BUILDING WITH NATURE FOR COASTAL PROTECTION: A CASE STUDY OF VINH CHAU TOWN IN SOC TRANG PROVINCE, THE MEKONG DELTA, VIETNAM

Valentin Janosch[1], Tran Van Ty[2], Liliane Geerling[1] and Hong Van Non[3]

Abstract: *In recent decades, unsustainable use of resources and the implementation of dams upstream accompanied with sea level rise acceleration has led to an extreme mangrove depletion, increase of coastal vulnerability in the Mekong delta. Extensive shrimp culture, where mangrove forest have been turned into aquaculture ponds are adding to the problem. The aim was to assess the current situation and find solutions which go in hand with the Building with Nature (BwN) concept for two selected locations along the Vinh Chau coast. Study location A is in an area where little mangroves have been left with highly used hinterland; and study location B where the sediment morphology changed from muddy to sandy soil. The Multi-criteria analysis (MCA) has been established to highlight the various benefits the BwN approach has. The results reveal that for both locations with different dilemmas, and the BwN approach would be able to solve the problems. It is recommended that the implementation of permeable fences for study area A and a coastal buffer zone for study location B would be the most suitable in terms of sustainability, costs and long-term safety.*

Keywords: Building with Nature (*BwN*) concept, Vinh Chau coastal area, mangrove, erosion and sediment, Multi-criteria analysis (*MCA*)

1. INTRODUCTION

The Mekong Delta (MD) is located in the South-Western part of Vietnam also known as "Nine Dragon delta", as nine estuaries intersected the 600km of coastline. With its 20 million inhabitants within 12 provinces, the delta plays an important factor on the country's economy. Often referred to as the "rice-bowl" of Vietnam, the MD produces 50% of the total rice cultivation of the whole country (Vriend, 2009). In the last decades, many rice farmers have moved to aquaculture particular to shrimp farming in order to generate higher profits. Rice plots which are used in the wet season for rice production are then transformed in the dry season to shrimp ponds. Additionally mangrove forests located in coastal zones, acting as a natural buffer have been cut down and converted to shrimp ponds as well. This rapid expansion has increased the economic growth of the whole delta and reduced poverty, but has been accompanied with severe environmental problems affecting both nature and people in the MD.

Previously the delta hinterland has been protected by a mangrove belt stretching along the coast acting as a natural buffer zone between sea and land. Mangroves inundate waves, trap sediments, guard the coast from severe storms and stop salt water intrusion. The depletion of mangroves is mainly due to inadequate and unsustainable management and has led to a mangrove lost up to 50% compared to the year 1980 (Linh *et al.*, 2015). Besides that, the

[1] *HZ University of Applied Science, the Netherlands*
[2] *College if Engineering Technology, Can Tho University, Vietnam*
[3] *Department of Agriculture and Rural Development, Soc Trang province, Vietnam*
Corresponding author: tvty@ctu.edu.vn

construction of dams in upstream countries like Laos PDR and China has limited the sediment flow in the Mekong adding to the erosion rate and limiting the water flow. Additionally, the MD is one of the most affected regions in the world by climate change and as a low lying country particularly prone to flooding. According to IPCC (2013), nearly half of the MD could be flooded by 2050, endangering people and livelihood. Recently the coastal protection system consisted of a sea dyke and foreshores (mudflats, mangroves…); however, due to erosion of the mangrove forest, the dyke became endangered and allowed wave overtopping at some locations. To secure the area behind the dyke, the natural protection barrier can be strengthened in form of mangrove rehabilitation while another possibility is dyke revetment. By heightening the dyke with concrete units or slabs, the dyke will be strengthened against erosion by wave action. Dyke revetment is not only cost and labour intensive, but it also proved not being sufficient enough against the incoming waves, as some parts of the MD coast experienced already failure and dyke breaching. As climate change related storms are increasing the chances of flooding are rising as well, which is endangering the livelihood of local people. For that reason, a sustainable long-term coastal protection system is necessary and by using the *Building with Nature (BwN)* approach which focuses on bringing back the natural mangrove belt, the coast can be secured. BwN will increase the biodiversity, engage local stakeholders in the development and protect the area in the long-term.

