Planning for Resilient Settlement in Port Fairy, Australia

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Abstract. This paper aims to discuss some strategies to address problems and challenges faced by a community living in Port Fairy, a coastal town located in Southwestern Victoria, Australia. It is about three hours’ drive from Melbourne’s CBD. Like other coastal towns, Port Fairy is also affected by climate change, severe weather events and sea level rise. The impact of these problems can be seen in East Beach, an important tourist destination in Port Fairy. Soil erosion and flood due to severe wind and wave, are main problems in East Beach. This will not only affect the housings, but also the landfill site located in this beach. Therefore, it is challenging to develop solutions to enhance the resilience of this coastal town. This study may inspire Indonesian planners to further develop the resilience of hundreds coastal towns in Indonesia.

1. Introduction
Planning for resilient settlement has been increasingly important due to climate change issue. This issue is particularly critical for coastal towns. They are vulnerable to disturbances such as sea level rise, severe winds and wave. Problems such as flood and soil erosion are faced by most coastal towns and these problems may endanger the communities living the settlement nearby in a long term period. Moreover, relocating people to another place which is safer is usually challenging and it does not solve the problem. Therefore it is critical to develop a set of strategies to deal with this kind of issue.

Port Fairy is one of important recreational destinations in Victoria, Australia. It is a small coastal settlement located in Great Ocean Road, a historical road in Australia. People visit this town for seeing beautiful scenery of white sand beach in East Beach, seeing wallabies and other animals in Griffith Island or just for fishing. Port Fairy is also the second largest port in Victoria, after Port Melbourne. However, some environmental changes which happened in this coastal town created some problems such as inundation, sand dunes erosion and bio-diversity loss that significantly affect the communities living there. People living in the area close to the beach, are vulnerable to disaster and had to spend more money on building renovation because of flood that often occur.

Hence, this study aims to analyse the problems in Port Fairy and formulate recommendations to further develop the resilience in this coastal town. The lesson learned from Port Fairy can be used for developing the resilience of other coastal towns, including the ones in Indonesia. Coastal settlements in Indonesia are also facing similar problems which occur in Port Fairy, Australia.
2. Literature Review

2.1. The Definition of Resilience
There are several definitions of resilience. In terms of engineering principle, resilience is an ability of a system to bounce back after a disturbance or a shock [1][2]. In terms of ecology, resilience is defined as not only an ability to return to a normal condition, but also an ability to absorb or accommodate a certain amount of disturbance [1]. It rejects the idea of single equilibrium and suggests that a system can create a new equilibrium. Kuei-Hsien (2012) argues that ecological resilience means ability to survive and it is not limited to just returning back to stability [2]. The last one is evolutionary resilience. It defines resilience as an ability of a system to change, adapt and transform in order to address a disturbance [1]. In this principle, there is a possibility of changing threshold. This also considers that socio-ecological system is complex, uncertain and keep changing [1].

![Figure 1. Different illustrations of resilience][2]

2.2. The Resilience components
Resilience consists of four components: diversity, modularity, redundancy and feedback [3]. Firstly, diversity means the more diverse a system, the more options it owns and the more resilient it is [3]. A system that consists of various components is considered as a resilient system because it provides many options. Secondly, modularity is owned by a system that consists of modules that each of them can be changed without seriously affecting other modules [3]. High modularity requires links among components of a system that do not make them highly dependent on each other. Thirdly, redundancy means having extra components that enable a system to survive. A loss of one component will not endanger the whole system because it still has some similar components [3]. Lastly, feedback means an ability of a system to create fast and strong feedback for other parts of the system due to change in a part of the system [3].

2.3. Types of Responses to Disturbances
According to IPCC, there are three types of responses to disturbances: retreat, accommodate and protect [4]. Retreat means preventing development in an area that is vulnerable to disaster [4]. In this case, it is possible to abandon that vulnerable area. It seems that this is the simplest and the best idea, but in practice it is very hard to be implemented. Social factor such as emotional connection to the place and economic factor such as working place are the challenges of this type of response. Another type of response is accommodating. The idea of accommodating disturbances is like an effort to live with the disaster by adapting to it. Some of the examples of this type of respond is creating houses that resilient to earthquake and flooding [4]. Lastly, protect is a type of respond that aims to create a barrier that can keep the settlement safe [4]. Both advance technology and natural-traditional elements can be used to protect the coastal settlement. Even though there are various definitions of resilience, this study will focus on ecological and evolutionary resilience. These definitions are suitable to address present day climate change issues that are unpredictable [5].
3. Method
The main inquiry of this study is what should be done to enhance the resilience of the community and physical environment in Port Fairy, Australia. This question can be broken down into following sub-questions:

- What are the problems and challenges faced to establish a more resilient settlement in the future?
- What are the existing responses to disturbances and what are their limitations?
- What are alternative solutions that can address the limitations of the existing responses?

