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THE RESILIENCE AND ADAPTATION FOR THE DISASTER MITIGATION WITH SPECIAL REFERENCE TO COASTAL DEFENSIVE MEASURES USED IN SRI LANKA

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Abstract: The resilience and adaptation for the disasters caused by climate change is the most emerging trend and the need of this century. Most of the countries including Sri Lanka, the mitigative strategies used are mostly sole implementations of engineering and nature-based, with a greater gap in-between. For the fulfilment of this gap, the role of Landscape architect is vital in the planning and design stages, from micro to macro levels in development projects. This research is concentrated on the coastal resilience and adaptation as the vulnerability for the coastal disasters is high in Sri Lanka as a tropical island. Here the effectiveness, resilience and adoptive abilities are discussed about the mitigative measures used so far in the local coastline. The methodologies used are the map analysis, photographic survey, re-synthesis of the previous research outcomes and timely evolution studies to analyse the effectiveness. The usage of integrated methods in disaster mitigation is the next lap of development in Sri Lanka. To use an integrated system of defensive measures, there should be common factor to be taken into consideration. The research is an attempt of revealing a common factor as such by investigating coastal defences, in order to apply in the integrated measures applications as post described. The usage of Landscape architectural solutions which are a hybrid of measures is a basic necessity in the development process, which is the sustainable no-regret strategy for the resilience and adaptation for the disaster mitigation.

Keywords: Disaster mitigation, integrated strategies, landscape architectural solutions, resilience and adaptation, sustainable development;

1. Introduction

1.1. Background

Climate change which is the ultimate outcome of global warming is now universally recognized as the fundamental human development challenge of the 21st century. It is a certainty that the present and future generations have to live under the threat of climate change. All nations are affected by the impacts of climate change. However, developing countries are particularly vulnerable, as they lack the necessary adaptive capacity (The national climate change policy of Sri Lanka).The vulnerability to disasters caused by climate change is comparatively high for a tropical country like Sri Lanka. As a third world country, general focus has not put on this big issue in Sri Lanka yet. Although the general focus is not on it yet, the climate change is happening for real. And there are great potentials to develop in our country to be adoptive and resilient to Disaster reduction by climate change. Being a developing island nation which is subjected to tropical climate patterns, Sri Lanka is highly vulnerable to climate change impacts especially on the coastline. Any adverse changes in already volatile weather patterns are likely impact adversely on the socio-economic activities in the country. Therefore, urgent action is necessary to take adaptive measures to build resilience of the country to face the adverse impacts of climate change (The national climate change policy of Sri Lanka).The UN Framework Convention on Climate Change adopted the Cancun Adaptation Framework (CAF). It particularly aims to reduce vulnerability and build resilience in developing countries, taking into account the urgent needs of those that are particularly vulnerable. In addition, local, state and national governments are developing a range of adaptation plans, some address only immediate needs, others lay out a longer-term "climate resilient" development trajectory, but all seek to reduce the vulnerability of people, places and resources. In coastal areas, the focus has been on coastal protection, to mitigate and adapt to sea level rise and coastal hazards (present and future). To date, efforts at coastal protection have relied heavily on 'hard' measures, especially for developed coastal areas with substantial assets facing increased risk. While such approaches can be important and highly effective they can also be costly both to build and to maintain. Hard structures can also fail, and there are many examples of such structures exacerbating problems of coastal erosion or damage in adjacent areas. Increasingly, however, there is recognition that healthy coastal ecosystems play an important role in coastal protection, and in reducing the vulnerability of coastal communities to climate change and coastal hazards. This has led to growing calls for the incorporation of such ecosystems into coastal adaptation planning (Spalding, 2014).Till now many Environmental based institutions and technology based institutions have done researches on the; the performance of coastal ecosystems for hazard mitigation, bio-shields, Eco-DRR and EbA measures, the role of ecosystems in disaster reduction, water resource management for disaster risk reduction, sustainable land management for disaster risk reduction, policy planning and future perspectives, etc. Ecosystem based adaptation (EbA) and Ecosystem based Disaster Risk Reduction (EcoDRR) measures which have been identified so far are used in the resilience and adaptation in means of disaster risk reduction and reducing vulnerability, are more relate to landscape architectural approaches. What have not been taken into consideration yet are the hybrid solutions which are composed of nature-based and technology which can be integrated and can be interpreted successfully as landscape components in giving Landscape Architectural solutions for the disaster mitigation. Mass investments have often transformed coastal areas into urban environments; largely stagnant establishments in comparison to the dynamic nature of coasts. In order to manage any environmental system, an understanding of the processes involved in the system is crucial. Limited understanding particularly in coastal evolution has meant management has been highly reactive and not appreciative of the natural timescales of coastal change. Therefore, the nature responsiveness is more important in the disaster mitigation approaches with relevant to the natural processes. Effect will require action decades before the impacts occur, because of time lags in natural processes. To ensure an effective and timely response, scientists, engineering and policy makers must join forces to consider the consequences for today's activities (Wind, 1986). While the scientific community continues to address knowledge gaps relate to climate change and weather extremes, scientists have also highlighted current drivers of risk, namely human created exposure and vulnerability owing to poor land-use planning, poverty, urbanization and ecosystem degradation (IPCC,2012), (UNISDR,2011a). The research objective is to search on Landscape architectural solutions, which almost of the above said hybrids are included, to be used in response for the resilience and adaptation for the disasters; coastal erosion and flooding caused by climate change. By doing this research, it exposes a new avenue to rethink and treat the climate change issues in a hybrid mode, and contribute to fill the gap in between the technological and nature-based measures implementations, which will be a sustainable and effective way to increase the resilience in the human and natural systems with special reference to coastal defences.