Therefore the main research objective is to analyze the current status of the coast, focusing on critical locations and on the basis of those findings to find a sustainable coastal protection system, using the *BwN* concept. *BwN* is able to enhance the overall resilience of the provinces while providing economic and social benefits for its inhabitants. In Soc trang province, the complications along the coast are very diverse as well as the land use behind the dyke. For this reason, two different locations (A and B) with contrasting problems in the town of Vinh Chau, Soc Trang province were selected, serving as case study for the implementation of *BwN* concept (Figure 1). By looking at two different study areas it becomes clear how diverse the MD coast is and that for implementations each area has to be analyzed accordingly to provide the best possible solution. Location (A) is characterized by muddy sediments and a highly used hinterland and endangered livelihood, where the approach of re-establishing the mangrove forest seaward will be the most preferable one. Study area (B), with a changed sediment morphology dominated by sandy soil and a hinterland where an existing mangrove forest is still in place but the existing seaward dyke has been destroyed numerous times in the last years. Over the course of the research, the current situation has been assessed and different aspects are taken into account, as well as the implementation of pilot projects. The solution should also empower and include the local people in the processes and strengthen the overall resilience of the MD. The results might provide insight in the topic of coastal protection and highlight the difficulties and the diversity the MD is facing in the future.

2. METHODOLOGY

This research is divided into two main activities: firstly, the current situation of the coastal area had to be assessed by means of literature research, interviews and an on-site visit to the selected project area. After assessing the current situation, two specific project sites which differ in their preconditions have been selected and applicable *BwN* strategies were chosen (Figure 1).

Literature research was carried out by already existing reports, articles and documents including German Development Organizations (GIZ) reports and annual reports from Department of Agriculture and Rural Development (DARD) in Soc Trang province to get a general overview of the MD and the

problems it is facing. Afterwards, interviews with organizations like GIZ and DARD (Soc Trang province) were executed to get an insight into pilot projects and the general status of the coast.

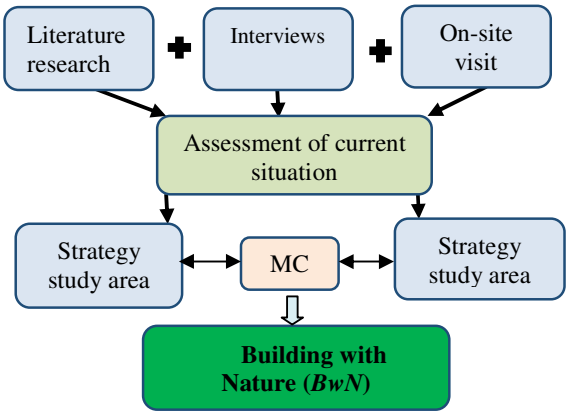


Figure 1. Overview of the methodological framework

The main focus point of ***the interviews*** were to investigate the most critical locations of the coast and to understand what prevention measurements have been implemented successfully and where it failed. Experts from GIZ which were involved in pilot projects gave insight into the successfulness of permeable bamboo fences.

Lastly an ***on-site visit*** to a coastal area was done to get a visual impression on the status of the dyke and the general situation on the mangrove forest (Figure 2 and 3). The on- site visit was also used to generate images of the area which are supporting the chosen strategy. On the basis of the assessment of the current situation, two *BwN* strategies were developed showing a possible plan of action for land use and area protection.

BwN approach: The goal of the research was to find sustainable coastal protection system which focuses on strengthening ecosystems and increasing the socio-economic value of the area while preparing for future climate impacts. The *BwN* concept is able to tackle this issues in a responsible way. *BwN* means instead of working against nature, rather including nature in the designs and processes and show that it is possible to create opportunities for nature and where possible, utilize natural processes while developing infrastructure (Vriend, 2009). Designs should serve more than just one purpose, adapting to cope with changing conditions, in the case of the MD to cope with future sea level rise and more extreme storm events.

