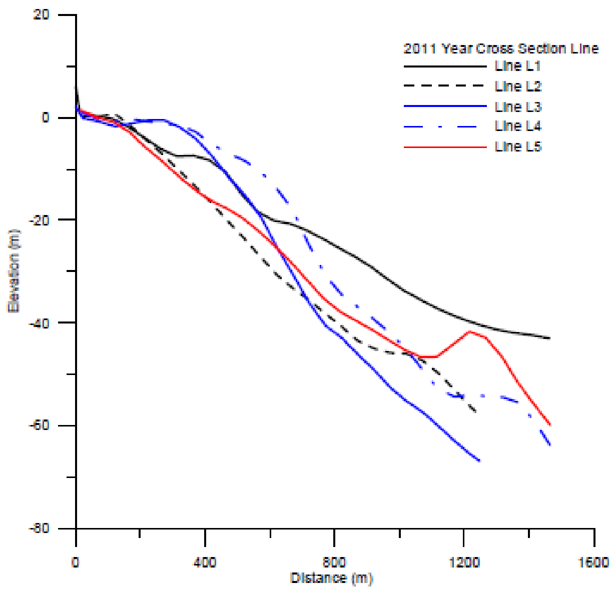


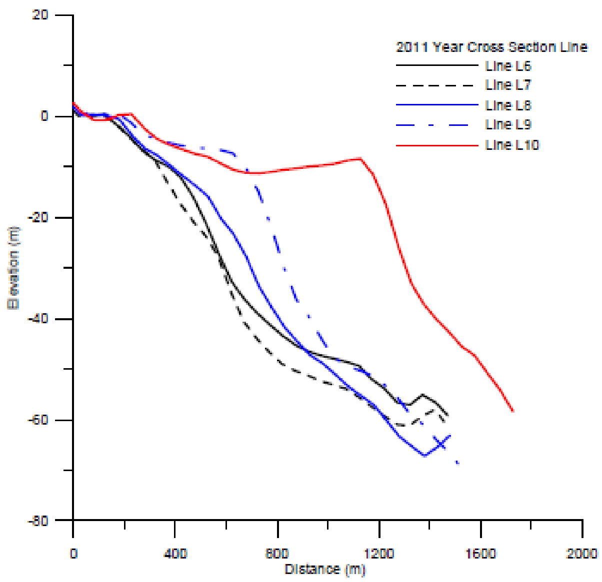




D.3 Cross-sections of beach and its slope (JICA, 2013)







D.4 Identification of stakeholders

STAKEHOLDERS	INTEREST	PROBLEM PERCEPTION	GOALS
A. Province of Bali	Increase the economic, safety, environmental and social value of Bali	Too high occupation in the South, too many erosion and waste on potential beaches	Attract and spread a variety of tourists around Bali beaches, by developing good infrastructure and clean beaches
B. BWS-BP (Bali Penida-River Basin Bureau)	Responsible for the construction of coastal structures, dams and water/sand storage	Homes, temples, agriculture in vicinity to the severe eroded beaches can be in danger - limited experience with beach maintenance	Developing structures with multi-functional structures with a maintenance plan
C. Experimental Laboratorium for Coastal Engineering(Balai Pantai)	Research and develop coastal structures to protect Bali	Growing erosion problems due to natural and human intervention(sea level rise, sand mining, etc.)	Develop safe and efficient coastal structures
D. Karangasem Regency	Optimize the welfare in Candidasa	Measures to avoid erosion deteriorate the beaches	Develop beaches that attract and retain tourists
E. JICA(Japan International Cooperation Agency)	Invest in Balinese economy, to create profit, job opportunities for Japanese companies and to maintain quality of tourism	Balinese environment and tourism is deteriorating due to erosion	Creating good will to Indonesia, make rendable investment, develop knowledge on beach erosion
F. Developers/Contractors/Subcontractors	Make profit and gain experience	Inexperienced with innovative, large-scale projects. Gaining of this experience can result in higher costs	Build decent coastal structures with lowest cost possible
G. Indonesian Hotel and Restaurant Association Chapter Bali	Increase tourism in order to increase profit	Redeveloping the beaches will also develop maintenance costs, which can higher their costs	Develop an attractive beach without having too high costs
H. Tourists/Tourist Agencies	Increase the quality of tourism area's	Too little qualitative tourist beaches	Development of attractive beaches
I. Local Village Organization/interest groups(Representatives for inhabitants, fishers, farmers,WAHIL Bali, etc.)	Maintain or enhance current quality of living and working	Concerned that tourism will prevail over their interest or that they will not benefit the growth of the tourism	Take advantage of new developments in their surroudings
J. Environmental Interest Groups/NGO's(Greenpeace, CCAI, etc.)	Protect or conserve the environment(forests, coral reefs, etc.)	Developing resorts/structures for the sake of financial development disturbs the natural surroundings in Bali	Develop sustainable structures that benefit the environment
K. Highway and irrigation Agency Karangasem	Increase the quality of infrastructure and water resources	More tourists/resorts can result in water shortage or traffic jams	Develop sustainable infrastructure and water supplies
L. Cleanliness Agency Karangasem	Maintain clean public space	Growing tourism results in more waste and waste on the shore does not get cleaned by the local stakeholders	Create a waste management concept
M. Environmental Agency Karangasem	Protect or conserve the environment	Construction of new structures interfere with the ecology	Develop sustainable structures that benefit the environment

D.5 Determination of critical stakeholders

STAKEHOLDERS	IMPORTANT RESOURCES	REPLACEBILITY (LOW/HIGH)	DEPENDENCY (LOW, MODERATE, HIGH)	CRITICAL ACTORS (YES OR NO)
A. Province of Bali	Power position: Highest governmental body of Bali	LOW	HIGH	YES
B. BWS-BP (Bali Penida-River Basin Bureau)	Production/blocking power: Execution Division of the Province of Bali. Have specific knowledge about management, planning and construction in Bali, which must be used to solve the critical areas.	LOW	HIGH	YES
C. Experimental Laboratorium for Coastal Engineering(Balai Pantai)	Production power: have specific knowledge on coastal structures and testing facilities	HIGH	HIGH	NO
D. Karangasem Regency	Blocking power: Smaller administrative division of the Province of Bali with high interest, are able to legally block/hamper developments if unsatisfied, no financial power.	LOW	MODERATE	YES
E. JICA(Japan International Cooperation Agency)	Production/blocking power: Their loans come with restrictions, which gives them production power and power to block the project is their requirements are not met.	LOW	HIGH	YES
F. Developers/Contractors/Subcontractors	Production power: are able to construct coastal structures	HIGH	HIGH	NO
G. Indonesian Hotel and Restaurant Association Chapter Bali	Blocking power: can refuse to collaborate in maintaining the public beach	LOW	MODERATE	NO
H. Tourists/Tourist Agencies	Blocking power: the tourists are the main driver for the optimization of the beaches, which gives them power to block the projects	HIGH	MODERATE/HIGH	YES
I. Local Village Organization/interest groups(Representatives for inhabitants, fishers, farmers,WAHIL Bali, etc.)	Blocking power: are able to obstruct plans if their natural habitat is damaged too much, are officialy recognized by the government, no financial power.	LOW	HIGH	YES
J. Environmental Interest Groups/NGO's(Greenpeace, CCAI, etc.)	Blocking power: experience in blocking project that are harmful to the environment	HIGH	LOW	NO
K. Highway and irrigation Agency Karangasem	Production power: possess knowledge to produce water resources	LOW	MODERATE	NO
L. Cleanliness Agency Karangasem	Production power: possess the resources necessary to execute cleaning projects	LOW	MODERATE	NO
M. Environmental Agency Karangasem	Blocking power: possibility to not give permits	LOW	HIGH	YES

E: APPENDIX COASTAL STRUCTURES

This appendix provides a comprehensive overview of the basic knowledge of conventional and innovative coastal conservation methods. Coastal defence structures are used to dissipate wave energy, prevent detrimental littoral drift, restore beaches or retain shorelines.

E.1 Conventional Structures

E.1.1 Hard Structures

E.1.1.1 Revetments

Revetments (Figure E-1) are sloping and are very often permeable structures placed on banks, beaches or cliffs to enhance wave energy absorption, minimise reflection and wave run-up and protect its bank against erosion. Revetments are used as a low-cost solution for coastal erosion defence in areas where crashing waves may otherwise deplete the coastline. Furthermore, revetments are often used in combination with other types of protection such as seawalls and dikes or submerged coastal structures (Mangor, 2007). Revetments consist of several layers of material. Although once popular, the use of wooden revetments has largely been replaced by upper layers often consisting of stone, concrete units or slabs or gabions. The bottom layer is called a filter cloth and is a crucial component of any revetment. Filter cloths separate the rip-rap (filling material) and armour stones from the banks, beaches or cliffs. It reduces settling, captures sediment and prevents the base material from washing away. This provides stability and safeguards the effectiveness of the revetment (LORA, 2007). Rubble revetments and similar structures have a permeable and fairly steep slope; normally a 1:2 slope is used. The maximum recommended slope of a random-placed armor stone revetment is 1:1.5. Slopes greater than this will tend to be unstable. Slopes greater than 1:3 are rare, mostly due to the higher cost (NYSDEC, 2006).

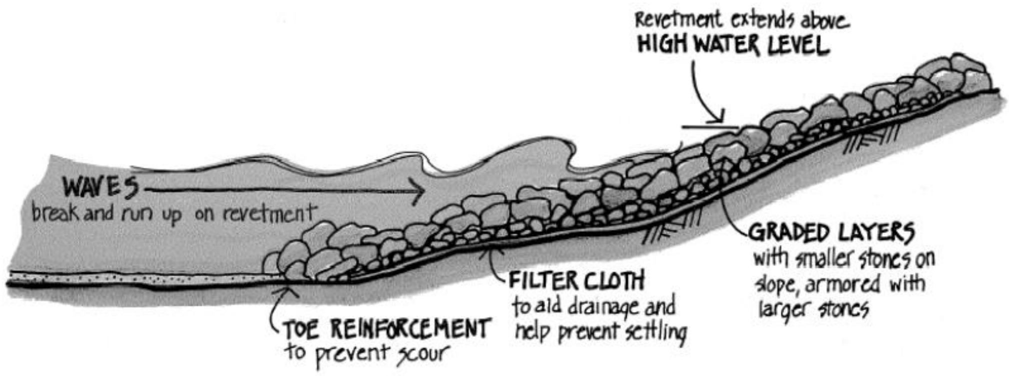


Figure E-1: Revetment principle *(LORA, 2007)*.

E.1.1.2 Sea Walls

A seawall (Figure E-2) is a structure separating land and water areas. It is constructed to prevent the hinterland from erosion and other damage due to wave action and storm surge. Seawalls are often very massive structures because they are designed to resist the full force of waves and storm surge (Mangor, 2007). In practice, seawalls can be seen as vertical and more solid revetments. Seawalls are mostly constructed of reinforced concrete with integral scour protection (USACE, 2012), but they can also be constructed as a rubble mound, gabions, steel or wooden structure. A seawall is a last resort measure mostly used at city fronts when there is very valuable upland infrastructure, harsh wave conditions or surge, space scarcity, or when there is no possibility for further offshore protection such as offshore breakwater structures.

Figure E-2: Seawall at La Crabiere *(Dixon, 2011)*.

Seawalls have a negative side effect caused by the reflection of wave energy. Construction will fix the location of the coastline but it often results in accelerated disappearance of the beach, which also creates an urgency to strengthen the foot of the seawall (Mangor, 2007). Waves can impact the face of seawalls, while overtopping waves damage the top and back of the structure and scour impacts the toe through the removal of sand. For the scour depth, the following rule of thumb can be used: the wave height equals the scour depth.

E.1.1.3 Breakwaters

Nearshore breakwaters are structures placed parallel to the shoreline. Their main purpose is reducing the wave action on the beach while they can also be used to alter longshore current and sediment flow. The main factors that should be taken into account when constructing a breakwater are, permeability, height and material. These factors are described in the section below. An example of a breakwater at Candidasa in beach is shown in Figure E-3 below.

Figure E-3: Breakwaters at Candidasa beach. Own Figure.

Design considerations

Breakwaters can be designed as permeable or impermeable structures and can either be submerged or with their crown above the mean water level. When designing a breakwater these characteristics have to be taken into account, as well as the slope, the surface roughness and the angle of the approaching waves. Careful design is therefore necessary to realise a breakwater which reflects the intended purpose.

Permeability of a breakwater

A breakwater can form a sediment trap, by intercepting drifting sediment it will enlarge the beach close to the breakwater. On the other hand this will block sediment flow to the beaches downstream, eroding these beaches. In order to manage the flow of sediment a degree of permeability of the breakwater has to be considered.

Height of a breakwater

A breakwater reduces the height of the waves landward and therefore reduces the wave impact on the beach. Breakwaters with their crown about the MWL will be more effective at achieving this than submerged breakwaters. By reducing the wave height, the sediment transport by the longshore current will reduce.

Material

A breakwater can be made from all sorts of material, from loose rocks to precast interlocking concrete blocks. The material and configuration of the material will largely affect the lifetime and effect of a breakwater. Materials which are often used to construct a breakwater are: concrete, natural rock, rubble. Rubble or recycled materials are often preferred over quarried rocks or newly cast concrete blocks, when taking costs and sustainability into account. In Bali granite is a common construction material for breakwaters. With a price of 500.000 IDR/m3 it is cheaper than using concrete with a price of 1.200.000 IDR/m3 (Adi, 2015).

E.1.1.4 Groins

Groins (Figure E-4) are rigid hydraulic structures built from the shore, that interrupt downdrift flow of sediment caused by currents. Groins are usually placed in groups, the areas in between are called groin fields.They are used to reduce beach erosion, maintain beach fills or fill groin fields with intercepted drifting sediment, by trapping or slowing down its longshore transport. Groins may be built of timber, masonry, sheet metal, boulders or concrete, depending on the expected impact on and desired permeability of the groin. Groins can be divided in several categories. Permeable groins (large rocks, timber) allow the water and sediment to flow through at reduced velocities. Impermeable groins (rocks, gravel, gabions) block and deflect the current and sediment. Groins can either be completely or partly submerged. Lower and submerged groins allow sediment to flow over at high tide. This can be problematic if too much sediment flows over. Too high, long and impermeable groins may however be loaded unequally (and collapse) due to updrift accretion and downdrift starvation. Different shapes of groins are possible (e.g. straight, T-, L-, Y-shaped). The orientation or angle in which groins are constructed has a large impact on their performance. This is illustrated in Figure E-5. Straight groins are the most commonly used. Repelling groins deflect the flow and allow sediment to settle in its ‘pocket’. Attracting groins are placed in an angle along with the flow, increasing water velocity and therefore prevent sediment from settling. This option is for instance used in shipping channels to maintain a certain depth. Groins are of little use where sediment from the beach is being withdrawn to a steep seafloor by an incoming wave direction perpendicular to the beach (Bird, 1996, p. 119).

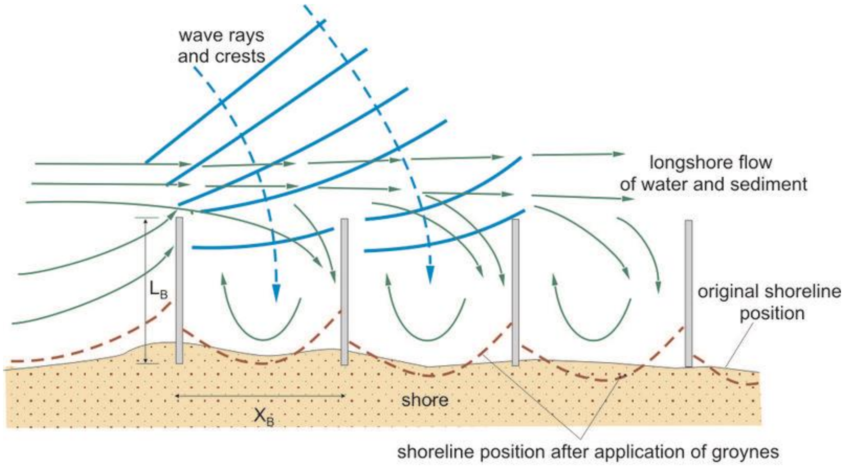


Figure E-4: Schematic interaction of groins, waves, currents and shore (CoastalWiki, 2012).

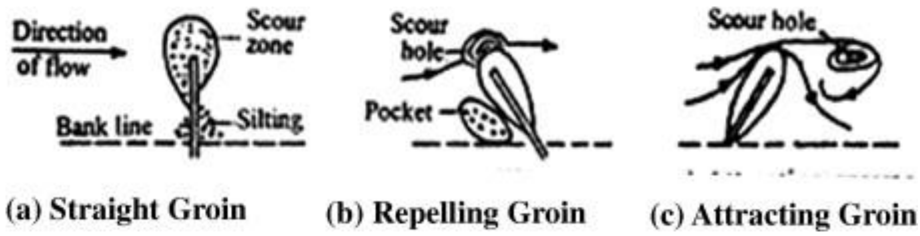


Figure E-5: Types of groins according to action on flow (Ibrahim, 2014).

The optimum length of groins depends on the angle of approach of the dominant waves and the nature of beach material. Waves arriving at 40° to 50° generate the most longshore drifting, requiring relatively long groins. If the beach is made up of shingles the groins can be shorter than if the beach is made up of sand. The spacing between groins should roughly equal two times the length on shingle beaches and four times their length on sand (Bird, 1996, p. 120).

E.1.1.5 Artificial Reefs and Sills

Another form of hard structures to stabilize beaches or soil are artificial reefs and sills. Artificial reefs and sills are submerged structures that block offshore movement of sand and are often used in combination with groin compartments. Reefs and sills also decrease the wave impact on the beach. In this respect artificial reefs are rather similar to offshore breakwaters. Sills however often serve to a higher extent as a solid base against which beach nourishments can be placed (Figure E-6).

Natural coral reef structures act as buffers for shorelines against waves, storms and floods, helping to prevent loss of life, property damage, and erosion. When the reefs are damaged or destroyed, absence of this natural barrier can increase the damage to coastal communities from normal wave action and violent storms (NOAA, 2014). The effectiveness of artificial reefs and sills depend on the height, slope and permeability of the construction. Artificial reefs and sills can be constructed as rubble mound structures or consist of sand containers and geotubes. Artificial reefs can also consist of reef units, more information about these reef units and other innovative methods to create coral reef are elaborated in Appendix E.2.

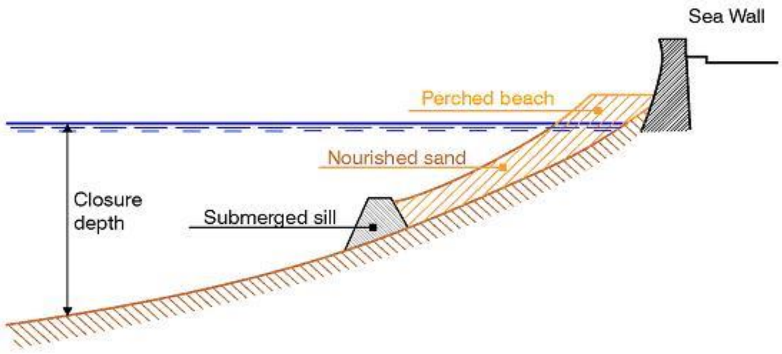


Figure E-6: Schematic illustration of a Sill (Mangor, 2007).

The sloping of artificial reefs and sills can be calculated similarly to that of offshore breakwaters. Costs for conventional reef or sill construction are moderate with $30,000 to $90,000 per 100 meters of construction (Scottish Natural Heritage, 2010). Innovative artificial reef construction methods can differ largely costwise.