1.2 Disaster risk reduction via resilient and adoptive approaches (Eco DRR and EbA, etc.) and 'no-regret strategy'

All interlinked with challenges of development. Given the current global economic downturn and shrinking financial resources, the importance of pursuing integrated, "win-win" solutions to disaster reduction and sustainable development is more critical than ever. (Renaud, Estrella, & Sudmeier-Rieux, 2013)

1.3 The coast

1.3.1 Human and coasts

About 44% of the world's population lives within 150km of the coastline of the entire globe. A larger density of the world's population is concentrated in these coastal regions and most of the world's cities are almost grown along the coastal regions to inlands. Coastal zone is used by human for fishing, transportation, recreation, waste disposal and many other uses. Rather than that the coast is used for the tourism purposes also settlements are congested along the coastline.

1.3.3 Coast and the coastal processes;

Coast is the boundary which is the interactional dynamic barrier between the land and the sea. Key influences upon plan form shape and evolution are the underlying geology and coastal forcing. Large scale shoreline evolution may be broadly considered in terms of those areas that are unlikely to alter significantly and those areas that are susceptible to change. Some shoreline may have reached their equilibrium plan form in response to prevailing conditions, whilst others have not and continue to change. 'Coastal zone occur at the interference between the three major natural systems at the earth's surface-atmosphere, ocean and land surface. Processes operating in all three of these systems are responsible for shaping the coastal zone, and the interaction between the three different sets of processes makes the coastal zone an extremely dynamic one. The coastal zone is also a zone of transfer of material from the land surface to the ocean system, being moved to the beach and near shore, and ultimately some to the ocean floor. In some areas accumulation of sediments may add to the land mass.' (Davidson-Arnott, 2010). Coastal landforms are created by a wide variety of coastal processes, which vary depending on the process, the wave climate, beach morphology, geology, and human activity. This results in the two umbrella processes of **erosion** and **accretion**. Both processes cover a number of sub-processes, some of which cause both erosion and accretion. Two types of coastal features are **Erosional landforms** and **Depositional landforms**. Erosional and depositional landforms of coastal areas are the result of the action of ocean waves.

In the implementation of coastal defensive measures either sole implementations or integrated measures, the understanding in the basics of coastal profile and the processes is a must in the successfulness. So the basic parameters influence the coastal environments are stated below.

- Wind climate
- Wave climate
- Currents
- Water levels
- Joint probabilities of the above

Challenges for the coastal structures resulted by coastal processes are; long shore drift, abrasion, attribution, corrosion / solution, hydraulic pressure, weathering, bio-erosion and scour.