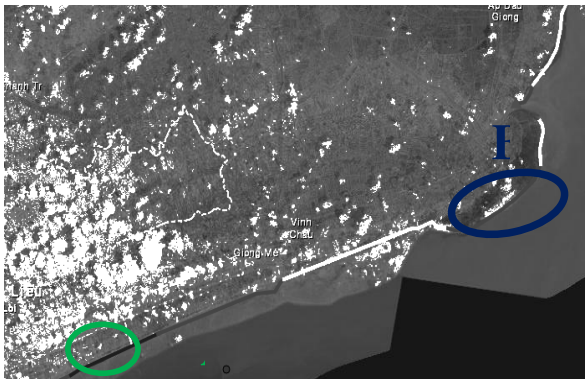


Figure 2. Locations of study area A and B (Source: Coastal protection web-map, 2017)

Figure 3: Aerial view of location A, depleted mangroves and aquaculture and agricultural used hinterland (Source: Coastal protection web-map, 2017)

2.1. Current situation location A

Located on the border to Bac Lieu province, study area A stretches out 5,400m, whereby 1,500m are defined as critical hotspots. "Hotspots" are areas the floodplains only consist of one row of mangroves or have disappeared completely (Schmitt, 2014). The hinterland of the area is highly usedwith aquaculture (shrimp farms) and agricultural land (rice farming), making it economically valuable.

Flooding's in this area are severely threatening the livelihood of local people making this area especially vulnerable to storms. The study area is characterized with only a narrow mangrove belt and serious erosion patterns, most of the mangrove degradation is due to an unsustainable land use and the deforestation of the trees to make rooms for shrimp farms (Berg, 2001). The sediment morphology is identified as muddy, making it suitable for mangrove rehabilitation. Areas where mangrove have been totally degraded, gabion revetments have been constructed, which need to be renewed every two years and are not sustainable and rather expensive.

2.2. Current situation location B

Study area B located at the eastern part of Vinh Chau has a length of 6,000m, where 1,000m are extremely vulnerable (Schmitt, 2014). In those endangered parts a dyke has been constructed (Figure 4), which has failed numerous times in the last years. The dyke consisted of revetments, making it expensive and time consuming to construct. A change in sediment morphology from muddy to sandy soil caused by building of dams upstream, has led to a high mangrove dieback on the seaward side of the dyke and a longshore drift has decreased the sediment balance (Groenewold, 2017). The sediment and erosion patterns of sandy material on this location change at different temporal and spatial scales which are hard to predict for the future. Behind the sea dyke, a wide mangrove forest is still in place ranging from a width of 200m up to 600m (GIZ, 2017). In general, the hinterland is not as much used as in location B, only a few aqua- and agricultural farms are located close to the sea. In recent years, approximately 200 houses have been built 500m from the seaside where mostly Khmer people were settled.

Figure 4: Failed dyke profile location B (Source: Own archive, 2017)

In *BwN* projects, stakeholders are important because *BwN* affects the physical environment as well as social sectors on different scales. They are usually complex implementations where a multitude of interests and actors are influenced. For this reason, a stakeholder analysis is made starting with identifying the stakeholders, afterwards assessing them followed but prioritizing them and finally determining their positions to *BwN*.

2.3. Multi-criteria analysis

Multi-criteria analysis (MCA) has been established to highlight the various benefits a *BwN* approach has. Implementing coastal protection projects where ecosystems are part of the design, not only the costs should be considered but other aspects might be from the same importance. Therefore focusing on financial, social and ecological impacts should be indicated as well.

In the MCA, the traditional approach by means of dyke heightening was compared to *the BwN* concept. MCA explicitly evaluates multiple conflicting criteria in decision making processes and includes the benefits that local communities can obtain from the implementation. The MCA was divided into different criteria (costs, maintenance, reliability, constructability, construction time, longevity, ecological value, stakeholder involvement and social benefits). Those criteria were given a weight of importance ranging from 1 to 10: weight "1" means the least important aspect while weight "10" scores the most important

criteria in a development. Each criteria has given a rating ranging from "-2" to "+2": negative value "-2" means not preferable to implement while possitive value "+2" means that the most preferred criteria is for the chosen approach. The rating will be then multiplied with the above mentioned weight and the sum of all criteria can show the possible successfulness of the chosen approach.