E.1.1.6 Navigational Structures

Navigational structures such as jetties navigational breakwaters are mainly found at the front of harbours and channel inlets, primarily for the boat traffic to be able to navigate into the right direction (Figure E-7). Slower moving vessels are more affected by waves and currents than faster moving vessels, and vessels generally have to slow down when they enter a harbour or channel. Navigational breakwaters and jetties are made with the same function and materials as the aforementioned offshore breakwaters. The purpose of navigational breakwaters is to shelter harbor basins and entrances against waves and currents. Jetties are used for the sheltering of channel and harbour entrances, but also to reduce of sedimentation in those entrances (USACE, 2012). The reduction of sedimentation takes place because the jetties allow the water to flow freely in and out of the entrance channels and intercept sediment which could otherwise settle there.

Figure E-7Jetties and Navigational Breakwater at Ventura Harbour (USACE, 2012).

E.1.2 Soft Structures

E.1.2.1 Beach Nourishment

Beach nourishment is the restoring or reclaiming a part of the coastline by adding sediment to the beach. The most common reasons for beach nourishment are: restoration of the beach or land reclamation for tourism, protection for the infrastructure behind the beach and provide for habitats for rare or endangered species. A typical beach nourishment project, using bulldozers and excavators, carried out in Jupiter Island, Florida is shown in Figure E-8 below. In this section the design considerations for beach nourishment, the source areas, methods for nourishment and costs are discussed.

Figure E-8: Beach nourishment project in Jupiter Island, Florida (USACE, 2012).

Design considerations

Beach nourishment is a complex form of soft structure, a lot of design factors have to be considered in order to make a nourishment a success on the long run. Factors that have to be taken into account are: grain size of sediment, compactness of the soil, source areas and the shape of the coastline.

Grain size of sediment

Using an appropriate grain size for beach nourishment is of vital importance for the durability of the nourished beach. Too fine sand will be soon lost offshore or taken alongshore by waves and longshore current. Too coarse sediment forms a too steep beach which can cause nearshore reflection scour. Coarse sand can be used to stabilize a beach with a high wave energy environment. On the other hand coarse sand can disintegrate into finer sand if a soft material is chosen for the beach nourishment. The slope of the beach depends largely on two factors: wave environment and particle diameter of the beach sediment. Usually beaches with coarser grains have steeper slopes. Below in Table E-1 the particle size of the beach is given with the accompanying beach slope.

Wentworth scale category	**Particle diameter [mm]**	**Mean slope of beach face**	
		[Degrees]	**[m/m]**
Boulders	> 256	n/a	n/a
Cobbles	64 - 256	24	1:2.25
Pebbles	4 - 64	17	1:3.27
Granules	2 - 4	11	1:5.15
Very coarse sand	1 - 2	9	1:6.31

Coarse sand	½ - 1	8	1:7.12
Medium sand	¼ - ½	7	1:8.15
Fine sand	⅛ - ¼	5	1:11.4
Very fine Sand	1/16 - ⅛	1	1:57.3

Table E-1: Particle size of the beach with its accompanying beach slope (Bird, 1996).

Specific gravity of sediment

The specific gravity of the sediment which is used for beach nourishment is of importance for the durability of the nourished beach. When using less dense material for the beach nourishment it is easily washed away by wave action. On the other hand very compact and impermeable material can lead to high scarps near the high tide line. Both cases are considered undesirable.

Shape of the coastline

If a beach is nourished with an irregular shaped coastline the parts of the beach sticking out into the sea will erode. The parts of the beach sheltered by these outcrops will grow with the sediment which is lost at the eroding parts. Beaches parallel to the prevailing waves will lose little sand by longshore drifting. Beaches with a right angle to the prevailing waves can lose sand seaward when a storm occurs. Beaches with an angle to the incoming waves other than parallel or perpendicular are subject to a longshore current generated by the incoming waves and are more likely to erode.

Source areas

Sites where sediment is obtained in order to nourish the beach are called source areas. The material acquired from this site should ideally have the same grain size and characteristics as the natural beach sediment. In order to reduce costs, the site should be sought as close as possible to the beach where it will be deposited. This will reduce construction time and transportation costs. Possible sources for sediment and their most important advantages and disadvantages are discussed in Table E-2 below.

Source area	**Advantages**	**Disadvantages**
Land quarries	Supply is continuous since it is not dependant on sea conditions.	High costs if demand for sand and gravel for other purposes is high.
Mines	Disposing of rubble and nourishing the beach simultaneously.	Grain size and material is not likely to match the natural beach material.
Rivers	Dredging a river channel allow for larger and more vessels to pass.	Depriving the sediment supply for beaches downstream of the river.
Harbours	Benefit both for harbour development and beach expansion	Grain size and material is not likely to match the natural beach material.

Lagoons	Likely to have the same composition as beach sediment.	Possible damage to the natural ecosystem in the lagoon.
Tidal inlets	Dredging an inlet can cause wave refraction patterns to change, thereby accumulating eroded sand on one place.	Deepening of an inlet can cause too much sand from the beach to flow into the dredged part of the inlet, eroding an adjacent beach.
Other beaches	High probability of same grain size.	Possible damage to the natural ecosystem of the source beach.
Seafloor	Large quantities of sediment. No visible impact to the surroundings.	Expensive process which can also harm the ecosystem on the seafloor

Table E-2: Sediment source areas with their (dis)advantages (Bird, 1996).

Methods for beach nourishment

Beach nourishment can be accomplished successfully with different kind of methods depending on the local circumstances. In this section the three most common methods described, the fourth is a newly applied method.

Conventional beach nourishment

This method uses excavators and trucks to bring new sediment to the beach. The major advantage of this method is the use of low tech and largely available machinery. This also does not require highly skilled and thus cheap workers. An example of this method is shown on the top left of Figure E-9 below.

Pumping of sand from a dredge vessel

The combination of a dredge vessel and a pipeline to shore is a fast and continuous method of beach nourishment. However this method has limitations. The source area has to be located within a certain distance from the nourished beach due to limitations in the equipment used, i.e. pumps and pipes will get bigger with a larger distance. An example of sand pumping is shown on the top right in Figure E-9 below.

Rainbowing from vessel

When dredging offshore for sediment to nourish the beach, the sand can be brought to the beach by spraying a sand-water mixture from the vessel onto the beach. This method is called rainbowing. For rainbowing the vessel must be able to come in close proximity to the beach which requires a sufficient depth of the sea near the beach. Today distances up to 150 meter can be achieved. With this method beaches can be nourished which are otherwise inaccessible to excavators and bulldozers. An example of rainbowing is shown in the bottom left of Figure E-9 below.

Sand Motor

A more natural way of beach nourishment is using the longshore current to transport sediment which is placed upstream. This method is called a sand motor and is elaborated further in the section innovative structures. An example of a sand motor placed in the Netherlands is shown in the bottom right in Figure E-9 below.

Figure E-9: Methods for beach nourishment, clockwise starting top left: Conventional filling (Hollywood Margaritaville, 2015). Pumping sand from dredge vessel (URBANE, 2015). Sand motor in the Netherlands (van Houdt, 2011). Rainbowing from dredge vessel (Climate Tech, 2015).

E.1.3 Natural Protection

In this appendix natural protection is discussed, these are structures that are developed by nature itself and that protect the coast from erosion and natural impacts. These structures might be duplicated by humans for the same purpose.

E.1.3.1 Mangrove forest

Mangrove is a type of forest which is built by rare and small groups of 73 species of different trees and shrubs, and are known for their ecological and socio-economic importance. Mangroves offer great coastal protection against storm surges and erosion. Some factors that are of importance for the protective performance of the mangroves are tree height, species composition, density, diameter of the roots and trunks, elevation of the habitats as well as the status of ecological degradation of the forest. They also provide shelter for a largely diversified ecosystem. 30 trees per 100 m^2 in a belt of 100 meter along the shore can reduce tidal flow pressure by more than 90%, if the wave height is less than 4-5 meter, something that cannot be accomplished by man-made structures (Sandilyan & Kathiresan, 2015, pp. 94-95).

E.1.3.2 Dunes

Dunes are hills of fine grained sand along the shoreline. They provide habitats for turtles, birds and other wildlife, and it provides tourism and recreational opportunities. In order to act as an effective coastal defence, it must withstand periodic storm damage and erosion. In case of a negative sand supply, erosion and scraping will slowly make the dunes shorter and narrower, where there is a high probability of overwash by waves. The same nourishment rules for beaches apply to dunes, where a careful consideration of the provenance and grain size of the nourishment sand is essential for the effectives. The presence of vegetation is more important for dunes than for any other sand structure, because vegetation helps to retain and accumulate sediment (Hanleya & Hoggartb, 2014, p. 141).

E.1.3.3 Vegetation(Grass/shrubs)

Vegetation along the beach is used to stabilize the sand and to avoid sand to be taken away by the wind. Stabilisation by using sand-binding vegetation has for the most part helped to maintain the defensive role played by coastal dune systems. Ammophila is a specie used as dune builders because of their extensive root systems and capacity to grow under constant sand burial (Hanleya & Hoggartb, 2014, p. 142).

E.2 Innovative Structures

E.2.1 Hard Structures

E.2.1.1 Natural Revetment

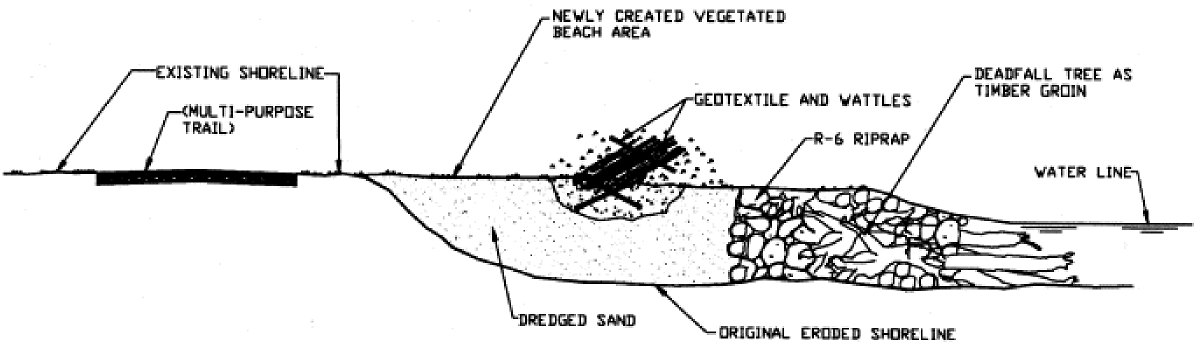


Figure E-10. Innovative low-cost coastal protection (Comoss, Kelly, & Lesie, 2002).

The innovative low-cost structure of Figure E-10 is a structure which is assembled with a set of different materials that can be found in the nature, resulting in an armoring structure, without harming the natural appearances of the environment.

The structure is built initially by placing riprap(stone boulders) eight meters off the initial shoreline. Then dewatered dredge materials are placed between the existing shoreline and the ripraps, creating a higher elevation dune line. Next, to enhance the natural appearance of the shoreline and to avoid scour at the toe of the riprap, trees without their limbs (diameters of 25-90 cm) are used as timber groins, by anchoring the bases behind the riprap. Within the dredged sand, trenches are dug and filled with geotextile and braided wattles, so that the roots of the vegetation can stabilize the sand. The final phase is vegetative planting, to enhance the natural appearance of the coastal area.

The structure is used to protect the hinterland and to avoid erosion, when there is the desire to achieve a high natural appearance or when there are no high-cost resources available. It is applicable in low energy zones where the average wave height is lower than one meter (ripraps with 30-61 centimeter height should be used). A case study in Presque Isle State Park in the USA, shows reduced erosion due to this structure of 90% per year, with costs of 33000$ per 100m (Comoss, Kelly, & Lesie, 2002).

E.2.1.2 Geo-textile Sand Filled Containers (GSC)

Geo-textile Sand Filled Containers (GSC), as seen in Figure E-11, are geo-textile bags filled with sand which are fixated by self-adhesive belts. The bags are predominantly manufactured from woven geo-textiles. There are two types of containers, namely individual containers and tubes of geo-textile bags. The tubes are of varying length and circumference, they are hydraulically filled with local sand. GSC are implemented for dune reinforcement and scour protection, they can act as an alternative for rock revetments, breakwaters or groins. This is an advantage when there is no rock material available (Bargado, 2013).

Figure E-11: Geo-textile Sand Containers (ElcoRock, 2015)

An individual GSC has a final fill height of less than 1 meter and a length of less than 3 meters, a tube however, has the same height but a length of 20 meters or greater. The largest GSC is 70 meter long, 2 meter high and 6 meter wide (Darshana & Oumeraci, 2012). For practical purposes the crest width of the barrier was twice the container length with a slope of 1:1 (Oumeraci, Hinz, Bleck, & Kortenhaus, 2003). This length of the sand containers should be large enough to ensure a proper overlapping for optimal stability.Stability increases with increasing sand fill ratio, the ratio is optimal between 90% and 100% (Darshana & Oumeraci, 2012). GSCs give a less ecological and visual impact than conventional structures. Reduced costs are applicable due to the construction and transport costs. The construction costs are low, as GSC have a lower specific gravity, compared to rock or concrete armour units. The GSCs are of a certain size so there will be no need for heavy equipment for them to be handled. The use of local sand used as fill material, reduces transport costs. Finally, GSCs are very flexible by being able to quickly adapt to different settlements.

E.2.1.3 Biorock Process

The Biorock Process structure has low voltage (above 1.2 volts) that direct currents running through a steel structure. The process can also be described as electrolysis happening between two metals receiving electricity in sea water, this results in a steel structure to grow solid limestone minerals and the other metal to disintegrate. Small pieces of live broken coral are strapped to the structure, as can be seen in Figure E-12, and grow 2-6 times faster than in natural conditions (Trawangan Dive, 2015). The hard rock structure that forms is ideal for coastal protection, as the open framework allows large waves to pass through (Gili Eco Trust, 2014). Biorock can be used to grow solid limestone rock structures in the sea of any size, which can serve as breakwaters for coastal protection. They get stronger with age and are self-repairing (Goreau & Hilbertz, 2002). There is no limit to the size or shape of Biorock Process structures and costs less than concrete or rock.

Figure E-12: Biorock Process Structure (Cole, 2011).

E.2.1.4 Reef Ball

A Reef Ball, as shown in Figure E-13, is a hemispherical hollow concrete unit, made by pouring concrete into a fiberglass mold. There are six mold types available with which any concrete can be used, including end-of-day waste.

Reef Balls act as submerged breakwaters, the internal voids in the Reef Balls deliver numerous benefits including:

- The Reef Balls attract greater marine life, which increases the diving, snorkeling and fishery activity.
- They have 3-5 times less mass and whilst functioning as breakwaters, the Balls can be built in a minimum of 1-2 meter depth where rock breakwaters have to be built in deeper water. Thereby needing more rock and are consequently more expensive.
- Acting as breakwaters, they allow water to pass through and prevent a ponding effect behind the breakwater. This also prevents accelerated currents around the ends, which cause scouring and the washing out of sand.
- Reef Balls enhance surfing areas. These areas are initially artificially created using GSCs. They are prone to anchor damage and attract fishermen. Reef Balls can provide added diversity of habitat and fish to help move fishermen away from containers.

Figure E-13: Reef Ball and Reef Ball implementation (Bargado, 2013).

The Reef Balls can be leased, bought or be acquired as pay-per-use. A requirement may be that artificial reef permits have to be obtained. To get the Reef Balls to their destination, they are cast around an extremely durable Polyform bladder which floats the Reef Ball whilst it is being towed. Once on the right location, the Balls can be deployed from a barge or by divers. The size and number of holes can easily be varied depending upon the reefs application (Reef Ball Foundation, 2007).

E.2.1.5 Tyres

Old tyres, as seen in Figure E-14, would be used as 'rubber rocks', filling the tyrees for 20% with conrete. These rocks would be wired and concreted together, and deposited on the seabed through a bottom-opening boat (Newton, 1995). The tyres are used for construction of embankments, dams and river bank protection (Simm, Wallis, & Collins, 2005). The durability and complex open shape of tyres is a distinct advantage in constructing artificial reefs for fishery enhancement. They provide a durable surface and the hollow structure is ideal for shoaling fish.

The intended function is to dissipate wave energy by means of the porosity characteristics of the tyre structures.

Figure E-14: Tyres (Bargado, 2013).

Only in very sheltered conditions, tyres can be implemented, the scrap tyres cannot be recommended for general use and are visually intrusive. If implemented, it should only be done in a stable environment. Tyres are available in abundance, cost very little and are almost indestructible (Scottish Natural Heritage, 2010).

E.2.1.6 Rigs to Reef (RTR)

The Rigs to Reef Scheme is converting decommissioned offshore oil and petroleum rigs into artificial reefs. Marine organisms attach themselves to the underwater portions of oil production platforms. There are three methods to RTR; tow and place the structure to its destination, remove the top part and place it on its destination and toppling the structure using explosives until it falls over on the mud line. Fish densities are 20-50 times higher around the RTR structure. However, RTR structures could create diver accidents. The rigs are donated, so there is no cost included for the material required. Ultimately RTRs support the fishing industry, diving and sport-fishing tourism (Texas Parks & Wildlife, 2009).

Figure E-15: Rigs turned into reefs (Bargado, 2013).

A standard regulation included in the Rigs to Reef Scheme is that a new RTR site will not be established within 5 miles of existing reef locations (Bureau of Safety and Environmental Enforcement, 2013).

E.2.2 Soft Structures

E.2.2.1 Sand Motor

A natural way of beach nourishment is using the longshore current to transport sediment which is placed upstream. This method can be referred to as a Sand Motor (or sand engine) and is placed in the Netherlands near Ter Heijde (Figure E-16). Instead of periodical replenishment, Rijkswaterstaat created a hook-shaped peninsula of 128 hectares (21.5 million cubic meters of sand) at once. In 20 years, wind, waves and currents will spread the sand along the coast and the coast grows naturally (Rijkswaterstaat, 2015). Besides the positive effects on coastal protection, the Sand Motor also creates a habitat for flora and fauna and it is a popular location for outdoor activities.

Figure E-16: the Sand Motor (Deltares, 2012).

For a Sand Motor to have the envisioned effect, several conditions must be met. Waves and longshore currents must carry the sand in the good direction. If all sand would be extracted offshore, the Sand Motor would not nourish the beaches alongshore and therefore not function properly. Since wind can also transport sand to other locations, the prevailing wind direction must also be corresponding. The former and latter however often correlate to a high extent.

E.2.2.2 Beach dewatering

Beach dewatering in order to prevent erosion is an unconventional method to retain sandy beaches by draining the water from the sand.Wet sandy beaches erode more quickly than dry ones, with the reason that wave scour is more effective on saturated sand, whereas dry sand absorbs swash water (Grant, 1948). The principle of dewatering is shown in Figure E-17.

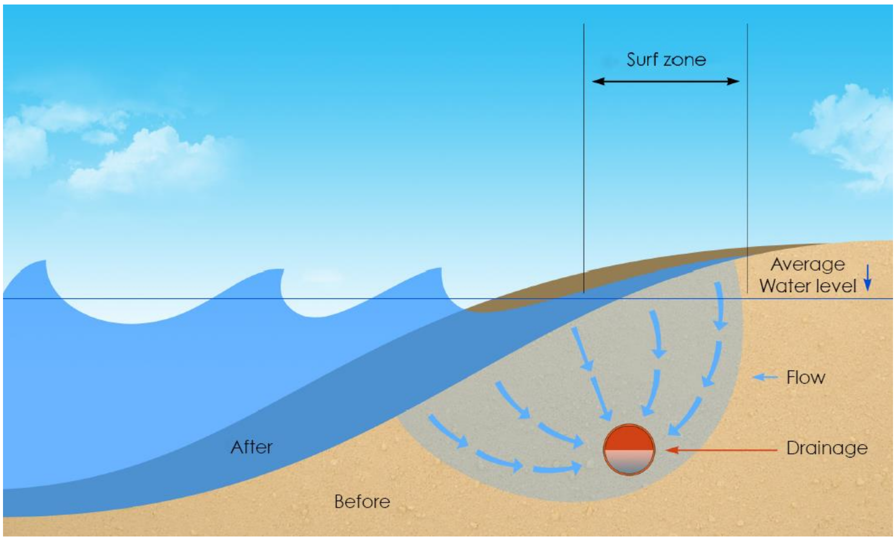


Figure E-17: Beach dewatering schematic. Own Image.