Processes that lead to transformation of waves as they propagate into shallow water include; shoaling, refraction, diffraction, dissipation due to bottom friction, dissipation due to percolation (into the bed), breaking, additional growth due to wind and other wind effects, wave current interaction , wave-wave interaction and run-up. However the southwest, west and northwest coasts are not verymuch affected by the long length waves with high energy in Sri Lanka.

1.3.5 Coastal disasters caused by climate change

There are two types of hazards arousing from natural phenomenon and human activities.

- Episordic hazards
- Chronic hazards

(Hettiarachchi, et al., 2013)

Vulnerability of the coastline to disasters caused by climate change deviates as per the different factors. When considered in global level, 'the land area influenced by a sea level rise is in order of five million square kilometres: about 3% of the total land area. According to future scenarios, oceans are on track to rise 2 to 3 feet (0.6 to 0.9 meters) by 2100. If climate change continues unabated, nearly all coral reef habitats could be devastated. Under the best-case scenario, half of all tropical coral reefs are still threatened. (sciencealert, 2016)

The impacts of sea level rise have a direct relevance to coastal lowlands, that are of immediate,

-loss of land by inundation of river deltas or by erosion or flooding of coastal areas.

-increased storm damage to dikes, dams, coastal structures; changes in morphology and ecology.

-increased saltwater intrusion into rivers and saline seepage.

1.3.6 Vulnerability of coasts in Sri Lanka

Sea level variations in Sri Lanka feature both tidal and non-tidal fluctuations super imposed on relatively large seasonal oscillations. Of Sri Lanka's 1400km of coastline, 60% is subjected to erosion (The National Atlas Of Sri Lanka) and vulnerable highly with the fast increase in the human population and infrastructure.

1.4 Defensive measures and strategies against coastal disasters

There are many measures that could be adopted to manage risk in coastal zone management when planning for coastal disasters and hazards that accompany high waves and heavy inundation and extreme impacts. These measures can be broadly classified into three categories, namely,

- Measures that mitigate the impact of hazard
- Measures that mitigate the exposure and vulnerability to the hazard
- Measures that improve preparedness and response

(Hettiarachchi, Tsunami risk assessment and management, 2014)

For the convienience of the study, almost all of the measures have been catergorized into two types, considering their formation either naturally or artificially.

1. Nature-based measures-naturally
2. Engineering measures-artificially

1.4.1 Nature-based defensive measures;

Natural defences play a vital role in mitigating the impact of coastal hazards, in coastal protection and conservation. Coastal ecosystems like mangroves, tidal marshes, and sea-grass beds provide protection from these events while improving local fisheries. These ecosystems store up to 10 times more carbon called "blue carbon" per hectare than terrestrial forests, and degradation of these ecosystems accounts for up to 19% of carbon emissions from global deforestation (CI, 2016). Natural features are created through the action of physical, biological, geologic, and chemical processes operating in nature, whereas nature-based features are created by human design, engineering, and construction (Bridges, et al., 2013). Natural and nature-based features can enhance the resilience of coastal areas challenged. Though the applications of disaster risk reduction have saved millions of lives, the ecosystems on which communities depend upon until now been largely ignored. Nature based defensive measures involves the use of natural processes of agents to protect or stabilize the coast such as,

- Planting of vegetation
- Beach nourishment
- Encouraging growth of coral reefs
- Planting Vegetation.

1.4.2 Engineering defensive measures;

The coastline has been 'engineered' for many centuries, initially for the development of ports and maritime trade or fishing harbours to support local communities. Coastal defensive structures are used to prevent shoreline erosion and flooding of the hinterland, to shelter harbor basins and harbor entrances against waves, to stabilize of nevigation channels at inlets, to protect of water intakes and outfalls and to retain or rebuild natural sytems or protect mans artifacts landward of the shoreline.They should retain with the facts, stability, safety, serviceability and economy (Yalciner, 2008).