3. RESULTS AND DISCUSSION

This research is focusing on achieving coastal protection measurements with the *BwN* concept on two diverse locations, after assessing the current situation it became clear that for study area A, a mangrove rehabilitation seawards would be the most sustainable solution in terms of future sea level rise and ecological resilience. For study area B, the most logical long-term solution would be to give up some land behind the dyke and transform it into a *buffer zone* as the land use is not as high as in area A.

3.1. Outcome- study area A

Study area A is typified by a still existing mangrove belt, although very narrow in nature and in some parts totally depleted. However, the boundary conditions like soil morphology and slope steepness speak for strengthening the ecosystem engineers and try to regrow the natural barrier. The goal for the future is to establish at least a 200m wide and closed mangrove belt which would inundate incoming waves and stop erosion. To help regrow the mangrove trees more sediment needs to be kept in place for trees to grow, this could be achieved with the help of permeable fences, also to protect the seedlings until they are strong enough. The first line of permeable melaleuca fences should be installed 100m from the tree line seawards, after approximately 2 years when the trees are strong enough a second line can be installed to increase the mangrove belt up to 200m. According to GIZ(2017) experiments in water laboratories, the wave height will be reduced by 70% with the implementation of permeable dams and enough sediment will be trapped for mangroves to grow.

Another important aspect is the planting of different mangrove species, bringing diversity and stability to the area. Mixed-species clusters, where one Rhizophora tree is surrounded by four Avicennia trees (Figure 5) will bring extra benefits. Avicennia is able to trap more sediments, where in return Rhizophore has a higher pH value and higher content of sulphur, nitrogen, phosphorus and carbon.

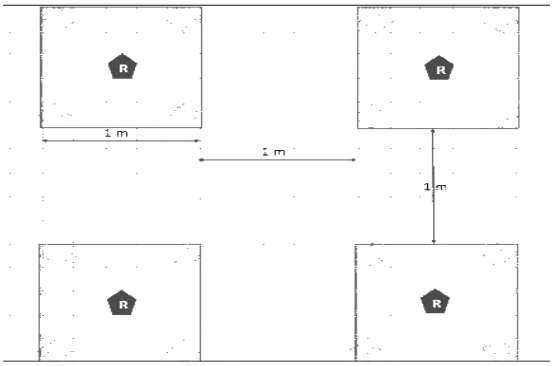


Figure 5: Mixed species cluster (Linh et al., 2015)

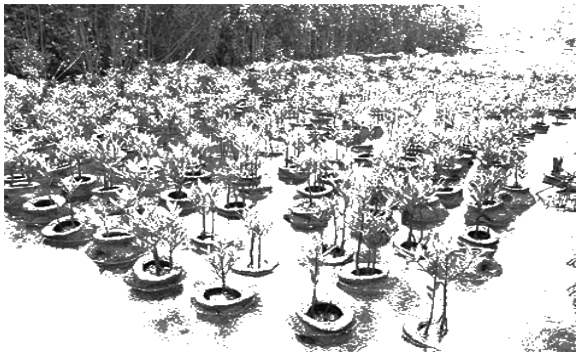


Figure 6: Reef balls with the purpose of mangrove pots, protecting seedlings from wave and storm impact (Reefball.com, 2016)

3.2. Hotspots area A

As mentioned in the assessment of the current situation, several “hotspots” where the mangrove belt is totally eroded and the dyke is endangered immediate action is required. Instead of strengthening the dyke first and then start re-growing the mangrove belt, a hybrid construction could be implemented which combines natural processes with engineering

techniques. The installation of reef balls could be a possibility, as they are partly submerged structures which are dissipating incoming waves while functioning as sediment traps where mangrove can be placed inside them (Figure 6)

The advantage a reef ball has to dyke revetment is the extra ecological value, it provides a habitat for fish, crabs and other animals as well as it can be part of the mangrove foundation. Once the mangrove roots are strong enough they can overgrow the reef balls as they are made of ecofriendly concrete giving extra nutrition to the trees. Reef balls could be placed in front of the "hotspots" and are easy to vary in size and number (Figure 7).