The apparatus that is used to dewater a beach is a perforated pipe which is placed beneath the MWL. This pipe is connected to a pump in order to drain the water which seeps into the pipe. Dewatering of a beach will have more effect when the grain size is fine to medium since the flow velocity of water is less high than in coarser grained beaches. This will extend the drained area. On average the beach at Candidasa has a high percentage of fine sand, described in Appendix D.2. The area of drainage will also be larger when the slope of the beach is between 1:10 and 1:50. Candidasa beach has a slope between 1:9 and 1:16, described in Appendix D.3. and an average slope of 1:12. So, Candidasa beach meets the two main criteria for beach dewatering.

E.2.2.3 Coral Nurseries

Coral Nurseries are submerged installed trees with thousands of coral fragments hanging from the branches. When they are grown, the corals are transplanted back into the reef.

An eco-friendly conservation course has been designed to create awareness and raise donations and volunteers to help restore the reef. The course teaches coral identification, biology, reproduction, why coral nurseries are needed and how the nurseries are created and maintained. After completion of the course, the diver is certified to assist in the coral nursery restoration including cleaning of coral structures and identification of paling, bleaching, predation and disease (Stuart Cove, 2013).

E.2.2.4 Degradable Breakwater

A Degradable Breakwater is an innovative structure that has not yet been implemented anywhere. It functions exactly the same as an ordinary breakwater. In the cases where a temporary breakwater is necessary, the Degradable Breakwater could be implemented instead. This saves decommissioning time and costs of the temporary breakwater as the Degradable Breakwater decommissions itself. The breakwater would consist out of porous coral sand that breaks down with every wave hit. The Degradable Breakwater can be designed to break down in different time frames, this is done by changing the mixture of the coral sand. The loose coral sand would then wash to shore and function as beach nourishment. This structure design was constructed out of own efforts of the authors of this project.

E.2.2.5 Energy Harvesting

The extraction of energy from the waves causes an impact on coastal processes such as erosion (Diaconu & Rusu, 2013). Due to the physical characteristics of reefs and the presence of seagrass and mangroves, up to 90% of the energy from wind-generated waves is absorbed by reefs (NOAA, 2014). This energy can be converted into electricity which provide for nearby (is)lands.

E.2.2.6 Submerged energy generating buoy

The two most known submerged energy generating buoys are CETO and PowerBuoy, they are both described.

CETO

A CETO, as seen in Figure E-18, is a fully submerged buoy that drives pumps for both onshore and offshore power generation.

Converting ocean wave energy into zero-emission electricity and desalinated water is done environmentally friendly. The buoy acts as a submerged breakwater, located far away from breaking waves and beach visitors, it has minimal visual impact and also attracts marine life.

The CETO is very flexible, it can operate in variety of of water depths, swell directions, tides and seafloor conditions. The buoy is a modular array design, so is fully scalable to the requirements (Carnegie Wave Energy, 2015).

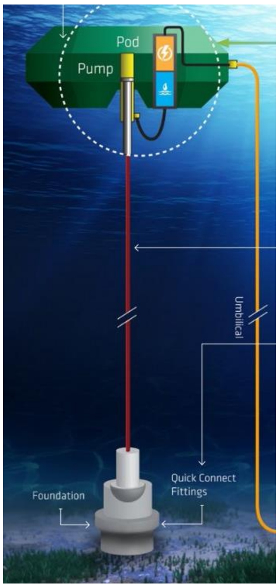


Figure E-18: CETO Mechanism (Carnegie Wave Energy, 2015).

PowerBuoy

PowerBuoy is a 43 meter tall energy-electricity converter submerged in the ocean, with only the handle remaining above water (Philips, 2014). A PowerBuoy perseveres during hurricanes and can operate on a fully autonomous basis, not needing human intervention by implementing the requisite power management and system protection functions (Pennington, 2011). The buoy is self-powered and is also able to switch off power production when waves are too large and strong (Handwerk, 2014).

The PowerBuoy creates electricity from the vertical motion created between the float and the stationary spar. AC electricity is produced by this motion through mechanical driven generators. A three point mooring system makes sure the PowerBuoy stays in place. These mooring anchors can provide benefits by serving as an artificial reef. The PowerBuoy has scheduled maintenance every 5 years (Tethys, 2014) and is barely visible from a distance of 5 km from shore (Handwerk, 2014).

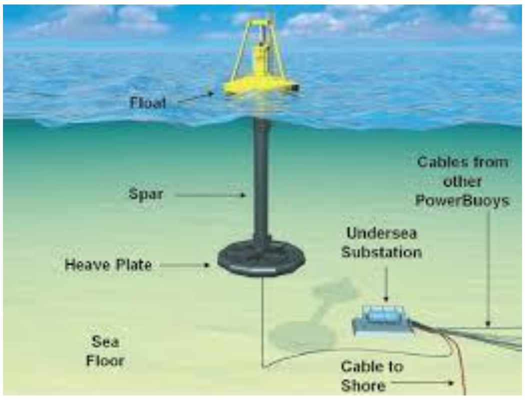


Figure E-19: PowerBuoy mechanism (Danko, 2012)

E.2.2.7 Pelamis

Pelamis, as seen in Figure E-20, is an offshore wave energy converter which is constructed out of five floating tube sections linked by universal joints. The Pelamis is flexible as the joints can flex in two different directions as waves roll by. Each joint holds cylinders that resist the wave-driven movements and pump hydraulic fluid to power the generators located onboard, sending electricity to shore via underwater cables up to 750 kW. The Pelamis can be anchored 2-10 kilometers from shore (Handwerk, 2014).

Figure E-20: Pelarmis (Bargado, 2013).

E.2.2.8 Wave Dragon

The Wave Dragon, as seen in Figure E-21, consists out of large and heavy reflectors and a main body located on deep water, 25 to 40 meters (Diaconu & Rusu, 2013). The reflectors direct the overtopping, incoming waves towards a curved ramp on the main body where the waves flow into a water reservoir, this is shown in Figure YYY. The water then drains through moving hydro turbines and this produces electricity. The Wave Dragon, being 89 meter wide and 37 meter long, is moored and able to turn and face the mean incident wave direction (Norgaard & Andersen, 2012). The structure of a Wave Dragon is durable and resistant and has a maximum height of 7 meters above mean sea level. This maximum height creates very low visibility (Diaconu & Rusu, 2013).

Figure E-21: Wave Dragon (Diaconu & Rusu, 2013)

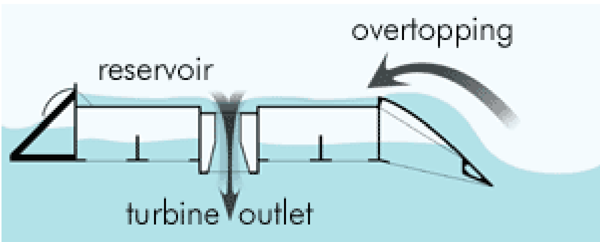


Figure E-22: Wave Dragon mechanism (Norgaard & Andersen, 2012).

E.2.2.9 Oyster Wave

The Oyster Wave, as seen in Figure E-23, basically functions as a wave-powered pump. It is a floating system featuring a large, hinged flap which moves due to the wave motion, which drives the attached pistons, pushing high-pressure water through an underwater pipeline. This water is then transported to shore, where it powers a standard hydro-electric turbine. The survivability of the Oyster Wave is high because the machine ducks under the water and excess energy flows across the back of the wave. The location of the system should be in shallow wave, anchored in 10-15 meters of water in the nearshore zone, about 0.5 km out from the shore (Handwerk, 2014).

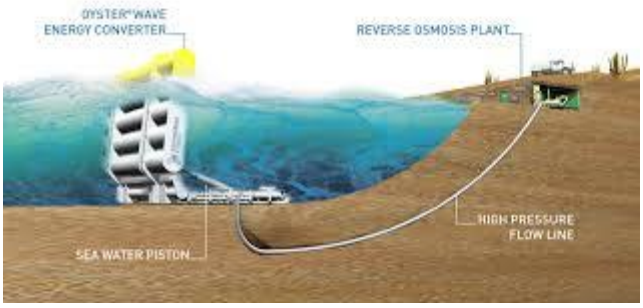


Figure E-23: Oyster Wave mechanism (Nusca, 2010).

E.2.2.10 Sea floor "Magic Carpet"

The device called Magic Carpet is a thin rubber or elastic composite carpet which stretches across a grid of cylinders and double-action piston pumps. The up and down wave motion of the waters moves the attached piston pumps, attached to the carpet, to produce hydraulic pressure. This pressure generates electricity, from which is estimated that one square meter of carpet is able to deliver 10,908 kWh per year(equals 1250 Watt/m2) (EIA, 2015).

The carpet is meant to be laid down as deep as 18 meter of water, where it is protected from storm damage due to the water column above. It should be carefully situated to avoid sensitive areas like reefs and surf breaks. The submerged carpet is also largely invisible to those on shore (Handwerk, 2014).

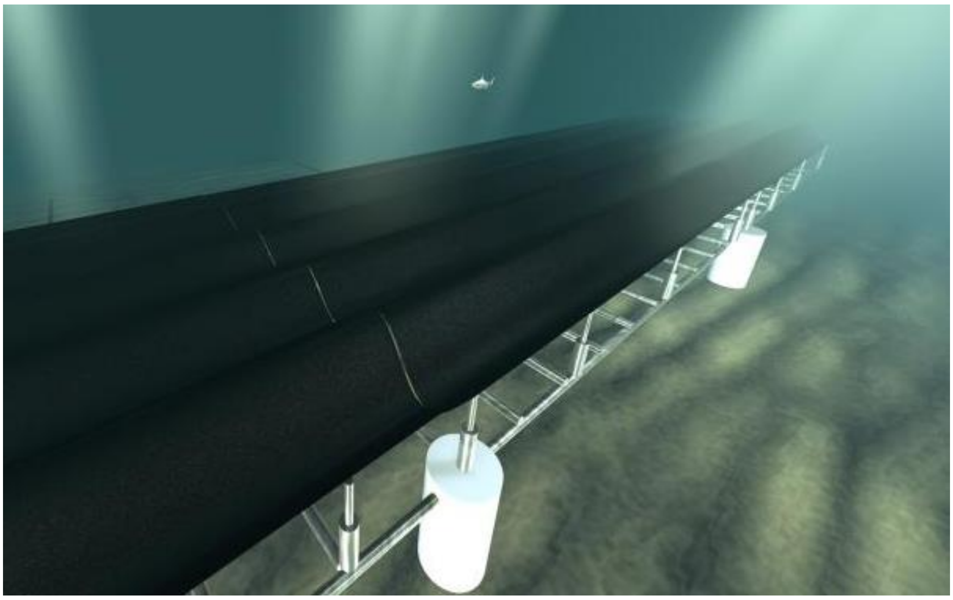


Figure E-24: Magic Carpet (Handwerk, 2014).

F: Appendix Alternatives

Various alternatives have been made to understand the different structures in the environmental aspects around Candidasa. The gained knowledge is used to make a concept final design. The following alternatives are investigated: Marine Life, Big Bali Beach, Cultural Heritage, Sustainable Awareness, and High-end Tourism. A detailed description of the alternatives is given here.

Due to the current state, existing structures such as seawalls, groins and revetments will be removed and the material will be recycled where possible for the new structures. As well, in all the alternatives a form of sand nourishment is applied to enlarge the beach. However, the sand nourishments differs in method and spatial and time scales.

F.1 Alternative 1: Marine Life

The first alternative focusses on marine life. This entails the stimulation of new marine life and preservation of existing marine life. These actions would be intended for the purpose of diving, snorkeling and other nautical activities. By applying this alternative, Candidasa would become a divers paradise. The target audience is active visitors, both high-end and backpackers alike, specifically diver and snorkeling enthusiasts. The coral reefs used to function as the natural protection barrier and can do so again, this alternative creates natural balance in Candidasa. A layout of the Marine Life concept is shown in Figure E-25 below.

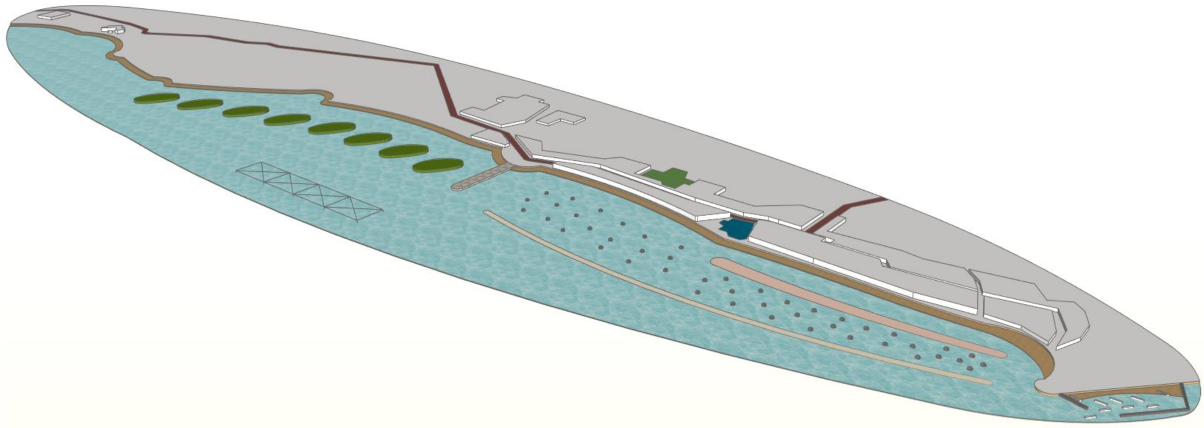


Figure E-25: Layout of marine life concept (Own Figure).

F.1.1 Structures

The structures that will be implemented are separated in two sections: structures to stimulate the growth of coral and increasing the fish population and structures that enlarge the beach surface.

First, existing structures will be removed and the material will be recycled where possible for the new structures.

Secondly, the coral reef will be extended sea inward and to halfway the coast of Candidasa.

To increase coral growth several innovative structures can be implemented. Individually the structures are Rigs-to-Reef, Reef Balls and BioRock. These structures all grow coral on itself, BioRock can even create designed shapes of coral. Coral nurseries are to be added, often these nurseries are combined with a diver course that educates divers about the importance of coral and how it should be conserved. This course specialises in coral restoration and will allow divers to help plant these coral nurseries and maintain them.

The comfort of divers are determined by the visibility of the water and the intensity of current.

For the visibility of the water to be high, sediment transport should be at a minimum. Ripcurrents are not favourable as this would be very challenging to comfortably dive, snorkel or swim with this amount of current.

Combined the aforementioned structures create an artificial reef intended to become a popular dive site. Reefs, both natural and artificial, act as submerged breakwaters. So when grown fully, the reefs help protect the beach from sand erosion.

This park of structures will be intended as an attraction for divers and snorkelers alike.

Structures that stimulate the increase of the fish population are most structures, as fish like to surround submerged parts of structures. Reefs also attract many fish and create a hospitable environment for fish procreation.

The beach is to be enlarged in this alternative, this will be an attractive asset for all visitors that visit Candidasa. A large, maintained beach invites lounging and is practical for dive site entry. The structures that will facilitate this are means of sand nourishment and retainment. The beach will initially be nourished by sand delivered on land. This sand was obtained through a harbour on the far left side of the coast of Candidasa. This way the sand nourishment does not interfere with the coral restoration.

At the start of the process of growing coral, the coral is vulnerable to the currents that create sediment transportation. To temporary shelter them, a degradable breakwater should surround the reef area. By the time the coral is strong enough to act as a submerged breakwater, the Degradable Breakwater has been degraded and replaced by the artificial reef.

A jetty will be placed between the coral reef and the start of the mangrove forests. The submerged part of the jetty will attract fish populations and lessen the impact of the waves on the sand coast in that area.

Finally, mangrove forests will be placed on the left side of the coast of Candidasa. This causes a change in view, possible activities and creates an entire different kind of dive site. The mangrove forests will be placed in small patches so the ocean view is not majorly obstructed. They will be placed between the different beaches, acting like borders.

F.1.2 Financial

To keep the costs of this alternative in perspective, prices have been included per structure. The artificial reef that will be created is scalable to accommodate available funds and/or space available. Keep in mind that almost all of the structures are innovative structures and not widely implemented, so the costs may vary. The companies that supply these structures are also small compared to their competitors supplying conventional structures.

The cost of one Reef Ball Unit is around €178 (Reef Ball, 2001), including tools to repair and implement. This ball would be of medium size, prices differ according to size.

A Rigs-to-Reef structure is estimated at €712,000 per structure, but ultimately this would save up to €3.56 million USD in terms of decommissioning for the responsible oil company (RTR, 2014). Having this in mind, negotiations can be started about funding the RTR costs, as it saves the company a lot of money.

BioRock has a price per square meter footage, between €1.4 and €2.5 per m2 (Goreau & Trench, 2012).

A Degradable Breakwater is an innovative structure that has never been implemented before, so costs are not specifically known. An estimation is made at between €2,385 and €5,860 per meter, as this is the price for an ordinary nearshore breakwater. The only difference between the two is the choice of material.

F.1.3 Economical

This alternative rebrands Candidasa as a top destination for diving and snorkeling enthusiasts. This a specific and lucrative attraction for an active and flexible audience on the financial higher end of the scale. Dive schools and dive equipment rental shops can flourish due to the opportunities this alternative supplies. Job opportunities will increase as well, specifically in the dive school and equipment rental sector. This will boost the local economy of Candidasa.

Hotels and restaurants will also benefit from the increase of tourists. Hotels can incorporate a house reef, should they border on the reef. As marine activities end at sundown, restaurants and bars can benefit from this by supplying special dive menus. For example, happy hours that start after sundown or an extensive lunch menu, as lunch is often used as a break in between dives.

Dive sites gain popularity through the years, this means that there will not be an instant surge in tourism in Candidasa. The amount of visitors will grow gradually but intently and so will the accommodation demand.

A diversity of dive sites are created so Candidasa can apply to every divers preference. The mangrove forest also lends itself for (non-powered) boat rides and tours, this diversifies the available activities and job opportunities as well.

Extra funds for the coral maintenance can be added by donations from visitors of the reef. For example, every diver and snorkeler is obliged to purchase a ticket to enter the dive site, this ticket will be in the form of a contribution to the maintenance of the coral reef.

F.1.4 Social

Local content will be widely available in this alternative. Some lifestyle changes are expected. The opportunities for fishing activities and agriculture remain the same, as they do not interfere with the new spatial plan. The port for the fishing boats will have to be relocated to the far right of the Candidasa coast, so it does not disturb the diving and snorkeling activities or pollute the reef. Ample employment opportunities in the nautical activity sector. Some personal investments will be required in form of a getting dive instructor licenses or acquiring rental equipment but this will end up being rewarding in the long term.

Local involvement in placing the structures is very beneficial with BioRock structures (BIC, 2012). Involving locals, that get training in placing and maintaining the structure, is the key to long term success. This is also the case in maintaining the other structures, inclusion creates commitment to the alternative.

As the beach is being enlarged, there will be plenty of room, which was not here before, for Bali natives to use the beach for religious intentions. Especially since a lot of temples are located in and around Candidasa.

F.1.5 Environmental

Candidasa already has a great starting point for flourishing marine life possibilities. Its clear waters and shallow reef makes an ideal diving and snorkeling destination. This clear water can only work to Candidasa’s advantage if they continue to be clear. For this to occur, no pollution is required, both visual or chemical. Fine sand should be avoided as well, to keep the visibility high. A minimum of boats contributes to this as well.

All structures are either degradable or stimulate natural growth on their surfaces. So no harmfull structures are implemented in this scenario. The implementation of this alternative creates a more natural environment and essentially stimulates the nature surroundings of Candidasa.