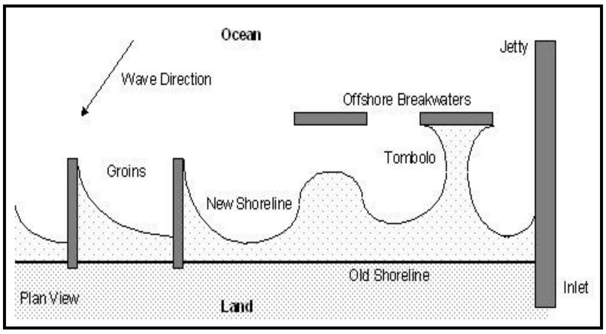

Fig 01. Shoreline protective structures (Yalciner, 2008)

The coastal structures used in Sri Lanka are in the basic level. Not advanced in the used technology. The materials used in the hard structures are the mostly available one to one implemented materials obtained from the resources itself like quarry stones. In the point of high absorption of wave energy with their irregular surfaces, it is a good material to use. Strategic materials like, recycled special materials, are not ever used. The oldest project done on hard structures is along the Negombo beach stripe which taken into consideration in the study.

1.5 Role of ecosystems in Disaster mitigation;

Incorporating ecosystems into disaster risk reduction can save lives, aid recovery and help build a more secure planet for all. It is an essentiality for policy makers, scientists, economists, sociologists and practitioners to have a vast knowledge in why and how to integrate ecosystems into disaster mitigation. Scientific studies have repeatedly confirmed the role of healthy ecosystems in providing resilience against disasters and they have demonstrated how ecosystem degradation contributes to more severe disasters. The Tsunami occurred in 2004 is a good example to show how the ecosystems matter in disaster mitigation from many local examples.Like mangrove swamps, they are a coastline's natural defence against waves. The rough surfaces of healthy corals act like natural breakwaters.

Nature-based measures which are existing in the coasts naturally are itself defencing the coasts. The degradation of such ecosystems are prominent in the recent past, not knowing the greater impact. Most recently there have been occurred a trend in restoration of such ecosystems. But any of the big plans like artificial coral reefs are not implemented in Sri Lanka yet.

2 Data and data analysis

2.1 Methodology description

In the research, with the goal of attributions, I have used three different data collecting methods and in the synthesis of data I have followed rather a different method collectively of different method for each of the two main categories that I'm considering about. Finally, the effectiveness of the structures are discussed based on the collected data from the available data on sole implementations as integrated measures are not implemented in Sri Lanka so far. For the data collection, three methods are used.

-Literature survey on previous research outcomes (conclusions and information on both categories)

-Satellite imagery (maps of the particular areas.)

-Field observations and photographic survey (These data are used in the comparison of the present situation with the old. The pattern change of Land use and other associated uses are captured here.) Limitation for this evaluation is that there is no any universal rating scale. Therefore, here used is 'a scale' which has been used by the Lauren Hunt, Christopher Sample, Kathleen Sullivan of the Natural Resources Department, Worcester polytechnic institute in December 16th, 2014 to measure the effectiveness of the measures. The effectiveness cannot be measured accurately. It varies with the perceptive angle and the need. Therefore, I have moderate the higher score gained in the sale as the result of fairly effective. In the analysis I used a mix method of re-synthesis of concluded data and the synthesis of collected data while comparing the results with the precedence studies.

2.2 Data

2.2.1 Nature-based defensive measures

To evaluate the effectiveness of nature-based defensive measures, expect for sand dunes, I have used the first method of data analysis, of resynthesize of data by a previous recent research outcomes held in Sri Lanka by a group of expertise of Sri Lanka, Prof. Sam S.L. Hettiarachchi, Prof. Saman P. Samarawickrama. Prof.Harindra J.S. Fernando, Eng. A. Harsha R. Rathnasooriya, Eng. N.A. Kithsiri Nandasena, Eng. Srimal Bandara. I am in-cooperating those extracted data and resynthesize them in the analysis. Here I have discussed about the main two natural features as follows.

- **Emerged- natural vegetation-**coral reefs
- **Non-emerged- coastal vegetation-**coastal vegetation

As the tsunami is an extreme event and in a time when Sri Lanka wasn't expecting such an event, it is perfectly showed up the effectiveness of the nature based defensive measures. Therefore, I am using the research outcomes of a modelling regard to the extreme event, tsunami.

Coral reefs

Here it discusses about the impacts of mining and destruction of coral reefs, using physical modelling to understand the influence of coral reefs in their normal and damaged sites.