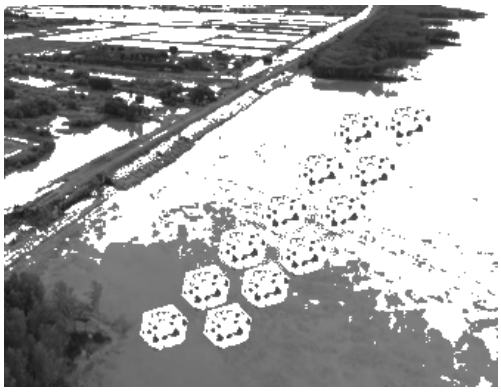
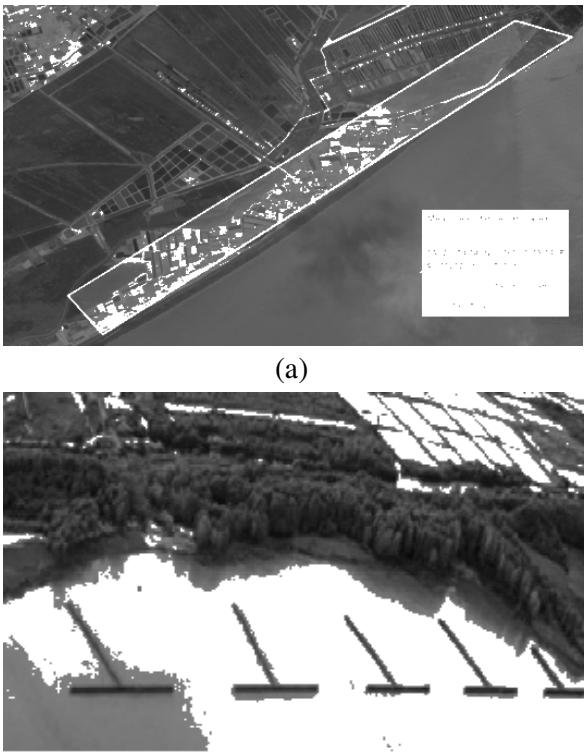


Figure 7. Reef balls in front of the "hotspots" (own design, 2017)

3.3. Outcome – study area B

Study area B differs in terms of soil condition, slope steepness and the land use of the hinterland from study area A, therefore a different *BwN* approach is needed. As discussed earlier, the soil changed to sandy soil due to building of dams upstream making it impossible at the moment to regrow the lost mangroves. Also the land in front of the dyke is too step and to sandy to install t-fences, additionally the wave impact would be too high to withstand those forces. In the past years constructed concrete dyke at location B failed numerous times due to wave impact and storms. The hinterland behind the sea dyke is not as used as in location A, in several parts there is still mangrove coverage of several hundred meters left. In terms of adapting for the future and limiting heavy investments a zoning strategy in form of a *coastal buffer zone* would be the most reasonable solution (Figure 8).



(a)

(b)

Figure 8. (a) Coastal buffer zone for study area B (own archive,2017) and (b) installed t-fences, pilot project Bac Lieu (Albers Schmitt, 2012)

Giving up some of the farmland and transforming it into a *buffer zone*, the area will predominantly become a salt/brackish zone between the existing sea dyke and the second dyke located more land inwards. The buffer zone can still partly be used for growing shrimps using a mixed cluster approach (Figure 10), mangrove areas where in between small ponds for shrimp culture are situated. The proposed buffer zone would stretch out to 130 ha, the width of the zone should be around 400m while covering a length of 4-5km (Figure 8). The existing and partly eroded dyke could be reinforced with simple measures such as sandbags as it is allowed for wave overtopping.

Sandbags can be placed on top of the dyke and in front of it to stabilize it as can be seen in (Figure 9).