F.2 Alternative 2: Big Bali Beach

The second alternative is about unburdening the tourism congestion from the southern area of Bali, by creating a practically similar or even better area in Candidasa. Large amounts of tourists will be attracted with large white beaches, residential cabins located in the sea, a harbour and a boulevard with palm trees and shopping facilities. A layout of the Big Bali Beach concept is shown in Figure E-26 below.

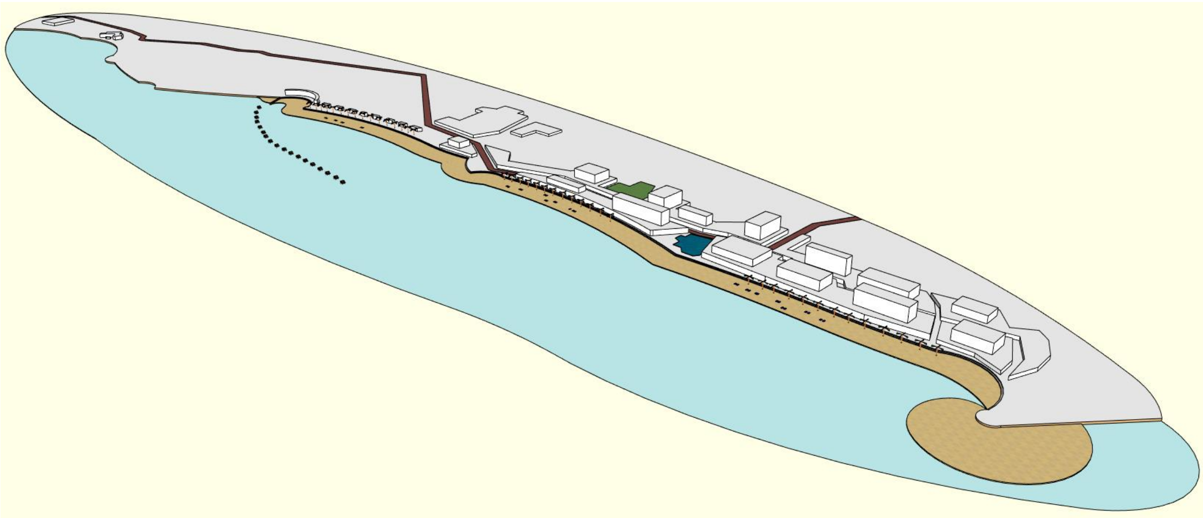


Figure E-26:: layout of the Big Bali Beach concept (Own Figure).

F.2.1 Structures

The structures that are necessary to create this alternative can be separated into the coastal structures and landstructures.

In order to create a coastal area where a large amount of tourists can simply sunbathe, swim or surf, the development of a long and wide white beach, without large unsightly structures, will be done with sand nourishment via a sand motor. Residential cabins combined with energy harvesting located in the sea, designed in such a way that they can be used as both hotel rooms and coastal breakwaters, will support the performance of the sand engine and offer a unique residential opportunity for tourists. The energy harvesting will be a CETO, with the semi-submersible cabin floor acting as the pod. This energy can be used to power the cabin itself and supply for nearby energy needs.

A small harbour will be developed in order to provide new infrastructure to reach Candidasa by speedboat, which enhances the current situation of the harbour in Padang Bai.

The development of shopping possibilities requires a boulevard together with tourism facilities along the coast, where in the present state the main road is situated. This means a new roadway is required, which will have to be redesigned or relocated more landward.

Phasing

The use of solely a sand motor will require a strict phasing of implementation of the structures, because the sand will gradually be added to the beach. A basis of sand has to be nourished, which will eventually grow towards a large, wide white beach.

F.2.2 Economical

The tourism industry will strongly develop in the form of hotels and shops along the boulevard and in the sea cottages. This industry will prevail over the agriculture industry. The development of a new roadway also gives potential for a tollway and thus extra income for the government.

Costs for government: Removal of current structures, placement of sand motor, development of wave breaking cabins and harbour.

Benefits: Higher taxation or ownership over rental of cabins.

F.2.3 Social

A social advantage is that inhabitants can more easily benefit from the tourists in Bali, because it is not only limited to the southern part of Bali anymore. As the beach is being enlarged the local inhabitants can use the beach for religious purposes. Especially since a lot of temples are located in and around Candidasa. The redesign of the roadway into a boulevard will also result in a better living environment for local inhabitants and the new harbour provides potential for fishers to enhance their business/start new businesses.

F.2.4 Environmental

There will be more pollution due to the higher occupation. Redeveloping the roadway will allocate the local pollution of traffic to a more landward location, which will be beneficial for the health of the local inhabitants. Potential energy harvesting in the cabin breakwaters can generate power to supply the offshore cabins.

F.2.5 Stakeholder Engagement

The alternative focuses on extending the over occupied southern Bali beaches, with the best possible recreational place for tourists, which is why they will not require extra attention.

The province of Bali, BWS-BP and JICA are key stakeholders and will be able to innovate and experiment with new structures in order to develop an economical attractive area, meaning that they are able to learn while gaining benefits.

Highway and irrigation office are given a high power by redeveloping the roadway, meaning their interest also has to be enhanced by focusing on what they think is important. …

The real crux will be the local village group/local inhabitants organization, who have a high interest and high power. The local farmers' agriculture will be replaced by tourism facilities, meaning if there is no suitable compensation the plans are likely to get blocked.

A solution has to be found in a well arranged process before the project is executed. Their main interest is to maintain or enhance current quality of living and working and they are concerned that tourism will prevail over their interest and that they will not benefit from the growth of the tourism. Their goal is to take advantage of the new developments in their surroundings.

F.3 Alternative 3: Cultural Heritage

This alternative focuses on the rich Balinese culture which can be made more evident in Candidasa. The cultural heritage combined with wellness facilities will cause tourism growth in Candidasa without compromising the character of the area. Candidasa houses a multitude of temples. Besides Balinese inhabitants, these temples can be visited by tourists, offering the real Balinese experience. This would be one of the main attractions in this alternative. Besides that, musea visiting, handicraft shopping, climbing of Mount Agung, traditional ceremonies, yoga and meditation classes and wellness activities are also part of the extensive palette of activities in Candidasa. These activities will mainly attract domestic tourists, backpackers, honeymooners and pensioners. A layout of the Cultural Heritage concept is shown in Figure E-27 below.

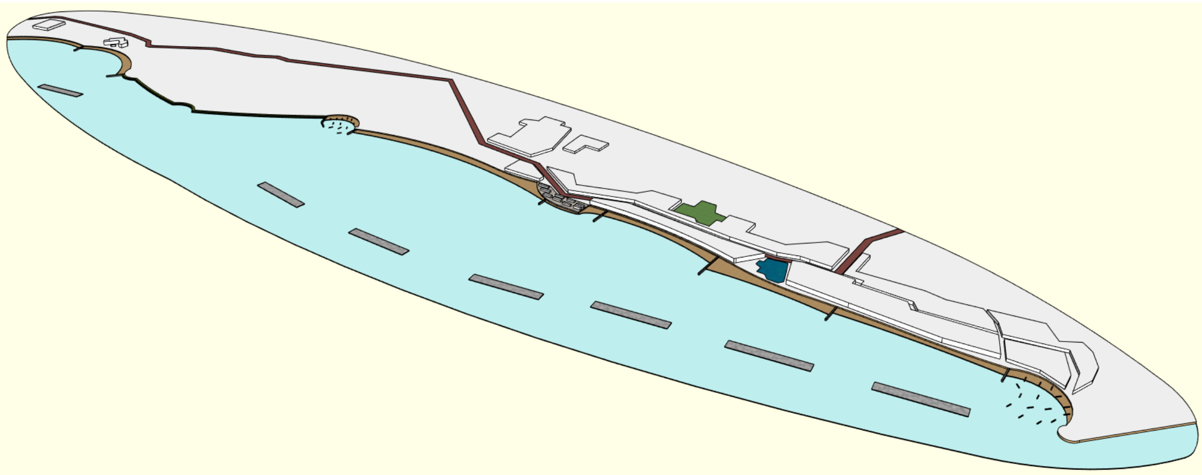


Figure E-27: Layout of the Big Bali Beach concept (Own Figure).

The beach needs to be restored to facilitate traditional ceremonies, yoga classes and create room for traditional fishery. Besides that, a cultural town center must be identified or constructed to make room for a cultural museum and a handicraft market. Infrastructure must be in such condition that all activities and facilities can be reached easily. Finally, care should be given to nature and surroundings, which both contribute to the envisioned experience of Candidasa. Large resorts, mass tourism, a strip full of nightclubs and large yacht or cruise harbours are not desirable in this alternative.

F.3.1 Structures

The existing groins and breakwaters will be demolished. In order to restore the beach, a revetment and sand nourishment is needed. Because the goal of this alternative is not to attract a lot of beach seeking tourists, the sand can be sourced locally and there is no urge for specifically white sand. The beach nourishment will be maintained by a series of newly built groins and offshore breakwaters or artificial reefs or sills. The groins will also function as spaces where people can enjoy the ocean view or meditate. If no location for a cultural center can be identified within Candidasa itself, a square can be located near the coast. Revetments will in this case be needed to provide stability and safety. The agricultural area will be protected by a natural revetment.

F.3.2 Economical

Main sources of income in Candidasa will remain tourism and agriculture. In this alternative the agricultural areas will remain the same to a large extent since they are part of the cultural heritage in Bali. Great opportunities are given for homestays, which generates extra income but does not compromise the agricultural area. An important factor in the economical impact that this alternative has on Candidasa is the main road that leads through the village. It provides advantages for the accessibility of all facilities including shuttle services to Mount

Agung for instance. A major negative aspect is that road traffic is rather dense, and the road is an obstacle for people who want to walk around in Candidasa.

F.3.3 Financial

Demolition of the existing groins will cost around €500,000 (half of total demolition costs). New groins will be constructed as rubble mound, costing €71,500 per structure. The offshore breakwaters will be relocated.. Beach nourishment and revetment construction at Candidasa will require approximately 300,000 cubic meters of sand, 3000 meter of rubble mound revetment, and 2000 meter of natural revetment. The cheapest way to nourish the beaches is by conventional sand nourishment at costs of €10.50 per m^3. The rubble mound revetment, which serves as a solid base for the beach nourishment, will cost around €7,500,000. The natural revetment will cost approximately €600,000 (Appendix E.2.1.1)

F.3.4 Social

An important social advantage of this alternative is that the Balinese culture is respected and preserved. Local inhabitants will be able to continue their religious ceremonies on the beach and temples will receive more visitors and thus income for maintenance. Religion is an important part of Balinese culture. The beach can also function as an area from where fishery can take place.

F.3.5 Environmental

To achieve the envisioned surroundings for this alternative, nature preservation is an important aspect. A clean beach is also crucial for this alternative to succeed. A plan to clean and preserve nature and beach is therefore important. The environmental impact of this alternative is relatively low. The beach will be overhauled thoroughly, but it is unlikely that this will impact the coastal environment negatively. Because the old coastal structures, which worsened erosion, will be removed, the impact on the coastal environment is expected to be positive. Surroundings on land will not suffer from the plans. On the contrary, it will benefit from the nature preservation plan.

F.3.6 Stakeholder Engagement

The Indonesian Government will probably not be too enthusiastic about this alternative. Enormous tourism growth is expected from Bali and this alternative offers only a small growth. Most tourists want white sandy beaches and newly built facilities and these are not included in this alternative.

The cultural heritage alternative can be more appealing to the local government which can be pleased by the fact that their village will be a showcase for Balinese culture. The underlying thought is that this will increase tourism, which is economically beneficial for the region. Hotel and restaurant owners prefer a white sandy beach, because this attracts the most tourists. Local inhabitants are unlikely to support the plan because the old groins are demolished and new groins will be built. This will not improve the situation, from their perspective.

F.4 Alternative 4: Sustainable Awareness

As for other parts of Bali nature has made place for tourism activities, while the people in the first instant came for Bali's beautiful landscape and coastline. The island of paradise has become as many other tourist destinations polluted, over constructed and overcrowded. In essence the tourist and nature should be in harmony to provide the highest benefit for both worlds. This alternative has to become an example in sustainable development, utilization and maintainability for tourism growth and erosion prevention methods. This concept entails the eco-tourism, small-scale culture, sustainable energy generation and employment of/selfbuilt by locals. This alternative should attract Hippies, nature enthusiasts, families and pensioners in first instance. Eco-tourism in Candidasa firstly consists of tourists coming to make use of the nature parks, volcano and marine around Candidasa. Secondly, the tourism sector should develop, utilize and maintain the area in a sustainable manner. A layout of the Sustainable awareness concept is shown in Figure E-28.

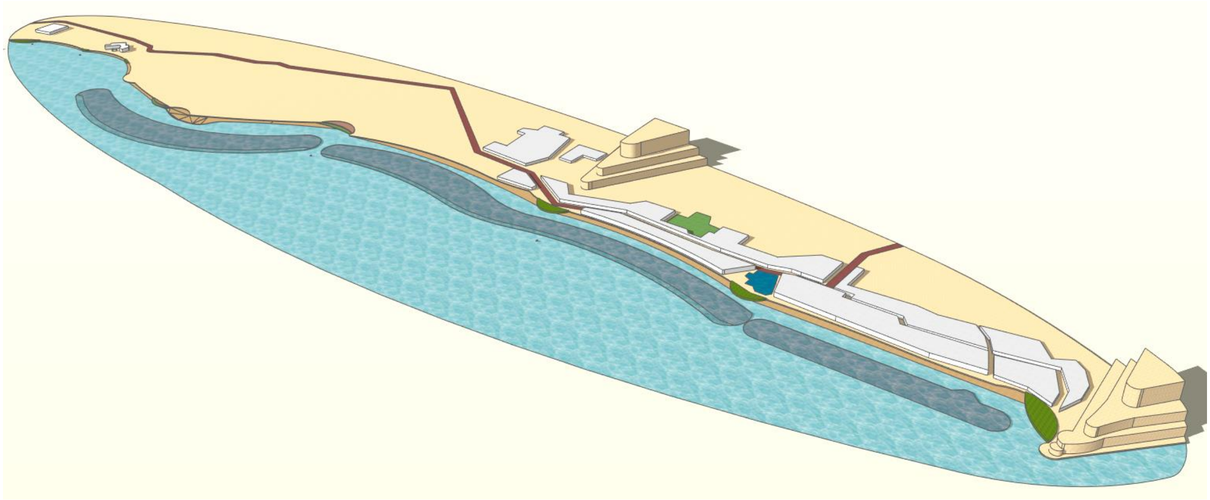


Figure E-28: Layout of the Cultural Heritage concept (Own Figure).

Awareness could be created in two ways, one of them is is showing how to do it and the other way is reminding people of the past. In the former this will be done by use of sustainable methods and recycled, local, and/or natural materials and educating inhabitants. Besides, areas could be assigned for the experimentation of undeveloped innovative ideas on natural and sustainable coastal preservation. The latter, will be done by setting examples in the form of cultural education of locals and tourists and recycling and showing old structures (landmark).

The beach will restored into a natural state of beauty. Natural boundaries will be used to divide the beaches into smaller section to avoid the feeling of mass tourism and to enhance natural population growth. Along with coral sandy beaches Candidasa will be restored to its origins.

F.4.1 Structures

The following aspects are important for constructing the structures: Building with nature, recycling, sustainable and local materials, energy harvesting, and simple construction methods. In general the following coastal erosion preservation structures are applicable for use in Candidasa: coral nursery, sand nourishment + retainment, mangroves, Biorock process, Beach dewatering, Natural Revetment, groin (hergebruik) and different kinds of energy harvesting.

Demolishment of old structures and new revetment

A large part of the current coastal prevention structures (groins and seawalls) will demolished. However, a small part will be kept remained as a reminder of the history on coastal development. These will be heightened and strengthened by to use of recycled material from the demolished structures. The new revetment for the beach will not be made of natural material, but will be recycled from the old groins and seawalls. On the new revetment a minimal layer of sand will be installed as the start of point for further accretion and to accommodate tourism immediately.

Coral reef & biorock process

Naturally the beach of Candidasa originated from sand of the coral reef. To restore the balance in supply of sedimentation a coral reef will be replanted in front of the beach. The nursery could learn divers and locals the importance and fragility on preservation of the coral reef. Second, the coral will enhance the fish population in the area. However, the replanting of coral reef will take a certain amount of time, therefore a temporary solution should be implemented to support the coral reef growth and reduce erosion of the beaches. This could by the use of biorock process filled with fast eroding stones. While the stones and metal dissolve, the coral will growth. As the stones are dissolved the coral will be sufficiently grown to protect the beach from high wave energy and thus reduce erosion.

Sand motor

As the coral growth in Candidasa is currently not sufficient to supply the beach with coral sand a sand motor will be built to nourish the sand. The sand motor is a complete natural way of nourishment and exploits the potential of the accretion process the most, as it imitates the natural process. Besides, no man-made structures are highly visible alongshore which could disturb the natural sight of the area. After 20 years the sand motor will be mostly dissolved and evaluation of the beach and the supply from the reef is assessed to determine if another sand engine is needed.

Beach dewatering & Energy harvesting

To support the accretion process against the rising sea level a Beach dewatering system is implemented. Beach Dewatering is an unconventional proven concept which will be used to stabilize sedimentation transport at the beach. In combination with the coral reef the beach dewatering should ensure that the beaches are self sufficient in maintaining an equilibrium in sedimentation transport after the sand engine is dissolved.

Energy for the shore activities and the beach dewatering system will be produced by the use of the Oyster Wave, The Oyster Wave will be submerged and contribute to the goal of transform Candidasa to self sufficient on electricity in 2025.

Mangrove forests & Natural revetment

As the tourist attracted by this development do not like mass tourism and manmade infrastructures, the beach will divided in several compartments by the use of natural revetments and mangroves. As well, both structures stimulate the growth of fish population and marine life. With their entangled roots in the ground the mangroves work as a natural filter for river silt and pollution of seawater and therefore substantially contribute to the quality of the seawater and help the fragile ecosystems like coral and seagrasses.

F.4.2 Phases

A division in phases is needed to understand the complete potential of the different structures and to get a comprehensive overview. In the first phase a (solid natural) base for the coastal area is developed. In the second most accretion of the beaches will occur. In the third phase the coastal area should be completely developed and self sustained. The three phases are divided as shown in Table F-1 below.

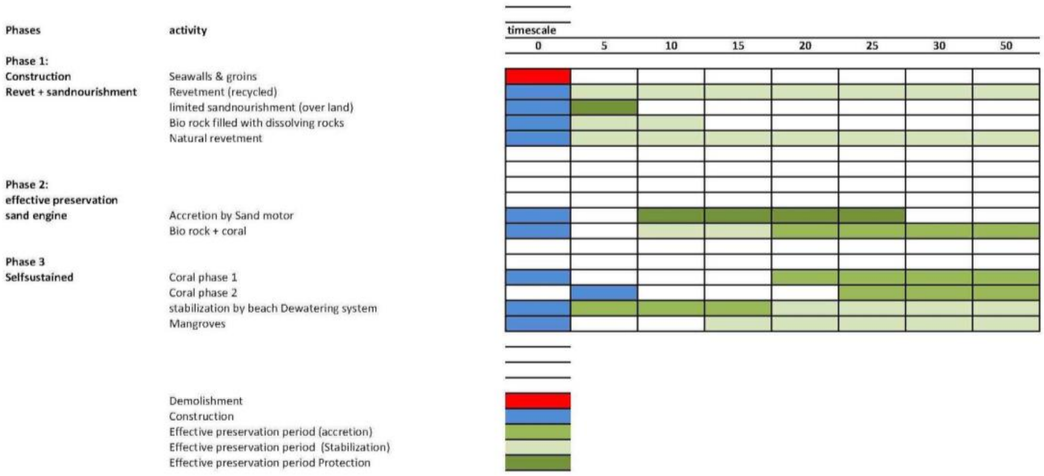


Table F-1: Phasing of construction (Own Table).