Results;

With the introduction of the structure, there was a considerable reduction in the velocities in the water column except for surface velocities. This was seen for all the wave conditions that was tested. The porosity of the reef system has a significant influence on the dissipation process. In the case of dense structure, the effectiveness of the reef in dissipating energy is high. When there is a gap in a coral reef there could be a significant increase in the wave velocity, and this increase is high for the dense structures. It can conclude that the coral reefs which act as submerged breakwaters, dissipate part of the wave energy and reduce the wave velocity. However, above experiment shows that the illegal coral mining creates defenceless low resistance paths to waves and it will lead into vast intensified destructions. These outcomes conclude the influence of a coral reef in wave dissipation and how a partial absence is leading to massive destructions without predictions. Most (86%) of the wave energy is dissipated by the reef crest; this relatively high and narrow geomorphological area is the most critical in providing wave attenuation benefits. The reef flat dissipates approximately half of the remaining wave energy, most of the wave energy on the reef flat is dissipated in the first part of the reef flat (that is, the 150 m closest to the reef crest). This means that even narrow reef flats effectively contribute to wave attenuation. These results are consistent with both models and observations of coastal barriers that identified cross-shore bathymetric profile, and in particular the height of the barrier (for example, reef crest), as the most important variable in coastal defence considerations. The depth of reefs, particularly at the shallowest points, is critical in providing wave attenuation benefits. In order to better quantify these benefits in the future, much greater emphasis needs to be placed on measuring the depth profile including across tidal cycles and during events when water levels are raised. (Ferrario, et al., 2016)

Coastal vegetation

In this investigation, the performance of coastal vegetation in the wave dissipation is taken into consideration. For the hydraulic resistance, the ground surface resistance and the resistance offered by coastal vegetation are contributing.

The experiment was set-upped in prioritizing three specific areas, considering the complexity of the varying characteristics with the inability of investigating in a single series of experiments. Those are as follows.

- Primary focus; to study the dissipation characteristics of tsunami like high wave propagation through coastal vegetation located on a slopping beach head.
- Secondary focus; to ensure variety with respect to vegetation and in this context to simulate at least two types of coastal vegetation.
- Tertiary focus; to see the impact of the accumulating water after arrival of first wave, before the next.

Results;

That was the mean water depth that determined the wave-breaking characteristics as well as the extent to which various components of vegetation come to play.

Type II vegetation was effective in energy dissipation when waves had a strong interaction with branches.

2.2.2 Engineering defensive measures

Negombo offshore coastal structure scheme evaluation (prior to 2001);

In this study I have used the outcomes of a research done evaluating the Negombo offshore breakwater scheme by Channa Fernando in December, 1995. To evaluate the structures after 2001, I have used the satellite images, survey maps, photographs and on-site observations. Also in the evaluation of the beach nourishment project carried out in the Unawatuna area here I have used the data collected by the Coast conservation department of Sri Lanka.

Negombo breakwater scheme evaluation- plot 1 to 6 (figure 1).

Negombo breakwater scheme- Prior to 2001

On the whole, this breakwater scheme could be considered a success as the effect on adjacent beach is minimal, except for the erosion north of Maha Oya (this erosion can partly be attributed due to the breakwater scheme itself and partly due to the reduction in sediment discharge from Maha Oya as a result of extensive mining). It would appear that tombolo trap more sand than foreseen at the design stage. This has resulted in larger recession of the coastline north of the fourth breakwater than expected. But, by comparing the rate of volumetric changes that have taken place between the bays in the reach, it seems that the system is getting stabilized. An analysis of sea bed samples taken at -1.5m, -3.0m and -6.0m indicate that there is no sediment movement beyond -3.0m, thereby confirming the assumption made that the closure depth is at -3.0m even though it appears too small for such a sandy coastline.

Negombo breakwater scheme- Post 2001

Sattelite images comparison of the scheme; Although the holding back lands' erosion is stopped, erosion can be seen on the either sides of the structure.

- Vegetation cover is clearly improved over the years.
- In the widened beaches, mostly boatyards can be seen.
- Although the beach line varies with the coastal processes relate to monsoonal changes, the fluctuation rate is almost not changes.

Onsite observations (photographic survey);

- All the structures were easily accessible with a road leading to the face of the structure itself.
- All of the accesses were perpendicular to the structure in the case of breakwaters and revetments or parallel to them in the case of groins.