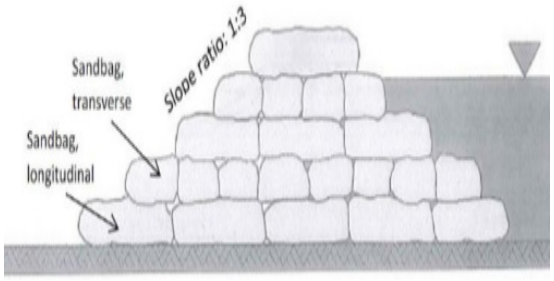


Figure 9. Dyke stabilization with sandbags (*Coastalweb, 2017*)

The sandbags could be filled and maintained but local farmers, recently 200 new houses for mainly Khmer people have been constructed. Their purpose is to take care of the area and with some monetary compensation and providing education for their children a win-win situation could be achieved. The local farmers could be trained to fill the sandbags and place them on the endangered dyke sections and with the help of students the threatened sections could be assessed. In theBwN concept focus lays on involving all actors in the processes who have a stake in the development, therefore including local people in the processes and developments is from great importance. In the processes, it is important to mobilize actors, give room to maneuver and create commitment, support and consensus for different actors to reach an integrated approach.

3.4. Multi-criteria analysis

In *BwN* projects where ecosystems are part of the solutions a simple budget analysis would not represent all the benefits an implementation has on an area, therefore a multi-criteria analysis is conducted where economical, ecological and social benefits are listed and compared to each other. A comparison of a traditional approach which means strengthening of concrete dyke and the *BwN* design in form of mangrove rehabilitation with permeable melaleuca fences for study area A and a coastal zoning strategy for area B with buffer zone has been made. For projects aiming at long-term solutions the *BwN* concept scored more than the traditional approach, the easy implementation, overall stakeholder involvement and cost reduction speaks for using the ecosystem engineering approach.

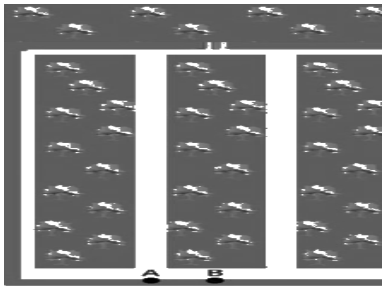


Figure 10. Mixed cluster mangrove/shrimps (Schmitt et al., 2013)

Results of MCA can be found in Table 1. It can clearly be seen that hard and expensive structures have a lower score (-30) than the *BwN* approach (+45), this score is reached by putting a weight on the criteria and comparing between traditional and BwN concept. *BwN* is scoring higher mainly due to the inclusion of non-monetary benefits on the proposed area and on the local people like stakeholder involvement and constructability, while the traditional approach is losing points in costs, construction time and social benefits.

When applying the *BwN* approach in Vinh Chau town, it will strengthen the natural system instead of interfering with it. This approach also brings the strength of including local people and other experts into the processes and to gain extra insight knowledge in the dynamics of the delta. Extra benefits obtained from the ecosystem engineers which the local community can use are also a plus point for this concept. Difficulties the *BwN* approach can bring is the willingness to co-operate as it is the foundation of successful *BwN* projects. If not all stakeholders are assessed properly and handled in the right way, it can impact the whole project. Therefore, the weakness of possible failure due to stakeholder engagement can be minimalized by putting more effort into actor involvement right from the beginning of the planning process.

Table 1: Results of Multi-criteria analysis

Criteria	Weight (1-10)	Traditional approach	*BwN*-location A
Costs	9	--	+
Maintenance	5	+	-
Reliability	6	+	+
Constructability	8	-	++
Construction time	3	--	+
Longevity	7	++	0
Ecological value	6	-	+
Stakeholder involvement	5	-	++
Social benefits	6	--	+
Total score		-30	–45

Rating	Points
++	2
+	1
0	0
-	-1
--	-2

4. CONCLUSIONS

The current coastal protection system for Soc Trang province in particular Vinh Chau town is highly unsustainable, the biggest problem is the depletion of the natural mangrove barrier previously protecting the hinterland. The biggest reason for this is the transformation from natural forest areas to shrimp farms and the deforestation of wood for energy production. The MD lost up to 50% of their mangrove forests compared to the 1960s resulting in ecological and socio-economic problems. Adding to this is the problem of climate change and especially sea level rise, flooding's are increasing, wave attacks are getting stronger while the land is subsiding and salt intrusion is also decreasing the land value. With the building of dams in upstream countries like Laos PDR and China the sediment flow into the MD was limited as well bringing more pressure onto the ecosystems. The concept of *BwN* means to work with ecosystems and use their elements and forces to create opportunities for humans and nature.