F.4.3 Financial

The planting of coral reef and the biorock process consists of time consuming activities, but rather inexpensive materials. Under guidance of experts this could be constructed by local contractors which reduce costs.

The combination of beach dewatering and energy harvesting will induce a high initial cost for systems and high expertise costs. However, the cost for energy and maintenance could be reduced because the system is self sufficient.

Mangroves has the advantage that it is the specialty of the local contractors. The development cost could therefore be reduced. As well, the mangroves could give potential benefit on the economy of the region in the form of wood and fish population increase. A natural revetment is a inexpensive solution of 33000 dollar for 100 meters, while being a natural way of protection of the coast.

Financial sidebar: As the beach is divided into several areas by the mangroves or natural revetments it is possible to assign a specific part to private investors for resort building. These could contribute to the cost of implementing the structures. To not disturb the natural image this could be done in one of the side bays.

F.4.4 Economical

The sustainable awareness alternative provide Candidasa with a tempered long-term tourism development plan while keeping nature and tourism in balance. By a sustainable tourism growth and attention for nature the welfare and the local character for the Candidasa area will be ensured and strengthened for generations to come. As an example of a good beach development, the project could regain Bali's image of paradise island and ensure Bali’s economic value. Because tourism growth will be limited in the area, the economic growth in the area will not be accelerated in first instance. However, large hospitality organizations are undesirable and local homestays will benefit the local community directly

Due to innovating and natural structures an extensive knowledge base will be developed and local companies and government are able to learn about the new techniques. These new adapted knowledge could be used throughout whole indonesia.

Local fish development by coral reef and mangroves will enhance the local economy and ecology, while also reducing the dependency on tourism in the region

F.4.5 Social

The local content is one of the main purposes of this alternatives. The local character of the village surrounding the nature will be maintained and enhanced. Compromising on the tourism growth, the locals will be able to establish a sustainable growth of their village. As mentioned before, major international hospitality and contractor organization are undesirable and therefore the income will mostly be benefited by to the local community creating a fair welfare distribution. Second, as a large investment is made in educating local contractors and governmental bodies, this will create an extensive knowledge and experience bases for upcoming projects. They will recognize the urgency of erosion and will respond better to future erosion problems. Third, this alternative gives space for development of different other economic activities to support diversity and sustainable growth of the local economy, such as fishery, mangrove exploitation, farmery and construction work.

As the beach is being enlarged, there will be plenty of room for Bali natives to use the beach for religious intentions.

F.4.6 Environmental

In this alternative sustainable tourism growth and environmental development go hand in hand. The aspects of nature preservation, recycling and ecological are supported by the interest of the tourist target group. A clean beach without visible man made structures and the natural supply and retainment of sedimentation support natural development of the coastal area. Although the beach has to be initially overhauled thoroughly, but it will be redeveloped in a natural area with local material and labour. As well, old structures are removed and recycled and the erosion in reduced to protect the hinterland. Second, local flora and fauna and marine life has space to develop.

F.4.7 Stakeholder Engagement

This alternative will have difficulties to get sufficient funds from investors or government to support the development. A PPP combination is not likely and desirable to occur, as organizations only care about profits. The financial support therefore has to come from the government. To convince the authorities to support this alternative the focus should be on local content, nature, uniqueness and long-term sustainable development. However, the focus of the national government is to grow into the top ten economies of the world and Bali's tourism growth is major factor to support this achievement. However, Bali's authorities should understand this clearly and think of a sustainable growth for Bali.

In Bali the main thought is that tourism is money and to get tourism, beaches have to be made. Second, no diversification in tourism is made and free flow of development occurs. Consideration of maintaining local natural beauty is of no importance. As it once was a paradise island, bali is now becoming one big tourist theme park. In a sense the government think 'more is better' and overdevelopment is almost certain to occur. Multiple examples of identical beaches are found in the south of the island. In that sense this alternative could give Bali a bit of its natural beauty back.

F.5 Alternative 5 - Unlimited Money

The purpose of this alternative is to provide an exclusive holiday experience for the more fortunate amongst us. With a scala of Beach clubs, Luxury hotels, gourmet restaurants with chefs from all over the world and a deep water yacht harbor Candidasa will be Bali's retreat for the rich and famous. But how to accomplish this? Below the necessary improvements and modifications to the infrastructure, coastline and tourist facilities are described in order to make Candidasa world renowned. Also the stakeholders involved in this project will be discussed. A sketch of the design of Candidasa beach is shown in Figure E-29 below.

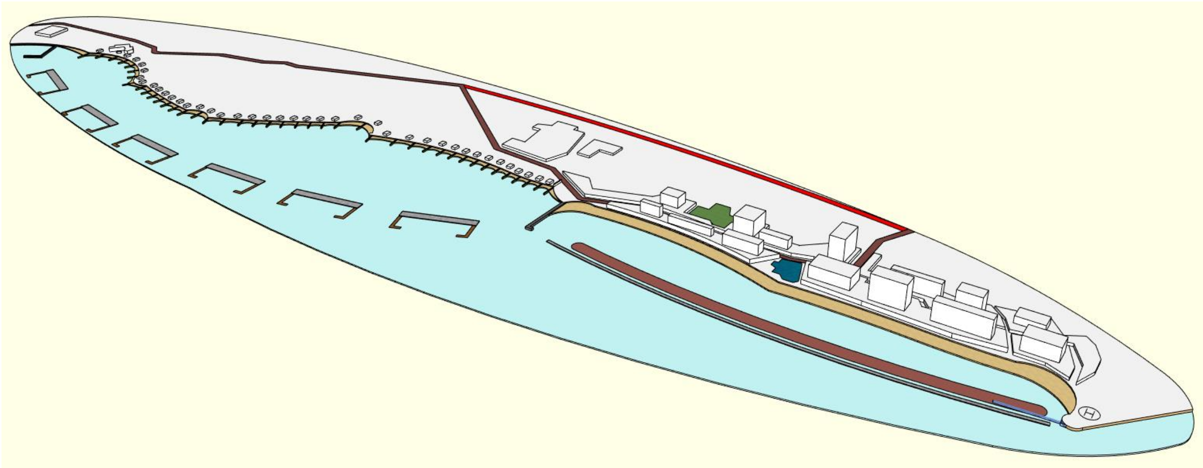


Figure E-29: Layout of the high-end tourism concept

F.5.1 Structures

F.5.1.1 Coastline Design
In order to attract wealthy people who seek comfort, beauty and excellent service Candidasa beach should be developed in a way to accommodate this. Beach villas with private beaches and a public beach where every comfort is met and is perfectly maintained. The public beach will have a length of 2 kilometers, the private beach section will be 3 kilometers long. This requires a design which includes beach nourishment, a single large groin, offshore breakwaters, a revetment and small mangrove patches at intervals will create the private beaches.

F.5.1.2 White sandy beach
Beach nourishment will create a white sandy beach, the beach nourishment will be done by sand supply through land transport every 5-10 years. The source of the sand will be the Philippines where the most beautiful white sand can be found. Beach dewatering, an offshore breakwater and a giant groin at the west end of the public beach will prevent the erosion of the white sandy beach. The mangrove patches separating the private beaches will act as natural groins and their roots will retain the sand of the small private beaches.

F.5.1.3 Offshore breakwater
There will be two forms of breakwaters in Candidasa. One will be a submerged breakwater which is a glass tunnel which gives tourists a magnificent view of the coral reef. The second breakwater will consist of multiple breakwaters also acting as yacht harbors for the villas with their private beaches.

F.5.1.4 Glass Tunnel - Public beach breakwater
The offshore breakwater for the public beach will be a first of a kind combination of tourist attraction and a wave height reducing structure. To provide a magnificent view of the coral reef in Candidasa the breakwater will be a tunnel made out of glass to give a spherical view of the coral reef crest while walking under the sea. The roof of the tunnel will be made energy absorbing material such as permeable rocks on which coral is growing. The tunnel will be constructed on a series of struts and anchors to keep it in place, there is need for a heavy construction to hold the weight of the tunnel since it will be made neutrally buoyant.

F.5.1.6 Yacht docks - Private beach breakwater
The offshore breakwaters for the private beaches will have a multipurpose design. They will reduce the wave action on the beach and act as docking place for the yachts of the villa tenants/owners. This breakwater group will consist of five separate breakwaters which allow small boats to sail through the openings to carry people to the beach. They will have a gentle

slope towards the beach covered with vegetation such as small palmtrees to reduce horizon pollution as seen from the beach. This vegetation will also hold the breakwater in place and prevent erosion and scour. The seaside of the breakwaters will harbor the yachts in a partially enclosed and protected entrance.

F.5.1.7 Revetment with walkway
Behind the public beach a walkway will be built for pedestrians to enjoy a stroll along the beachside. This revetment will be constructed of white/light grey natural rock to create a smooth natural transition between the walkway and beach.

F.5.1.8 Giant groin
The giant groin will be placed at the west end of the public beach to keep the nourished sand in place. This groin will extend approximately 300 meters into the sea up to the reef crest. The great length of the groin in combination with the offshore breakwater will provide sufficient protection for the 2 kilometer stretch of public beach (claim has to be calculated). The west side of the groin will consist of low vegetation to block the view toward the private beaches, but will not obstruct the view of the beautiful surroundings. At the tip of the groin there will be place where jetski's can be rented and boats for parasailing and waterskiing can take off.

F.5.1.9 Mangrove patches
The private beaches will be separated by patches of mangrove forest. The mangroves will run approximately 10-20 meters into sea to form a visual and physical barrier. The mangrove roots will also act as a retainment structure for the beach.

F.5.2 Infrastructure
The infrastructure in Candidasa will see some significant changes. The main road will be constructed around Candidasa to divert ongoing traffic. West of the private beaches, a port will be build for yachts and the docking of cruise vessels. On the top of the peninsula a helicopter pad will be constructed in order to allow fast transport from and to Denpasar airport.

F.5.3 Tourist facilities
The existing hotels in Candidasa require a renovation to meet the high-end standard. New hotels with all western luxuries will be constructed in the area behind the public beach. Nightlife in Candidasa is provided by a few beach clubs along the public beach. The most exclusive club will be built on the small island of the coast, only accessible by boat. Restaurants with world renowned chefs provide the required standard for the expected high-end eating experience. The best restaurant will be build on the top and end of the peninsula in the east looking over Candidasa beach and its surroundings.

F.5.4 Economic analysis
In order to realise this concept, large investments has to be made. These investments are most likely to come from companies and wealthy individuals. Investment in real estate can be done by both. While companies can also link their name to events organized in Candidasa in order to gain positive publicity. The local community will benefit from this concept since it gives job opportunities and with rich people coming to Candidasa tips will be according to this.

The construction of the revetment, mangrove patches, road diversion, new hotels and restaurants can be done by Balinese contractors. The more complex structures, comprising of beach nourishment, the giant groin, the breakwaters, underwater hotel, helicopter pad and cruise and yacht harbor, have to be constructed by foreign companies.

F.5.5 Stakeholders
The major players in this concept are investors and the national government on the on side and the local government and inhabitants of Candidasa on the other side. If this will be realized in Candidasa, large parts of original Candidasa will be replaced by new infrastructure and

buildings. This will not sit well with the inhabitants and local government. The investors and national government will make a large profit on this project, if it proves to be successful. One way to solve this inequality is to share a part of the profit with the local government and inhabitants.

G: Appendix Criteria Cross Comparison

G.1 Weight Factors Criteria

The criteria have been appointed weight factors that describe the influence the criteria have on each other. As can be seen in Table G-1.

	Technical	Design complexity	Construction complexity	Maintenance	Erosion prevention	Accretion	Implementation time	**Economic**	CapEx	OpEx	Availability	Lifetime	Local Content	Economical benefit	Tourist attraction	**Social**	Safety	Environmental impact	Visibility	Innovative	Local support			**Weight factor**
Technical																								
Design complexity		-	0	0	1	1	0		0	0	1	1	1	0	1		1	1	1	1	1		11	0,059
Construction complexity		1	-	0	0	0	0		1	0	1	0	1	0	0		1	1	1	1	1		9	0,049
Maintenance		1	0	-	0	0	1		0	1	1	1	1	0	1		1	1	0	0	1		10	0,054
Erosion prevention		0	0	1	-	1	1		1	1	1	1	0	0	0		0	0	0	0	1		8	0,043
Accretion		0	0	1	1	-	1		1	1	1	1	0	0	0		0	1	0	0	1		9	0,049
Implementation time		1	0	0	0	0	-		0	0	0	1	0	0	0		0	0	0	0	0		2	0,011
Economic																								
CapEx		1	1	0	1	1	0		-	1	1	1	1	1	1		1	1	1	1	0		14	0,076
OpEx		0	0	1	1	1	1		1	-	0	1	1	1	1		1	1	0	1	1		13	0,070
Availability		1	1	1	0	0	1		1	1	-	1	0	0	0		1	1	0	1	1		11	0,059
Lifetime		1	0	1	0	1	0		1	1	1	-	0	0	1		0	0	0	0	1		8	0,043
Local Content		1	1	1	0	0	0		1	1	1	1	-	0	1		0	1	1	1	1		12	0,065
Economical benefit		0	0	0	1	1	1		0	0	0	1	1	-	1		0	1	0	1	1		9	0,049
Tourist attraction		0	0	1	1	1	1		0	0	0	1	1	0	-		1	1	1	1	1		11	0,059
Social																								
Safety		1	1	1	1	0	0		1	1	0	1	0	1	1		-	1	0	0	1		11	0,059
Environmental impact		1	1	1	1	1	1		0	0	1	1	0	0	1		1	-	1	1	1		13	0,070
Visibility		1	1	1	1	1	0		0	0	0	1	0	1	1		1	1	-	0	1		11	0,059
Innovative		1	1	1	0	0	0		1	1	1	1	0	0	0		1	1	0	-	0		9	0,049
Local Support		0	1	1	1	1	1		0	0	1	1	1	1	1		1	1	1	1	-		14	0,076

Table G-1: Weight factors criteria. Own Table.

The score of 0 or 1 is given to the criteria based on if there is any influence to be had between criteria. In the case of the score 1, there is indeed influence and subsequently the score 0 means that there is no influence.

G.2 Structure Scores

Table G-2, shows the scores according to the structures when compared with the criteria.

Weight factor criteria		0,059	0,049	0,054	0,043	0,049	0,011		0,076	0,07	0,059	0,043	0,065	0,049	0,059		0,059	0,07	0,059	0,049	0,076	
	Technical	Design complexity*	Construction complexity*	Maintenance*	Erosion prevention	Accretion	Implementation time*	**Economic**	CapEx*	OpEx*	Availability	Lifetime	Local Content	Economical benefit	Tourist attraction	**Social**	Safety	Environmental impact*	Visibility	Innovative	Local support	**Score**
Breakwaters																						
Coral		5	2	2	3	1	5		3	3	2	4	4	1	4		5	5	5	2	4	3,349
Biorock Process		2	2	2	3	1	2		4	4	3	4	4	1	4		5	4	5	4	3	3,296
Glass Tunnel		1	1	1	3	1	5		1	3	2	3	1	5	5		2	1	5	5	4	2,565
Degradable Breakwater		2	2	5	3	2	5		3	5	3	2	2	1	1		5	4	5	5	3	3,190
Coral Nurseries		4	4	1	1	1	5		5	3	4	5	4	4	4		4	5	5	4	4	3,747
Offshore Breakwaters		3	2	4	3	1	5		3	5	4	3	4	1	1		5	3	5	1	3	3,112
Yacht Docks		3	2	2	3	1	5		2	1	3	3	2	5	5		3	2	3	4	3	2,732
Rigs-to-Reef		1	2	1	2	1	2		5	5	1	4	1	1	4		2	4	5	4	3	2,796
Reef Balls		3	2	2	3	1	2		3	5	2	4	1	1	4		4	4	5	4	3	3,036
Residential Cabins		2	2	1	3	1	5		2	1	4	3	2	5	5		4	2	3	5	3	2,786
Groins																						
Giant Groin		3	3	4	4	1	5		3	4	4	3	5	1	3		4	2	1	1	1	2,800
Jetty		4	3	4	2	1	5		5	4	5	4	5	2	3		3	2	2	1	3	3,228
Mangrove Patches		5	5	1	4	1	5		5	4	5	5	5	3	3		4	5	3	1	2	3,653
Revetments																						
Recycled Revetment		3	2	4	3	1	5		4	4	5	3	5	2	2		4	4	1	3	2	3,147
Revetment Walkway		3	3	4	3	1	5		4	4	4	3	5	3	3		4	3	2	1	3	3,212
Energy Harvesting																						
Oyster Wave		2	2	1	2	1	5		2	1	2	3	1	4	1		5	5	2	4	4	2,512
CETO		2	2	1	2	1	5		2	1	2	3	1	4	3		5	5	2	4	4	2,630
Sand Nourishment																						
Sand Nourishment by Land		4	4	4	1	5	5		2	2	5	1	5	3	5		5	5	1	1	5	3,521
Sand Motor		2	2	5	1	5	5		1	4	5	2	2	1	5		5	5	1	4	5	3,320
Beach Dewatering System		3	3	2	4	3	5		3	3	4	3	2	1	5		5	5	5	4	5	3,599

Table G-2: Structure scores. Own Table.

The scores are given in the range from 1 to 5, with 1 being the lowest and 5 being the highest. These scores are then multiplied with the weight factor belonging to the respective criteria. Finally, these multiplied scores are added for their structure.

Further explanation of specfic scores

The complexity of the structure is divided in design and construction complexity. If the design is complex, it is not necessary the case that the construction has to be complex.

The economical benefit speaks to the economical benefit that the local community will experience, not to be confused with tourist attraction. Whilst economic benefit would indeed increase with tourist activity, not all structures are a direct cause for economic benefit. For example, all coral related structures will attract tourists through diving but do not directly have economic benefit.

The assumption is made that all structures are implemented with the highest standard of safety. But a respective difference has to be made between the structures. So the score of 5 ischosen for all structures unless people are expected to enter or be located on or around the structures. In that case, the level of safety depends on the amount of people are in/on/around the structure. Should an unfortunate event take place, this is the amount of people that are at risk.

The score according to visibility is based upon a matrix as can be seen in Table G-3. If the structure not visible, the highest score is given. If ithe structure is visible but also nice to look at, it gets the sccore 3. This applies to all gradations of the aesthetics and visibility of the structures.

Visible?	Ugly	Pretty
Yes	1	5
No	3	3

Table G-3: Visibility Matrix. Own table.

Local support is based on the inhabitants of Bali but of Candidasa particular. Factors that are taken into account are the amount of beach, in terms of recreation and spiritual activities for the locals, economic benefit from the structure and the visibility of the structure.

The criteria local content is based on in what capacity the structure can be installed by local contractors. Should they be entirely self-sufficient without outside help, a score of 5 is given. But should they be able to install the structure themself but only lack the knowledge, a collaboration with an expert has to be atained. This results into a score of 4.

OpEx and maintenance are intertwined because costs that have to be made during the operational time of the structure is actually maintenance. This is why the two scores are occasionaly alike.

These structures are compared according to their scores and displayed in Figure G-1.

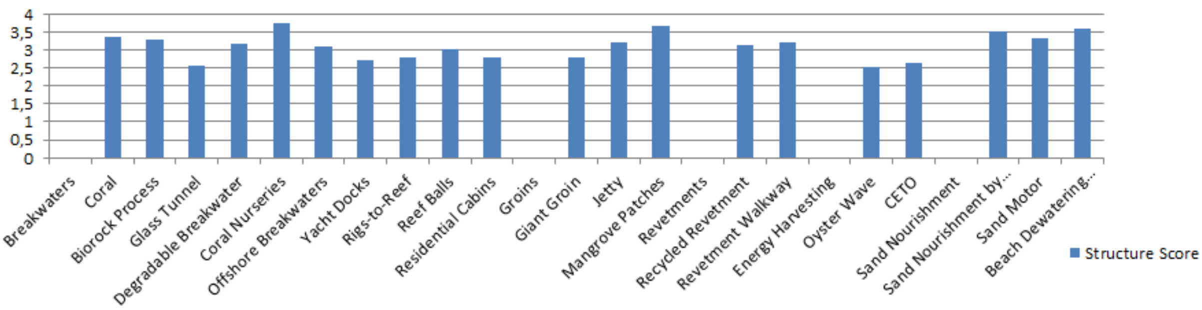


Figure G-1: Compared scores structures. Own Figure.