Beach nourishment in the Unawatuna- plot 7

This case was selected in order to compare the before and after aesthetic variation of a holding back land in a coastal defense implementation, converted to a recreational area after the implementation.

- Multi-function area, with given room to various functions with demarcations.Tourism is prominent as observed.
- As a lateral outcome, comparatively healthy beach can be observed.

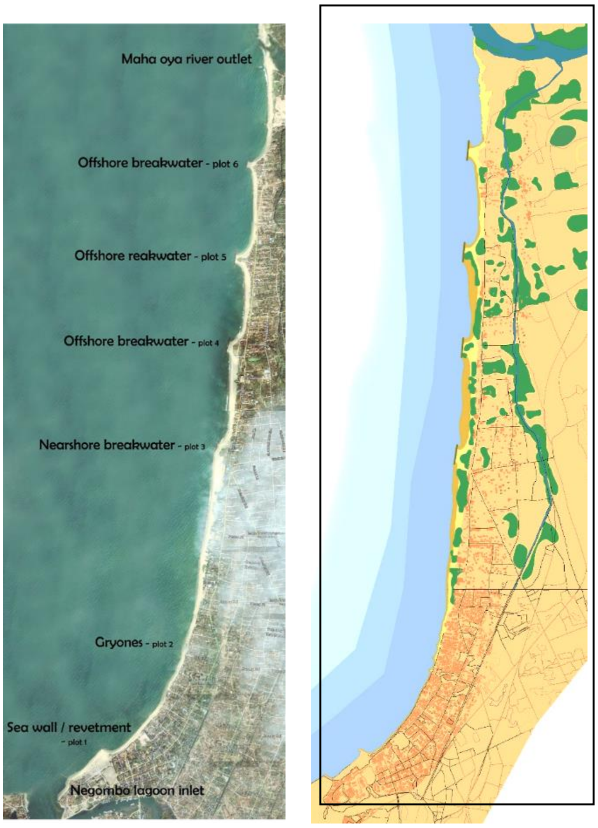

Fig 02. The evalution of the Negombo breakwater scheme

2.3 Data analysis;

According to the analysis, **71.43%** of the analysed structures are fairly effective in the coastal defensive measures while having some response to the context. This is more about the structural effectiveness but not about the resilience and adaptation. Almost all of the plots are holding the line. Many of them are now subjected to degrade with the inability of facing and permitting the changing context caused by changing climate and the sea levels. So the resilience and adoptability can be categorized as very poor.

Table 1: The effectiveness scaling of the selected engineering measures

Condition		Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7
1) Structure	a) Integrity with the context	2	2	1	2	2	1	1
	b) Condition	2	2	1	1	2	1	2
2) Property	Condition of the holding back beach	2	1	1	1	2	1	2
3) Beach present in front of the structure		1	2	1	2	2	2	2
4) Vegetation	a) Primary vegetation on the structure /Materials are not subjected to scoring	2	2	2	1	1	2	1
	b) Coastal vegetation in the holding back land	0	2	1	1	1	2	2
Score		9	11	7	8	10	9	10
Effectiveness		E	E	A	A	E	E	E

3. Conclusion

Concluded reason for the defences to be fail without been resilient and adoptive; is that they don't have the bearing capacity against the wave energies which are also fluctuates with various short-term and long-term factors.

Identified solution; the defences have to be implemented in a resilient and adoptive manner with considering the main factor, wave energy dissipation.

Challenges; is how to convert a strict/fixed defence to a resilient and adoptive one, because it cannot be done, except for introducing more energy absorptive materials and forms.

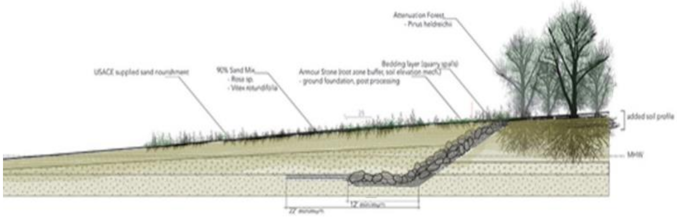

Fig 03. An example of engineering measure which is further developed for better stability

Even these were implemented, the wave energy cannot be dissipating by that accordance with the fluctuations completely, and also they cannot stand against all the wave energy alone.