Therefore the main objective of this research was to find out how BwN can add to a coastal protection system which focuses on long-term solutions rather than "quick fixes".Soc Trang province was chosen as a research place as it is located in the heart of the MD and has a unlike coastline with different problems. To highlight those diverse problems two study locations were selected with different boundary conditions where the *BwN* approach can be applied. The overall goal was to enhance the mangrove forest bringing back the natural coastal protection.

For study area A this is best with the help of permeable t-fences and reef balls to trap sediments and protect the mangrove seedlings from waves and storms. By doing this the natural ecosystem will be restored having benefits for nature and local population in this area as well as tackling water quality problems and enhancing the biodiversity. Including local people in the process and implementation is key in *BwN* approaches decreasing budget and maintenance costs.

Study area B is characterized by the change in sediment morphology and slope steepness, therefore the best long-term option is to transform some land behind the dyke into a *buffer zone.* Accompanied with land use changes into a mixed cluster approach, the local people in this area should be trained into stabilizing the dyke with sandbags receiving monetary or educational compensation. This approach will enhance the biodiversity of the area and limiting the vulnerability of the area.

Building with Nature would therefore only work if all involved actors come to an agreement and a successful stakeholder participation process is established. Therefore the following conclusions have been drafted:

- *BwN* is possible when all actors work together, including the governmental institutions, local people, shrimp and rice industry and research institutes;
- The MD is highly diverse therefore for each coastal segment an individual approach has to be formulated while fitting within the national policy;
- Ecosystem engineers (mangroves) should be strengthened in order for long-term safety and resilience of the MD.

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Tóm Tắt:

XÂY DỰNG VỚI THIÊN NHIÊN BẢO VỆ VÙNG BỜ BIỂN:

TRƯỜNG HỢP NGHIÊN CỨU TẠI THỊ XÃ VĨNH CHÂU

TỈNH SÓC TRĂNG, ĐỒNG BẰNG SÔNG CỬU LONG, VIỆT NAM

Trong những thập kỷ gần đây, việc sử dụng tài nguyên không bền vững và xây đập ở thượng nguồn cùng với nước biển dâng đã dẫn đến tình trạng cạn kiệt rừng ngập mặn, tăng tính dễ tổn thương tại các vùng ven biển Đồng bằng sông Cửu Long. Nuôi tôm công nghiệp đã biến rừng ngập mặn thành ao nuôi đang làm trọng trọng thêm vấn đề. Mục tiêu của nghiên cứu là đánh giá hiện trạng và tìm ra các giải pháp gắn với khái niệm Xây dựng với Thiên nhiên (BwN) cho hai vị trí dọc theo bờ biển Vĩnh Châu. Vị trí A nằm trong khu vực có ít rừng ngập mặn còn lại để bảo vệ vùng đất liền; và vị trí B nơi có hình thái trầm tích thay đổi từ đất bùn sang đất cát. Một phân tích đa mục tiêu đã được thiết lập để làm nổi bật các lợi ích khác nhau của phương pháp tiếp cận BwN. Kết quả cho thấy rằng cả hai vị trí có những quan điểm khác nhau, và cách tiếp cận BwN có thể giải quyết được vấn đề. Nghiên cứu đề xuất lập các hàng rào bẫy cát cho vị trí A và vùng đệm ven biển cho vị trí B là thích hợp nhất về tính bền vững, chi phí và an toàn lâu dài.

Từ khoá: Xây dựng với thiên nhiên (BwN), vùng ven biển Vĩnh Châu, rừng ngập mặn, xói mòn và trầm tích, Phân tích đa mục tiêu (MCA)

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