Figure G-1 shows that the scores of all the structures are close together. Because all of the structures already went through a first screening by being placed in the alternatives and seeing how they function in different circumstances. So it is logical that the structures all score on the higher scale and that there are not any real outliers.

H: Appendix Final Suggestions

H.1: Appendix Structure Packages

H.1.1 Sand Retainment

Sand nourishment volumes of area 1 are shown in Tabel 1 below.

Sand nourishment volume		300,000 m3
Width of beach	LWL	55,5 m
	MWL	39,9 m
	HWL	24,3 m
Total sand motor volume		60,000 m3
Length of one motor		167 m
Extra width of beach at location of motors		

Tabel 1: Sand nourishment volumes of beach area 1 (Own Table).

H.1.2 Beach Nourishment and Mangrove Forest

Sand nourishment volumes of area 2 are shown in Tabel 2 below.

Length of nourishment	1,700 m
Cross sectional area of nourishment	100 m2
Volume of fillment	170,000 m3

Tabel 2: Sand nourishment volume of beach area 2 (Own Table).

The dense root systems form a home for fish, crabs, shrimps, and molluscs. They also serve as nurseries for juvenile fish. Many coral reef fish, for example, spawn in mangrove forests. The young fish stay in the forest, where there is plenty of food and they can shelter from predators, until they are old enough to move to the reef (LeGuen, 2014).

Mangrove forests thrive near the mouths of large rivers where river deltas provide lots of sediment (sand and mud). Mangrove roots collect sediments and slow the water's flow, helping to protect the coastline and preventing erosion.

Mangroves have special aerial roots and salt-filtering tap roots that enable them to thrive in brackish water (brackish water is salty, but not as salty as sea water).

Mangroves need to keep their trunk and leaves above the water line. Yet they also need to be firmly attached to the ground so they are not moved by waves.

Mangroves are salt tolerant trees (halophytes) adapted to live in harsh coastal conditions. They contain a complex salt filtration system and complex root system to cope with salt water immersion and wave action. They are adapted to the low oxygen (anoxic) conditions of waterlogged mud.

Mangrove swamps protect coastal areas from erosion, storm surge (especially during hurricanes), and tsunamis. The mangroves' massive root systems are efficient at dissipating wave energy. Likewise, they slow down tidal water enough so its sediment is deposited as the tide comes in, leaving all except fine particles when the tide ebbs.

H.1.3 Coral Restoration

As demonstrated in the cross criteria comparison, coral nurseries and Biorock scored highest in the type breakwater. As previously mentioned, Candidasa's coast used to be protected and preserved by the original coral reef. After mining, this protective feature was lost and the coastline eroded even faster. To restore the natural dynamics, the coral reef will be restored, strengthened and extended to sustainably and cost-effectively withstand the future severe conditions, such as the rising sea level and pollution. In this appendix the additional factors for the design are elaborated.

Coral reef rehabilitation

Coastal preservation by coral reefs have several benefits, such as protection of property, important ecosystems, tropical storms and to save initial maintenance cost of breakwaters. This is due to the ability to reduce wave impact on coastlines and the possibility of coral reefs to adapt to sea level rise. Secondary goals for the development of this coastal reef are: retain water quality, sediment supply, stimulate marine life and the choice of specific fish populations. These secondary goals should stimulate economic growth by tourism as well fishery.

To understand coastal preservation by coral reefs, it is divided into two parts: the tallest (crest) and shallowest part (flat). The majority (86%) of wave energy is reduced at the reef crest alone. The first 150 meters of flat behind the crest reduces half of the remaining wave energy. (Ferrario,2014)

Also, the reefs ability to dampen waves depends on the physical qualities of height and roughness. In general coral with rougher texture and/or taller crests can reduce wave energy better. In the study is found that corals, on average, reduce wave height by 51-74% with a maximum of 97 % (Ferrario,2014). Artificial structures, for example, can only reduce by 30-70%. Candidasa has a rather calm wave climate as Nusa Penida islands form a shelter. A reduction range of 50-80% will therefore sufficient to reduce the wave energy. This implies that a full-grown coral reef crest with 50-100 meters of coral reef should be able to offer enough support against coastal erosion.

Second, the seabed material and the water characteristics are important for coral reef development. Candidasa has a degraded coral reef crest with a back lying reef flat. This reef flat has been mined over the course of years for construction purposes. Therefore the seabed exists of the remaining limestone covered with a layer of sand degraded from the beaches (JICA, 2014). Excellent conditions for the start a new coral reef, from a substrate point of view, and the easiest place to add a reef substrate is an empty sandy bottom that has hard of firm bottom 10-20 centimetres underneath.

The water characteristics, such as water temperature range, saliently range, current, waves and tides match the rather suitable climate that Candidasa has. Candidasa's ocean is characterised as clear and warm water around 28 degrees Celsius with a rather calm sea climate. Typically, tropical corals flourish best in temperature ranges of 19-30 °C (RB Foundation, 2008) and in optimal light ranges in clear water. Optimal living condition for coral, in Candidasa, is concentrated at the forereef, while the reef crest and flat support less favourable living conditions (JICA,2014) The growth rate of coral differs form 0.3-2 centimetres per year for massive corals up to 10 centimetres for branching corals (US Department of Commerce, 2008). Dependable on the environment the corals are planted, it can take up to many years to fully grow.

Advantages and disadvantages of building a new coral reef

A fresh start on the new site can reduce coral predators and the possibility for disease contact. Another benefit is that new sites can be configured to maximize project goals or targets. One can choose a site based on features like diving, travel distances to the reef, locations protected from future damaging activities and the possibility for erosion control. New sites can also be selected to reduce budget or resource burdens, which makes it highly economically attractive (RB Foundation, 2008). However, a new site may require substantially more base substrate to ensure enough protective void space to provide an equivalent amount of essential fish habitat. In general, the construction and deployment of the base artificial reef substrate is the most expensive part of the coral in a coral rehabilitation project. Moving coral to an area without natural coral, careful attention must be paid to water quality to ensure that conditions are suitable for coral growth (RB Foundation, 2008)

Construction

Coral Nurseries are submerged installed 'trees' with thousands of coral fragments hanging from the 'branches'. When they are grown, the corals are transplanted back into the reef. A Reef Ball is a hemispherical hollow concrete unit, made by pouring concrete into a fiberglass mold. Reef Balls act as submerged breakwaters, the internal voids in the Reef Balls deliver numerous benefits for fishing and marine life. Reef balls will be made from the recycled groins and seawalls.

Phases

The structures used have different implementation and lifetimes. Therefore the effective times of the structures are aligned to ensure optimal coastal protection at all times. Three phases are defined to understand the importance of the time planning in this plan. In phase 1 the structures are planted and the coast will be preserved by temporary initial structures (Biorock metal). Phase 2 (transformation) the limestone and coral on Biorock is almost fully-grown and the coral nursery is midway development. In phase 3 limestone or coral covers all structures and a limestone crest with hind lying coral reef is situated, which is properly grown to support coastal preservation.

Biorock

Design

One great benefit of Biorock is the adaptability to a wide scope of situations and environmental conditions. If required, the resulting forms can be designed to be highly robust and are well suited even for high wave energy shores and reef crests. This is because they do not block the water movement and reflect the waves but act as permeable barriers. Biorock structures normally grow 1 to 5 centimeters per year, which is ten times the current pace of sea level rise (Goreau & Trench, 2012). Due to this dynamic feature, Biorock is able to sustain for decades whilst seawalls are degrading.

Energy

A wide range of electrical sources can power Biorock projects. This could include renewable energy devices such as windmills, photovoltaic panels, tidal and wave current generators. Although renewable energy sources are a more expensive alternative, they allow for deployment of Biorock on sites where conventional electric power is unavailable (BIC, 2012).

A basic rule, a structure of 6-7 meters in diameter uses around 30-50 watts. Larger structures of around 20 meters use a few hundred watts or a reef the whole length of the beach uses for same amount of electricity as the shore lights. After the growth phase, it is possible to reduce the amount of voltage, to reduce the energy consumption, as the limestone does not need to accrete as fast anymore (Goreau & Trench, 2012).

Construction & Material

To build a Biorock reef, an electrically conductive frame, often made from construction grade rebar, is welded together, submerged and anchored to the sea bottom. This method is well suited for remote sites where exotic building materials, construction equipment and highly skilled labour are non-existent. Afterwards, a low voltage directly runs through the construction. This initiates electrolytic reaction-causing mineral crystals, such as calcium carbonate and magnesium hydroxide, naturally found in seawater to grow on the structure (BIC, 2012). The structure will be built from ordinary construction materials available on Bali, such as steel rods, pipe or rebar. Other materials necessary for the project include electrical cables and epoxy or silicone sealants to protect the electric connections. As the main structure act as the cathode, another electrode, the anode, is a special titanium mesh that does not corrode (BIC, 2012).

SWOT Analysis

In Tabel 2 is an SWOT analysis given of the Biorock and Coral package. As the coral restoration has a lot of advantages and disadvantages, threads and opportunities that make it a complex issue, they are summarized in this SWOT. This SWOT analysis is used as feedback loop on this design package and improvements are adjusted in the main text.

Strengths	*Weaknesses*
Enhanced marine life *Experience in Bali and Gili with Biorock* *Self sustained/Healing capabilities* *Inexpensive structures* *Zicht vervuiling* *Tourism activities increase (diving & snorkelling)* *Enhanced fishery* *Local employment* *Local material* *Long-term employment* *Growth outruns sea level rise* *Reduction wave energy* *Multiple economical purposes (fishery, farmery, target species, diving, watersports)* *Fast implementation time Biorock* *No scour holes Biorock* *Permeable structures reduces forces on it* *New site gives possibility to special purpose for coral* Biorock's adaptability to a wide scope of situations and environmental conditions	*Necessity of power* *Long implementation time coral* *Scale of coral nursery* *Many Structures enhances the complexity* *Many Structures enhances the dependency* *Critical alignment in time schedule structures* *Coral reef is fragile* *New site need more base substrate* *Need of skilled supervisor* *Need of careful allocation of money* *Careful monitoring*

Opportunities	Threats
General tourism growth Harbour / cruise ship development Overexploitation tourism Kuta area International ecological funds for project	Sea level rise Pollution sea water Mining industry Local poverty Waste water Tourism industry overexploitation

Table Swot analysis Biorock and Coral restoration (Own Table).

H.1.4 Offshore Bungalows

An offshore overwater bungalow is a housing facility located over water. These kind of bungalows are located all over the world. From Bora Bora and Tahiti to Fiji and the Maldives. They have also been previously implemented in Asia.

The structures and bungalows must be at least 5 metres from the shoreline (Buckley, 2003), this requirement is achieved as the bungalows will be located 0.5 kilometers from the shoreline. Shuttle boats will sail between shore and the offshore bungalows to transport the guests.

An onshore pier of 50 meters will be constructed that functions as a dock for the shuttle boats sailing to and from the bungalows. There will be a floating pier attached to the offshore bungalows that will extend 20 metres into the ocean for docking at sea. The offshore pier has a T-shaped ending (Buckley, 2003) with the bungalows located at the ocean side of their pier for an ocean view. Due to the changes in tides and possible waves, the pier will be floating. The T-shaped ending will have a slight curvature to it, in order to contain as much sediment as possible. All bungalows will be located at the ocean side of their pier to create bungalows with oceanview.

To calculate the dimensions of the bungalow, deck and structure Formula 1, 2 and Table 3 have been used. Table 3 displays the parameters which have been used in the formulas.

Parameter	**Value [m]**
Design wave Height	2.6
Max Wave (1 year)	3
Mean Sea Level (MSL)	10
Surge	1
Airgap	1.5
Settlement	Negligible
Subsidence	Negligible

Table 3: Vertical Parameters of Offshore Bungalows (Own Table).

Both subsidence and settlement are negligible as there is little to none present in this case. The max. wave is based on a one year return period, with the bungalows being able to withstand these waves for 10 years before any maintenance due to the max. wave is required. The value for surge was an assumption, minding the expected surge in a calm area as Candidasa.

The bungalows will be built on structures that reach 5.15 meters above the MSL and 15.15 metres above the seabed to avoid wave collision, as calculated with Formula (8.1).

*Ddeck=MSL+0.5*surge+subsidence+0.55*max.wave+airgap+elevation above mud line = 15.15 m(8.1)*

The elevation above the mud line is assumed at 1.5 metres, this is calculated by adding 0.5*diameter of the lowest horizontal beam to the 0.5 m the beam should at least be above mud level. As an extra precaution, 1.5 metres was assumed.

The structure beams have a diameter of 0.4 meter, as per Formula (8.2). So for the beams to fit through the deck holes and give them 0.05 meter room on each side, the deck holes have a diameter of 0.5 meters.

$$D = 0.029 * \text{Length Structure Beams} = 0.4 \text{ m} \quad (8.2)$$

The piles have to extend 1.94 metres into the soil for the wind and wave forces not to tip them over. With the help of Tabel 4 and Formulas (8.3), (8.4), (8.5) and (8.6) the length of the beam into the soil was calculated.

$$Q_{s,sand}=\beta*\gamma*z*\pi*D*L_{sand}=5491.504\ L_{sand}^{2} \quad (8.3)$$

$$Q_{t,sand}=N_q*\gamma*z*\pi*r^2*L_{sand}=15200L_{sand} \quad (8.4)$$

$$Q\ =Q_{tssand} + Q_{t,sand} = 50.000\ kg \quad (8.5)$$

$$L_{sand}=\frac{-b \pm \sqrt{b^2-4*a*c}}{2*a}= 1.94\ m \quad (8.6)$$

Parameter	Definition	Value
β	Shaft friction factor	0.46
γ	Effective unit weight of soil	9.5 kN/m^3
N_q	Bearing capacity factor	40

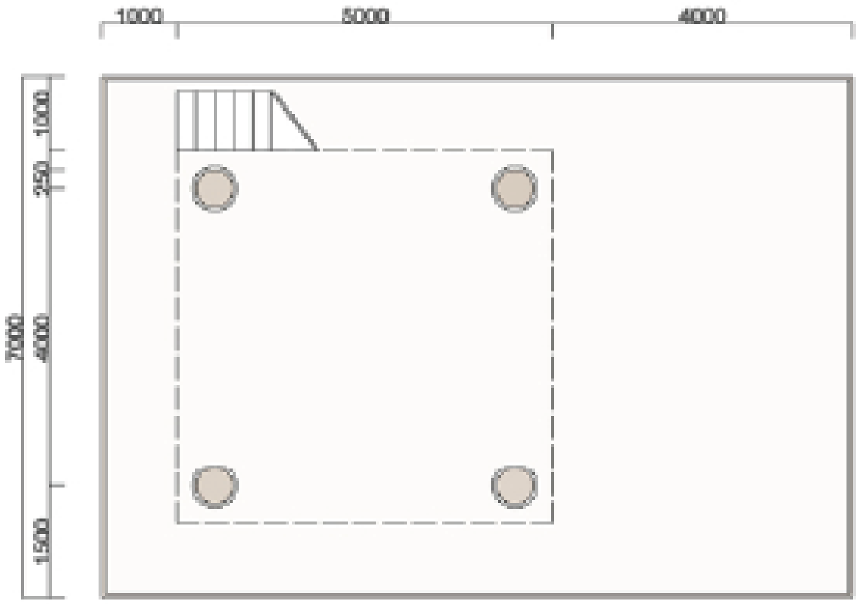
Tabel 4: Parameters and Values representative for Formulas (8.3), (8.4), (8.5) and (8.6)

Table YYY: Parameters and Values representative for Formulas (8.3), (8.4), (8.5) and (8.6)

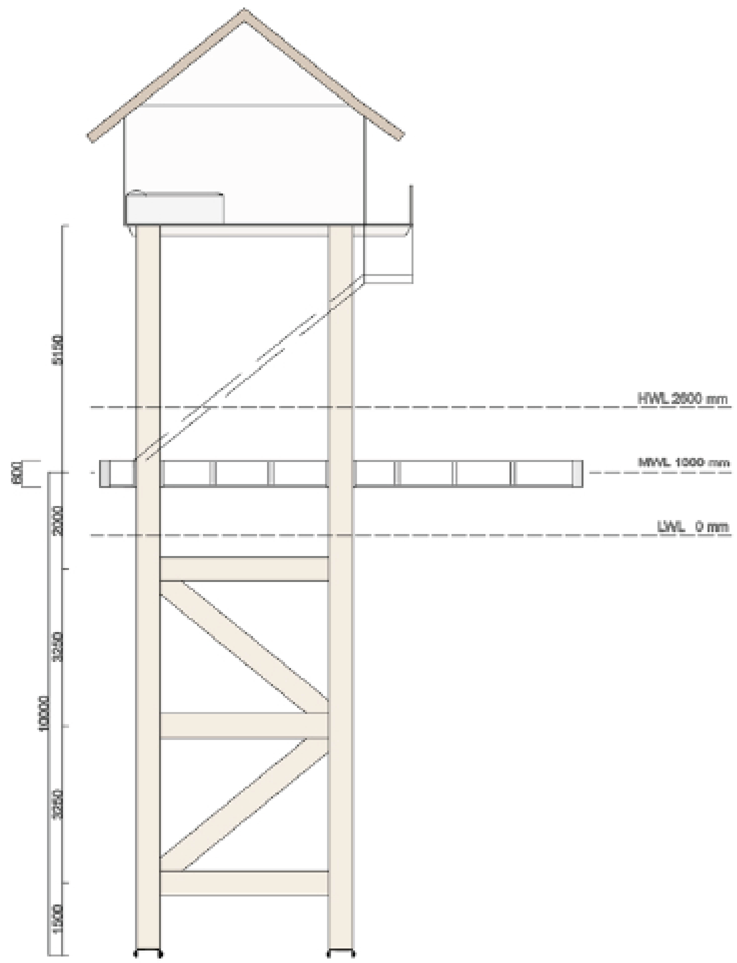
Each honeymoon bungalow will have a floor plan of 5x5 meters with a deck of 7x10 meters below the bungalow. Each of the deck sides will extend one meter outside of the bungalow but one side of the deck, facing ocean view, will extend extra to maximally enjoy the ocean surroundings. A bungalow includes one bedroom and one bathroom.

The family bungalows will have a slightly larger floor plan of 6x7 metres and a deck of 8x12 metres. The space will be separated into two rooms, one family room with a double bed and one small bedroom with a bunk bed. The remaining design is similar to the honeymoon bungalows.

The floor plan for the deck and side view of the bungalow is shown in Figuur 1: Floor plan deck Offshore Bungalow andFiguur 2: Side view Offshore Bungalow.



Figuur 1: Floor plan deck Offshore Bungalow



Figuur 2: Side view Offshore Bungalow

All water and electrical supply and distribution to the overwater bungalows will resemble conventional supply and distribution systems.

Eco-friendly measures are to be taken in the design of the bungalows. Cooling systems run with water extracted from the sea, energy extracted from waves and solar panels will be implemented (Zahir, 2014).

Construction

In order to efficiently construct the bungalows, structures and piers, guidelines have to be set in coordination with land zoning and environmental parties to ensure practical placement and management of the overwater bungalows. During construction and operation adequate management and monitoring is required to minimize potential short- and long-term impacts.

The structures on which the bungalows will rest have to be piled into the sea bed to establish sufficient foundation. The footprint of piling will cause a loss of vegetation and disturbance of sediments but the potential for regrowth will depend largely on the installation method implemented.