Suggested solutions;

- Introducing a step by step energy absorptive system of series of defences (so that a one defence doesn't have to stand against the whole energy reaches the shore).

- For that, introducing an integrated defensive system combined of nature based measures and engineered measures.
- Most importantly, 'rooming' (giving room) for the dynamism of the energies and their fluctuations while implementing adoptive and resilient defensive measures.

According to the above investigations, it is clear that if a nature-based measures can resist extreme events like tsunamis with their huge energies to some of an extent, they surely can resist the regular wave energies with their actions and surely can dissipate the waves in disaster mitigation. So the nature-based measures not only a sustainable cost effective measure, but also hold the line while diffusing the coastal processes through them, without restricting which are adoptive and resilient way of additional losses due to poor infrastructure. When concluding the precedence studies and the analysed structures of both types, study concludes that it is almost all about energy absorption of the waves either by wind or water. Because of the fluctuations of these waves due to climatic changes, the resilience and adaptation ability of the defensive measures stands a must factor to be concerned even before the planning developments. While the engineering measures 'holding the line', the nature-based measures allow the penetration some of the wave energy which is a need when defencing against wave energy which cannot be ignore. But when applying these measures, not all the measures can stand all the processes of a shore. So my finding in this research is 'a step by step dissipation of waves' is the best way of defencing, in order to enhance the ability of the shorelines to mitigate disasters loss of land. In this kind of approach, integrated or hybrid solutions of both engineered and nature-based measures are the so far identified solution for the disaster mitigation. Accordingly, following conclusion was emerged with the study as a better integrated approach for the disaster mitigation in coastal regions with related to the dynamic region in-between the sea and the land, which provides the room for the dynamism of the coasts to some extent and holding the line to some extent, allowing the natural processes.

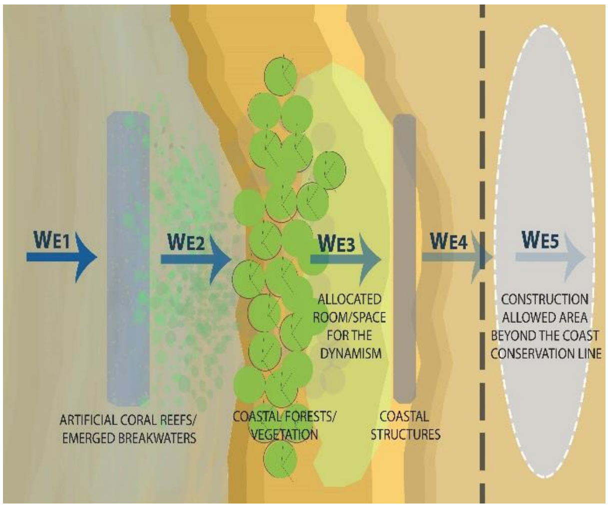

Fig 04. Overall conclusion; for a resilient and adoptive defensive scheme

As predescribed, the various strengths of waves absorption by different measures either nature-based or engineering, have taken in to consideration. The design of the deffence system may vary according to the context. Also the NbM(Nature based measures)and EM(Engineering measures) can switch when integrating measures to face the waves with the need, according to the context and their bearing capacities. 'WE' in the diagram reffers to Wave energy, either wind or water. Passing wave energy through a series of permeable barriers, eventually decreases the wave energy by absorbing step by step, by the particular barriers when arriving from the sea to the land. Also the above suggested approach providing room for the resilience and adoptation while giving some space for adjustibility and the dynamism too.

Such a sustainably integrated deffensive system is a result of master plannig in the aspects of landscape architecture to a severly affected site by a disaster (although, in the study it reffers to coastal disasters) by involving specialists in different fields and considerations. In such a schematic design, the landscape architectural perception and its major involvement is severe because, it is the integrated field of both engineering and environmental including ecological perceptions which are nature-based which can input the hybrid solutions of both engineering and nature-based measures in any developments. The degradation made by short-sight decisions take, in order to fulfil needs are irreversible and when the consequences occurs it will be too late to turn back. That is why the big picture and the planning in macro level in disaster mitigation is the current need of the country. That is why the mitigative measures have to be integrated and the experts have to join hands in the development process from the basic level to the implementation and even the maintenance level. Because the big picture is only seen by those who expertise in different fields.

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