The installation method for pile installation that is preferred, during similar projects in the Bahamas, is socketing. This technique uses a displacement tube that indicates the area that will receive the piling. Consequently the material is evacuated by either chiseling or augering through the displacement tube. All impacts will be largely be contained in the vicinity of the displacement tube (Scott & Co., 2012).

Material

The entire structure and frame of the bungalow will be constructed out of wood. It can be compared to wood that is commonly used for dock structures, this wood is continuously exposed to saltwater, which is accelerates decay. To minimize this effect a wood preservative designed for marine use is applied to the wood. Chromated copper arsenate (CCA) is the most commonly applied wood preservative. Wood placed in seawater receives the highest concentration of CCA at 2.5 lbs/cu. During the first 90 days, 99% of the leaching occurs. After the wood is immersed in seawater, the leaching rate daily decreases by half.

The deck will be hollow, for potential flooding, and consist of cement. Wood with CCA could be layered on the top of the deck for esthetic reasons.

Maintenance can be simplified by careful selection of building materials. As routine painting, staining, scraping or other seasonal maintenance can introduce contaminants into the water column (Scott & Co., 2012).

Prefabrication

Prefabricated bungalows will be made and placed on the structures. The prefabrication takes about 30 days delivery. The structures are placed with help of high neck excavators, which are able to venture into the water. The crane picks up the prefab bungalow and places it on its desired location. Shipping of the prefabricated bungalows will have to be done by sea through a nearby port or harbour (Zahir, 2014).

Environmental

Environmentally speaking the bungalows have an impact on their surroundings. In terms of light, the bungalows form shade and lessen the light intensity through the water column. This is a vital condition for plant growth. This can be mitigated by not placing the structures above seagrass beds or other sea water plants.

Waste from the bungalows whilst in operation is split in liquid and solid waste. Liquid waste is processed by compact, yet highly efficient, macerators and vacuum systems that have an application to overwater structures. The solid waste will be stored in max. 30 gallon storage units and physically transported onshore for disposal along with land side solid waste.

H.2: Appendix Stakeholders

H.2.1 Stakeholder Engagement Explanation

The shifts and measures for the stakeholders' interests are elaborated below.

Environmental agency: from context setter to player

The environmental agency possesses a lot of knowledge on the environmental possibilities and they have a high blocking power when it comes to serving out environmental permits, which can be used to enhance the speed and solutions of the project. A collaboration can be generated by involving them in the design and incorporate their recommendations to the maximum extent possible, resulting in a quicker approval of the request and in innovative measures that enhance the environment and create a sustainable image for candidasa.

Highway irrigation agency from crowd to subject/player

The highway agency is uninvolved in developing the coastal areas, but has high production power when it comes to enhance the local infrastructure. This can be used to gain extra support for the projects and to enhance the complete project performance. By involving the agency into the project, the effective and beneficial scope of the project is able to reach further than only Candidasa. This can be done by involving them early in the design phase, letting them tell their issues and try to find couplings with their issues and the ones of the Candidasa coastal area. For example, coupling the redevelopment of Candidasa's beach, that will attract tourists from the southern part of Bali, with the unleashing of tension of the over occupied infrastructure, will make the redevelopment of Candidasa beneficial for the highway and irrigation agency.

NGO's from crowd to subjects

NGO's(e.g. Coca Cola or Greenpeace) have a huge financial liquidity and social responsibility, that can be used as a production power to develop sustainable measures, as long as it is in their interest. They should be informed e.g. by means of newsletters and listening to them and providing feedback on how their input influenced the decisions will create the opportunity for them to contribute to the project.

Freeze the Local Inhabitants

Because of their extremely high blocking power, it is of great importance to collaborate with the local inhabitants and use their perspectives to develop structures.

Freeze the JICA and tourism industry

Both stakeholders are context setters and should be kept satisfied by involving them to ensure their concerns are considered and reflected in the alternatives, and provide feedback on how their input has influenced the decision making.

Developers/contractors from crowd to subjects

In the start of the project a choice has to be made from a several contractors who only have production power. As soon as a project evolves the blocking power of the selected contractor grows, because of this blocking power their interest has to be improved so that the project is not hampered and the quality of construction is maintained. This can be done by lowering the risks of the project in the form of contracts or adjustment of boundaries that benefit the profit of the developers, but is still acceptable to the environmental agency. Enhancing their interest will also be mitigate the fear of local inhabitants that the contractors will try to construct in the cheapest way possible.

Hotels and restaurant association, Karangasem regency and the Laboratory for coastal engineering are freezed as subjects

Keep them informed and consult where necessary, in order to avoid expected reluctance.

H.2.2 Survey
SURVEY CANDIDASA - OCTOBER 2015 - Bali Beach Project

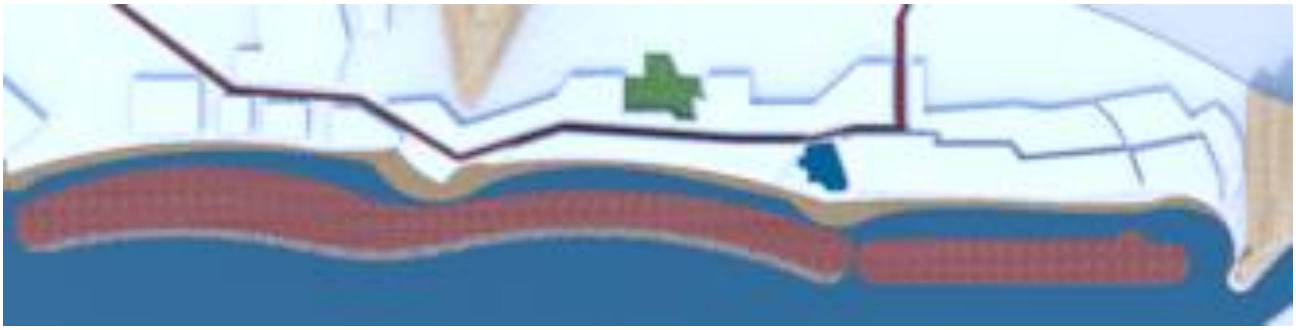
1. New beach development in Candidasa - what is the public opinion of the proposed measures

2. Are you aware of the beach issues? Yes. Continue to 4.

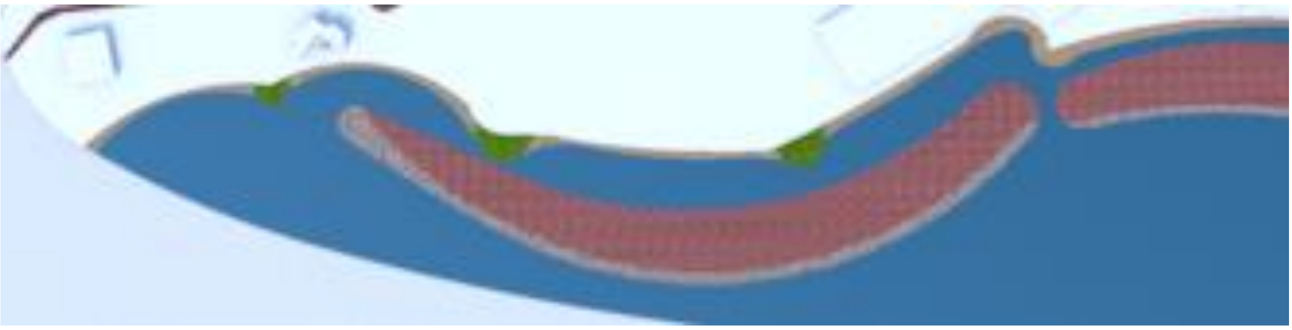
3. Beach is severely eroded and is a danger for the hinterland and economy

4. Questions about specific measures to solve problems

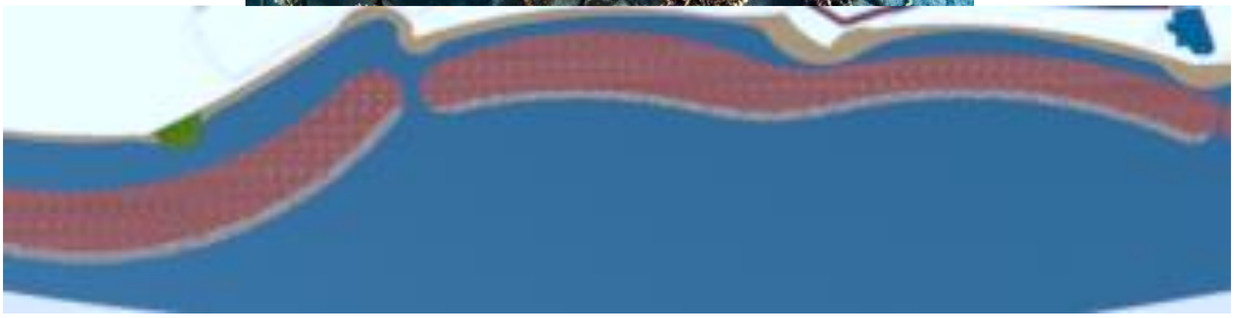
Beach nourishment



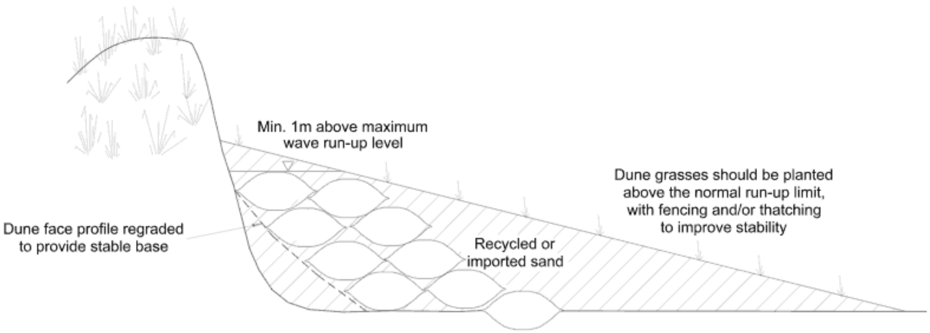
Mangrove patches



Coral nurseries/Biorock

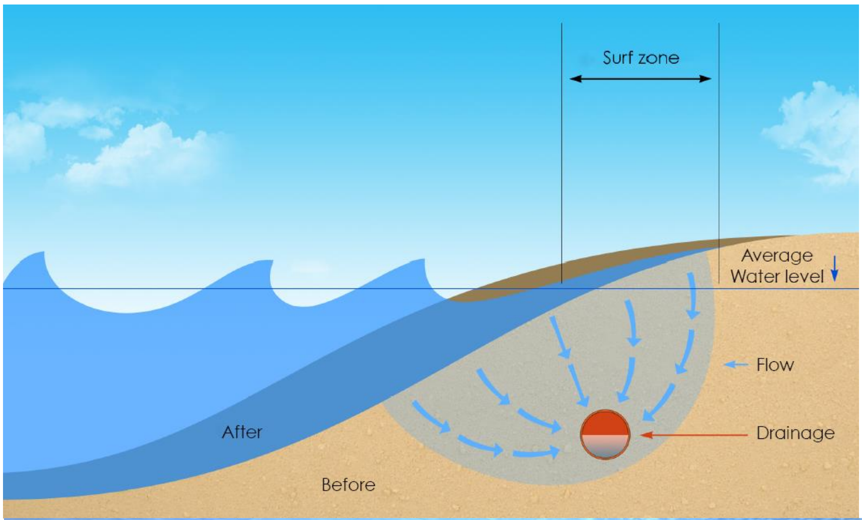


Recycled revetment



Offshore houses

Beach dewatering and energy harvesting



Questions NAME Are you a: tourists/ local inhabitants/ business owner/other:

1. Sand Nourishment

Would you mind if the beach has this shape?

2. Mangrove patches

Would you mind mangrove forests planted along the beach?

3. New coral

Would you mind if new coral is planted to protect the shore?

4. Recycled revetment

Would you mind recycling of the current revetments/stones on the beach?

5. Offshore houses

Would you mind houses were build in the sea to help protect the beach?

6. Beach dewatering and energy harvesting

Would you mind a pipe underneath the beach and buoys in the sea?

Interviews with stakeholders

	Structure	Beach nourishment	Mangrove Patches	Corel Restoration	Recycled Revetment	Offshore Bungalows	Beach Dewatering and Energy Harvesting
Group	**Name**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**
Tourists	Patrick	+	+	+	o	+	o
		This shape looks okay. Right now there are few easy ways to enter the water	This looks nice, very natural	It keeps the sand on the beach and it's good for snorkeling	Can be very ugly if it shows up again. Won't the erosion start again?	Looks very attractive, I would stay there!	It must be proved first, otherwise I think it is a waste of money.
	Jeff	+	o	+	o	o	+
		A beach is a beach, function is not really clear to me	It looks okay	That's a nice plan, because this is where it went wrong in the first place	Recycling is always good, but not sure if the sand would remain in place if groins are gone.	Depends on how many are built and you would have to show how effective it is. Otherwise you would just ruin the view.	Nice! I understand the function, looks good.
Expert BWS	Adri	+/o	+/o	+	o	o/-	+
		We would have to check the technical possibility with small reef flat (300m). May be a good possibility for North of Sanur	If efficiency is proved, very useful. Again, we have to check water condition, nutrients in the soil and soil condition.	Restoring nature is always good. Restoring the coral has almost no downsides, maybe expensive?	We would have to check the sand transport. otherwise there is a possibility of exposure.	If the wave load can be absorbed could be useful, but that's questionable	If it has proven efficiency, great idea
	Gina	o	-	+	-	-/o	o

	Structure	Beach nourishment	Mangrove Patches	Corel Restoration	Recycled Revetment	Offshore Bungalows	Beach Dewatering and Energy Harvesting
Group	**Name**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**
Hotel or business owner		Worried for abrasion and big waves. that's why we constructed the groins	It will probably not work, not strong enough for the waves	This is good for diving, snorkeling and tourism	Groins protect our restaurant, if not, abrasion occurs and hotel/restaurant will collapse. We feel safe with the groin	Not strong enough, you cannot build there, what if it is broken? No soil to construct again.	I don't understand this structure
	Fred	-	+	+	+	-	+
		Currently it is quit at the beach, he and other Western do not prefer a second Kuta, also because infrastructure is not capable and the beach gets polluted.	Restoring the nature is good	If the coral is not used for the export, as is the case in front of my house, it is great.	Groins can be removed, fear of big waves is irrational because of the protection of Lombok	Horrifying, the bay is small and the view will be taken away by the houses.	As long as they remain invisible, it is okay
	Made	+	+	+	-	-	o
		Nice for the tourists	Good to keep seawater away from the land	Good to save the coral and diving areas for tourists	Revetments are expensive, and if removed the sand will immediately move away	Can be bad for coral/fishes, ecosystem	Nice to keep the sand but never seen it, don't know if it will work. The energy harvesting seems bad for fish.
		+	o	+/o	o/+	o	+

	Structure	Beach nourishment	Mangrove Patches	Corel Restoration	Recycled Revetment	Offshore Bungalows	Beach Dewatering and Energy Harvesting
Group	**Name**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**	**+/o/- and why?**
	Made Jon	As long as we have beach, it is good. The government put concrete blocks on the beach, resulting in erosion	Sand is differently mixed in Nusa Lembongan, if possible it is good, but questionable efficiency	Afraid for dynamite fishing, if this can be avoided it is good	Remove the perpendicular part of the groin, the other part protects the beach and let the sand flow along the beach	Is good for public access, nice place to fish and to park boats. Private would be bad for the view.	If it is not dangerous for the people, very good. Good circulation, like swimming pool. Energy harvest buoys attracts big fish, good for spear fishing.
Local Inhabitant	Nyoman	o	-	+	o	+	o/+
		Afraid the it goes into the ocean, the perpendicular part of the groin on the beach must be cut.	too weak, offers no protection	Fish can come which can enhance the area, also good for tourism.	Keep the parallel parts	Good for relaxing of tourists, which is good for all the people of Candidasa	Seems dangerous for the people, energy harvesting is oke
Head of the village	Made	+	o	+/-	o	-	o
		Not allowed to take the sand from other villages, from the offshore is ok. The shape is ok. Plans from the JICA to grab	Natural look is ok, but can be dirty, dark sand	If placed close to shore, diving school think no boat is needed for deep sea diving.	Only keep the parallel part of the revetment and if the sand moves down it will lose its natural look	Better if the view is clean and empty. Local people want to be able to move easily into the sea for business and fishing	Seen the dewatering in Japan, good idea. The harvesting is new, should be used in local areas, not in tourist areas.

Tabel 5: Interview among stakeholders (Own Table).

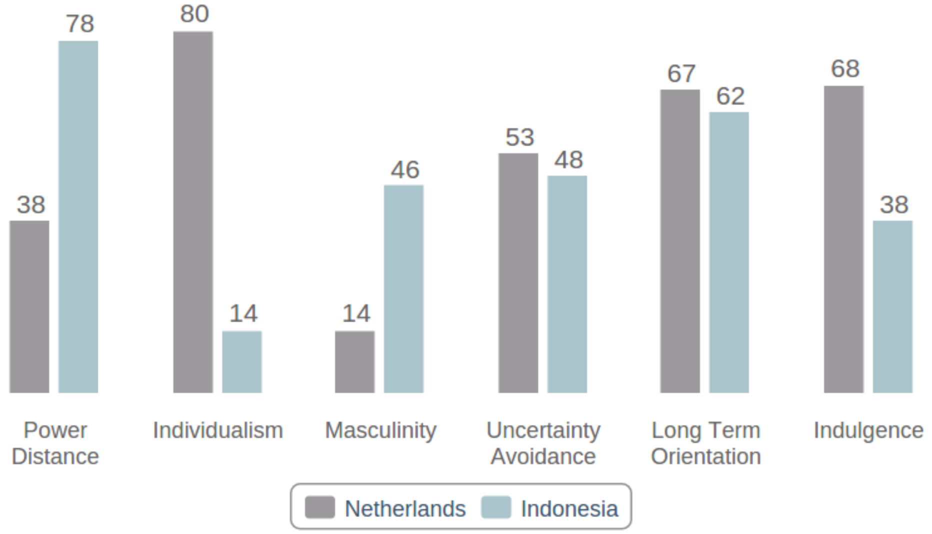
An important finding from the survey is, amongst others, that the main crux of welfare distribution in this project seems to stem from two different factors:

- The root cause of the erosion problem is not acknowledged by every stakeholder. This results in a difference in opinion about what is the best solution.
- Local inhabitants and/or fishermen do not always trust the local or national government. This result in a defensive attitude of these stakeholders in which they question every decision made by the government.

Because there is no consensus about what is the best solution, some stakeholders feel that a lot of money is wasted by constructing 'useless' structures. Together with the lack of trust, stakeholders may get the impression that structures are being built to benefit specific stakeholders and not to improve the general welfare of the population.

Impression of the interviews

H.2.2 Cross cultural differences between the Netherlands and Indonesia



Figuur 3: Differences on cultural dimensions between the Netherlands and Indonesia(Hofstede, 2015).

In order to oversee cultural differences between the Netherlands and Indonesia, these are explained before the framework. Because of the differences between the Western and Asian cultures, imposing and xeroxing a Western framework into an Asian country can be counterproductive. In order to make suggestions on how to implement a Dutch framework in Indonesia, it is of great importance to make the cultural differences between these countries explicit. This is based on the theory of Hofstede's cultural dimensions(Hofstede et al, 2010). In Figuur 3 the differences on the cultural dimensions between the Netherlands and Indonesia are shown.

The biggest discrepancies can be seen on the dimensions of Power Distance, Individualism and Masculinity, so these are listed and explained below.

- *Power Distance Index (PDI)* is the extent to which the less powerful members of institutions and organisations within a country expect and accept that power is distributed unequally.
- *Individualism (IDV)* is the degree of interdependence a society maintains among its members. In an individualistic society the individual interest will prevail of the interest of the group, the people will look after themselves and immediate family only.
- *Masculinity (MAS)* is the extent to which emotional gender roles are clearly distinct in a society. A masculine society is a competitive one, which prefers achievement, heroism, assertiveness and material reward for success. A feminine society is consensus-oriented and stands for preference for cooperation, modesty, caring for the weak and quality of life.

Power Distance Index

The Netherlands has a low score(38) on this dimension, which means that the Dutch are characterised by being independent, hierarchy is only used for convenience, there are equal rights among the people and the superiors are accessible. In an organisation the power is decentralized, meaning that the organizational structure is horizontal and the manager counts on the experience of the team members, who expect to be consulted, not controlled. Communication is direct and participative.

In contrary to the Netherlands, Indonesia scores high(78) on this dimension, which means the Indonesian style is characterised by dependency on hierarchy, unequal rights between in-accessible power holders and subordinates. The leaders are directive, controlling and delegating. Subordinates are expected to be told what to do and when, a clear direction and control is expected and managers are respected for their position. Communication can be indirect and negative feedback is often hidden.

Dutch people may be considerably surprised with the visible, socially acceptable, wide and unequal distribution between the rich and poor. The difference in Power Distance can mean that a Dutch framework should be applied different to Indonesia, because it requires a participative attitude, instead of submissive one.

Individualism

The Netherlands scores very high(80) on this dimension and is an individualistic society. As a result there is a high preference for a loose connected society where individuals solely take care of themselves and direct family. Offence causes guilt and a loss of self-esteem. Businesslike relationships are based on contracts with mutual advantage and promotions and hiring are based on value of an individual only, causing management to be the managing of individuals.

Indonesia has a collectivistic society with a low score(14) on individualism. The society prefers to have strongly defined relationships between in-groups, which act conform to the ideals of the society. This results in families where children have the desire to make their parents' life easier, by taking care of and supporting them in their old age. Their social network, the in-group, is their primary source of information and the individuals of the group are generally treated better.

Increasing welfare results in higher individualism, which on his turn is correlated with a lower power distance index. This can mean that an enhanced welfare changes a society's perspective on the individualistic Dutch framework. It also emphasizes the idea that process management should focus on involving collectivistic groups instead of only addressing individuals.

Masculinity

The Netherlands is a feminine society(14). It is important to keep a balance between life and work. Supportive managers make decisions based on involvement, negotiation and compromising with his or her subordinates. There is a urge for consensus among the people, who value equality, solidarity and quality in their working lives.

Indonesia has a low Masculine society(46), meaning they are not like the feminine societies, such as the Dutch's, but also not entirely like other Asian countries like Japan or China. Status and visible symbols of success are important, but it is not always the material gain that motivates the society. The position a person holds can even be more important. This concept is called the 'gengsi', which roughly means outward appearances. It is important that the gengsi is highly maintained, resulting in a different outward appearance that focusses on impressing and creating an aura of status.

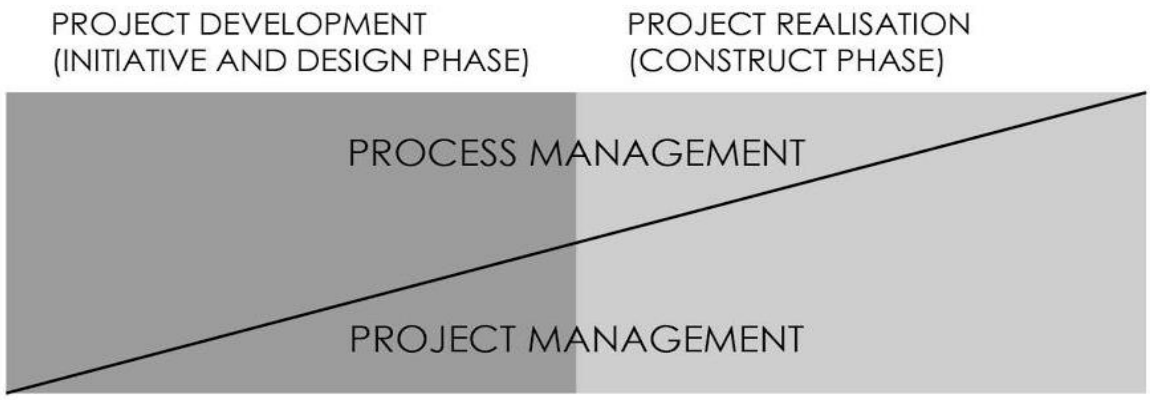
These differences can mean that masculin stakeholders can be incentivized in different ways than feminine stakeholders.

H.2.3 Elaboration of the process management framework

In the current process management in Bali, it is called a social consideration to organize meetings with local stakeholders. Information of projects is given and opinions are changed during these meetings. In Candidasa for example, the conclusion of the meeting was that the tourism industry, fishermen and residents give full support by the stakeholders to handle the beach issues, without knowing the specific structures yet (JICA, 2013, pp. 377/14-1-418/14-42). Although this is a good beginning for the initiative phase of a project, no clear strategy is mentioned on how to manage stakeholder involvement during the rest of initiative, design and construct phase of the project. The stakeholders are mostly informed instead of consulted, involved or empowered. This is why a process management framework is proposed that will create consensus, commitment and tolerance with the outcome of the project.

The framework is based on the theory of Professors de Bruijn and Ten Heuvelhof from the Delft University of Technology and is meant to involve and manage the interaction between all stakeholders during the initiative, design and construct phase of the project. As mentioned before the current approach in Bali is to DAD: Decide, Announce, Defend. The purpose of this framework is to DDD: Dialogue, Decide, Deliver. It will avoid potential problems and obstruction with stakeholders and can enrich innovative solutions, transparency and support.

Framework



Figuur 4: Process management and project management during a project lifecycle. Adapted image from (Leijten, 2014).

Process management gradually goes hand in hand with project management, as shown in Figuur 4 As soon as the main objective of a project is defined, a process should be initiated and managed. A process consists of iterative rounds of meetings. Firstly the process manager has to identify and analyse the stakeholders, the issues that can occur due to different perspectives and which stakeholders are involved in which issue. Then the issues are framed as dilemmas and a process is designed. The rounds of meetings will discuss the different dilemmas with the relevant stakeholders, which will eventually contribute to the project development during the initiative and design phase of a project. If all goes well, the process manager is less needed at the realisation of a project during the construction phase, and will then make place for complete project management, until the project is delivered and ready for use.

Before the process is designed, the issues that are discussed during the different rounds of meetings should be framed into dilemmas. The difference between an issue and a dilemma is that an issue only states a difference between an existing and a wanted situation, whereas a dilemma requires a choice between two different values that cannot be chosen together, for example: high quality of construction with high prices versus lower quality of construction with lower prices. The advantages of framing issues into dilemmas are (de Bruijn, ten Heuvelhof, & in 't Veld, 2010, pp. 70-71):

- All stakeholders see their views represented in the dilemmas, no substantive choice has to be made beforehand;

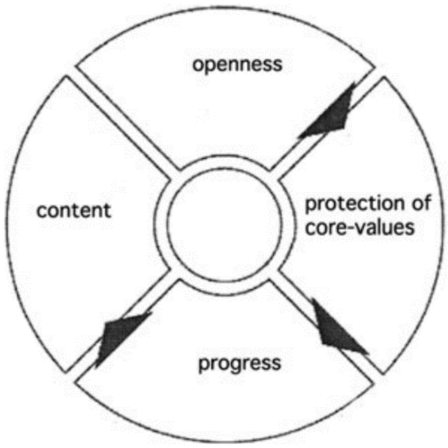
- Conflict between stakeholders is reduced, they are forced to make a trade-off;

- Stakeholders put their own views into perspective;

- Stakeholders become more susceptible to process agreements.

The design of a process that helps to enrich innovative solutions, transparency and support, and thus avoids obstruction, is elaborated next.

Process Design



Figuur 5: Four core elements of a good process(Heuvelhof et al., 2010, p. 42)

The process is composed of four cornerstones, namely openness, protection of core-values, progress and content. The cornerstones are related in the following order:

- A good process is characterized by the open attitude of the initiator, in this case BWS. Other parties are offered an opportunity to take part in shaping the agenda and the decision making.
- However, the potential participants may perceive this openness as threatening. The process will not be regarded as a safe environment until the core values of the participants are protected.
- The openness of the process and the protection of the participants may stall the process. Therefore there should be incentives for progress and momentum.
- This results in too much focus on keeping the process going. Therefore there is a need for arrangement that lead to sufficient substantive input into the process(Heuvelhof et al, 2010, p. 42).

Guarantee of openness

BWS, as an initiator of the process should not take unilateral decisions, but should offer other stakeholders the opportunity to participate in the decision making, which will enhance the support and gains of a process. An open process can be reached according to the following three principles.

All relevant parties are involved in the decision-making process

The first principle of an open process is to involve all relevant stakeholders. Stakeholders become relevant when they have productive or blocking power. If these stakeholders help in drawing up the agenda of the meetings, the process will become appealing if the subjects contain their interests. Per different issue there will be a different meeting, where the stakeholders can join when it is relevant to their interest. In order to keep the process controllable the number of stakeholders is limited. The process manager selects the stakeholders based on the analysis and the issues discussed. In case unmentioned stakeholders feel excluded and gain blocking power through collaboration with other stakeholders, they are able to join the process via representation of an already involved stakeholder (de Bruijn, ten Heuvelhof, & in 't Veld, 2010, pp. 82-88).

Substantive choices are transformed into process-type agreements

A second principle for an open process is to minimize the amount of substantive choices. This creates room for all the different ideas of the stakeholders, so the project does not feel like a funnel trap. It will bring the stakeholders together and BWS will have a prospect of results. If a substantive decision has to be made and the stakeholders are unable to do this together, the following approach is advised: translate the problem into possible alternatives, examine the alternatives and then make a decision. BWS can resolve the tension between substance and process, which can delay the process, by making substantively ambiguous agreements. For example, not mentioning specific measures like a sand motor or a mangrove forest, but use a concept such as building with nature(de Bruijn, ten Heuvelhof, & in 't Veld, 2010, pp. 88-93).

Both process and process management are transparent

Lack of openness will eventually lead to mutual distrust between the stakeholders, and thus for conflict. The process and the process manager should should protect the stakeholders' core values as an independent facilitator. The process manager should be independent when it comes to substantive decision making, which will enhance his position in a non-cooperative environment and avoids that stakeholders turn against the process manager(de Bruijn, ten Heuvelhof, & in 't Veld, 2010, pp. 93-95).

Protection of core values

It is hard to create process results with which all the stakeholders are satisfied, because they all have their own interests and perception of what is important. This dissatisfaction may lead to a lack of commitment. Protection of core values will keep all stakeholders committed by offering sufficient protection to allow stakeholders to take risks, without harming their core values.

The core values of parties are protected

Protection of core values is often an important condition for stakeholders to cooperate in a process. They can be protected by establishing relevant process agreements (de Bruijn, ten Heuvelhof, & in 't Veld, 2010, p. 105). In a case like Candidasa, for example, the main interest of the contractors is making profit, of the local inhabitants is maintain their quality of living, and of BWS is to keep the area safe. These interest can dis correspond and it should be respected that confidential information is not always shared during the process.

Parties commit to the process rather than to the result

The final results of a process and its meetings is hard to define in the beginning(de Bruijn, ten Heuvelhof, & in 't Veld, 2010, p. 106). Therefore, it is necessary for the process manager to commit stakeholders to the process rather than to the result. Stakeholders can be reluctant to commit to the process if they do not have an idea of the outcome. Protecting their core values will enhance the possibility of stakeholders to commit to the process.

Parties may postpone their commitments

During the meetings in a process many sub decisions have to made in order to reach the final result. If all stakeholders are required to completely commit to their sub decisions, they may feel that the process is a funnel trap (Bruijn, ten Heuvelhof, & in 't Veld, 2010, p. 115).

This means that stakeholders are able to come back from sub-decisions, which will make decision making easier, stimulates cooperation between multiple stakeholders and stimulates the learning process.

The process has exit rules

After a several meetings, a stakeholder may decide that he or she no longer wants to participate (de Bruijn, ten Heuvelhof, & in 't Veld, 2010, p. 119). Although controversially, this can be quite valuable for the process: because they have the option to leave, they are more willing to participate in the first place. Rules have to be established to make sure that the progress of the process is not harmed. A stakeholder can exit the process in between the different phases and only if their core values are not satisfied, given the fact they can prove it so that it will not be used as a strategic instrument in decision making.

Progress

A process does not contain a prior made commitment to a final result, which can lead to sluggishness and failure of producing any results. The following principles will make sure that the process will maintain its speed in producing results.

Stimulate early participation

Inviting the relevant stakeholders early in the process to voluntary discuss the points and drawing up the agenda will make them more aware of the process. This will lead to a multi-issue agenda where relations between stakeholders will promote the decision making. Therefore a meeting should be arranged prior to the start of the process (de Bruijn, ten Heuvelhof, & in 't Veld, 2010, pp. 49-51).

Incentives for cooperative behaviour and quick wins

Stakeholders should be convinced that the process is and will remain sufficiently appealing to them to fully participate and to bring it to a good and quick conclusion. This is primary done by developing a multi-issue agenda as mentioned above. Planning of the activities will be incremental by means of a several phases of the development of a project such as Candidasa, inside these phases the issues with the least resistance are placed high on the agenda which will create quick wins. This will make it easier for stakeholders to accept agreements and there are repeated opportunities to realize one's own interest, for instance on applying innovative coastal structures(de Bruijn, ten Heuvelhof, & in 't Veld, 2010, pp. 126-131).

The process is heavily staffed

A heavy staffed process means that the participants in the process are the ones who hold high positions within their organizations, which will give them authority to make decisions. In order to lure them towards the meetings, the simple meetings during the process could be framed into a dinner with the 'leaders of the development of a new coastal area in Bali', which will make it more appealing for important staff (de Bruijn, ten Heuvelhof, & in 't Veld, 2010, pp. 131-132).

Substance

Substantive insights are used for facilitation

Redeveloping coastal areas in Bali asks for a process approach because it is rather complex. Each stakeholder can bring its opinion forward in negotiations, which could make the process drift away from its goal. Experts can be consulted to bring qualitative ideas or information in the process, check argumentation or select the opinions that are substantial for the process. These expert insights can be used to gain understanding, and, as an additional advantage, adds speed to the process.

The process proceeds from substantive variety to selection

After all opinions, ideas and argumentations of both stakeholders and experts are gathered, the best, most substantial, options have to be selected. These options are investigated more thoroughly. A quality decision-making process is characterized by this variety and selection (de Bruijn, ten Heuvelhof & in 't Veld, 2010, p.159).

Points of interest on cultural differences

The differences in culture between the Netherlands and Indonesia were especially in PDI, IDV and MAS, as described in H.2.2 Cross cultural differences between the Netherlands and Indonesia.

Due to the high PDI of Indonesia the core values stakeholders that are considered less important in the process, might get harmed, because of their acceptance towards authority. Eventually this might lead to a point where the less important stakeholders that are excluded will start a collaboration with considerable blocking power, which might damage the progress of the process. The process manager should make sure the less important stakeholders are well represented. It is also of great importance that there is a participative attitude of all stakeholders, which might be lacking because of the high PDI. This attitude can be stimulated by putting extra focus on the early participation and drawing up a multi-issue agenda. A unilateral intervention for a flying start can also be used, which means that BWS-BP unilaterally decides to implement a particular structures, in order to create a high urgency to participate of all the stakeholders.

The high MAS makes the position of the stakeholders during the meetings in Indonesia more important than it is in the Netherlands. Important stakeholders are less willing to cooperate or meet with less important stakeholders, or will communicate indirectly, meaning that extra attention has to be paid on when to invite which stakeholder to a meeting.

A final point of interest will be because of the low IDV of Indonesia, meaning their social network consists mainly of large in-groups and members of their in-groups receive a preferential treatment. This emphasizes the idea that the process manager must be as independent as possible and must not be able to take substantive decisions, in order to guarantee an open and fair process.

H.3: Appendix Economic

H.3.1 Costs

2.1.1.1.1 H.3.1.1 Recycled Revetment

The cost for the revetment material without recycling is €45.5 - €68.2 per ton of material (Lake Ontario Riparian Alliance, 2011). The revetment will weigh 51768.24 tons, as revetments with this dimensions typically weigh 9.84 tons per linear meter, so the cost for material becomes €2,353,101.8 - €3,529,652.7. In the revetment mass, the assumed percentage of 30% , so 15530.472 tons, of the material will be recycled. This material will have to go through the cleaning and recoating process, as previously described. Due to transportation cost, the price of limestone becomes about twice as high than that of andesite. The total cost for the revetment will be around €14,856,000 (JICA, 2013, p. 328). The material costs are included here.

2.1.1.1.2 H.3.1.2 Offshore Bungalows

In Belize similar overwater bungalows are built including glass bottom floors, a spacious overwater sundeck, an overwater hammock and a private plunge pool over the water. This bungalow consists of 3 bedrooms and 2 bathrooms and the price with pre-construction is €281,818,- for glass bottom floors throughout the floorplan, spacious overwater sundeck/veranda, overwater hammock and private plunge pool right over the water (Belize Investor, 2015). Based on the Belize example assumptions are made in order to calculate the total cost of the offshore bungalow complex. The 1-bedroom bungalows are assumed to cost

€90,909,-, 2-bedroom bungalows €136,363,-, the restaurant/bar €454,545 and the onshore lobby €227,272,-.

H.3.1.3 Coral Restoration

In the initial phase an area with a length of four kilometres and 50 metres width will be planted and one kilometres of existing coral strengthened. Therefore, an area of 200000 m2 will be redeveloped and existing coral area of 50000 will be strengthened. To compare, in Kuta were the cost for transportation and restoration of coral were around 10$/m2. Kuta is a comparable site to Candidasa as an old mined coral reef with similar or worse environmental conditions. (JICA, 2013) Therefore the estimated initial costs for the coral reef in candidasa are roughly estimated on 2,0 mln for plantation and 0,5 mln for restoration. This, in comparison with the price of building breakwaters, which on average the costs are 15 times more than coral restoration projects (Ferrario, Beck, & Storlazzi, 2014).

The cost to construct Biorock is estimated €0.9-2.7 per m2. (Maynard, 2000) [hh29] However, these do not include licensing, consulting fees, labour, maintenance and power supply. Therefore three reference sources are used to estimate the real costs of implementing Bio rock installations. To be secure, choose the most reliable and as Thailand is the most comparable to Indonesia the costs of 160 euro/m2 are used. A total of four kilometres and five meters wide gives a cost of 3,2 mln.

Reference:

Koh tao Thailand.	160 euro/m2 for 160 m2 (Scott & Co., 2012).
Various locations USA	129 dollar / m2 (Ferrario, Beck, & Storlazzi, 2014).
General Biorock 2005)	100 dollar / m2 for 5000 m2, 2 meter high (Goreau & Hilbertz,

H.3.2 Schedule

Phases Coral Restoration

The structures have different implementation and lifetimes. Therefore the effective times of the structures are aligned to ensure optimal coastal protection at all times. Three phases are defined to understand the importance of the time planning. In phase 1 the structures are planted and the coast will be preserved by temporary initial structures implementing Biorock foundation. Phase 2 the limestone and coral on the Biorock is almost fully-grown and the coral nursery is midway development. In phase 3, limestone and coral covers all structures and a limestone crest with hind lying coral reef is situated, which is properly grown to support coastal preservation.

H.3.3 Phasing

In the first option, phase 1 consists of all demolition and construction works apart from the construction of the offshore bungalows and placement of the energy harvesting buoy. The second option uses the two project areas as a base for phasing. All structures in area 1 are constructed in phase 1 and structures in area 2 are constructed in phase 2. The phasing options are with €52.5 million and €48.3 million respectively 7,9% and 15,4% cheaper than executing the project without applying phases.

H.3.4 Labour cost estimation

A Deloitte assessment on major infrastructure projects has shown that labour costs (in Australia) for these projects typically range between 19-36% (Deloitte, 2014). Because wages in Indonesia are relatively low compared to Australia, a labour costs estimation of 20% is made.

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