This study focus on examining the East Beach area in Port Fairy because it is one of the most vulnerable area in this town in terms of soil erosion, flooding and landfill site. Moreover, any problems occurred in this area may affect the settlement nearby.

The secondary data regarding the existing condition in East Beach, Port Fairy was collected from the websites. Moreover, field observation was done in December 2014. This field observation includes brief non-formal interview with the local residents and community leaders. Communication with the local communities enabled researcher to better understand the condition in the study area. Therefore, the recommendations suggested in this study can be accommodated by the local communities and the municipal government to further develop the resilience of their town.

The data collected was analyzed by using SWOT analysis. The SWOT analysis was used to include challenges and opportunities in the problem analysis. This is important to see the problems in broader spatial and temporal context. The result of this analysis was used to formulate some suggested solutions to solve the problems.

4. Result and Discussion

4.1. Problem Analysis
Considering that coastal zone has a strong human-nature relationship [6], the problem analysis discusses both social and ecological aspects of East Beach site. It is critical to relates these aspects because they are interrelated and dependent on each other. The community in Port Fairy has strong social network, intense sense of place and belonging. Moreover, most part of this area is under heritage overlay [7]. These are the positive social aspect that should be taken into account in developing a resilient settlement in this community. However, ageing population is a problem faced by this community [7]. It is critical to attract young people to live in and develop this area.

In terms of ecological aspect there are several environmental problems in East Beach area (see Figure 2). It has a high risk of flooding from the river, the lough and sea level rise. There is also a significant erosion occurs because of waves and lack of sedimentation [8]. This erosion also leads to land contamination because it is affecting the landfill and night soil site located under the sand dunes [9].

![Figure 2. Environmental Problems in East Beach, Port Fairy](image-url)
Flooding, coastal erosion and the issue of night soil site are major problems in East Beach. Based on the problem analysis (see Figure 2), coastal erosion is caused by both climate change and the presence of causeway [8]. Flooding is also caused by two climate change impacts, sea level rise and storm surge. Moreover, these environmental problems are affecting both human and nature. They endanger human settlement with its economic, social and cultural aspects as well as damaging the coastal ecological system. Solutions for addressing these issues should consider four aspects, minimizing the exposure of night soil site, adapting sea level rise, accommodating severe winds and waves and redesigning the causeway to bring back the sedimentation to East Beach.

In terms of opportunities, there is a local movement called ‘sea change’ and ‘tree change’ that aim to create more jobs opportunities in coastal towns [7]. This movement may attract more skilled migrants to live in Port Fairy. In terms of environmental aspect, wind and waves in this coastal area can be used as the sources of renewable energy. The environmental problems such as severe wind and waves can be an opportunity for this town to develop an approach of climate change adaptation. Furthermore, a pilot project of resilient settlement in Port Fairy may be potential for developing an educational tourist destination in Port Fairy. This destination can be a part of the Great Ocean Road tour, one of famous tourist destination in Australia. However, the uncontrolled development of tourism and gentrification in this town are challenges that may lead to the decline of the local identity, volunteering activities and environmental degradation. The summary of problem analysis is depicted in Figure 3.

![Figure 3. Problem Analysis for East Beach, Port Fairy](image)

### 4.2. Suggested Solutions

According to SWOT analysis (see Figure 3), several weaknesses and threats are possible to be addressed by utilizing strengths and opportunities owned by this site. Social problem such as ageing population and diminishing young workforces can be managed by the opportunity to encourage skilled migrants to move there. Climate change challenges and environmental issues can be addressed by adaptation. This also creates a potential for developing an educational tourism and an opportunity to create jobs attractive for young people. Educational tourism can minimize damage on coastal natural environment unlike uncontrolled commercial tourism. These opportunities are supported by some strengths such as strong community network and the beauty and uniqueness of natural environment. These positive aspects provide quality of life there. However, the community must be aware of the negative trends such as decline in volunteering and loss of local identity caused by urban gentrification.

Three strategies were developed to address the issues mentioned before. The first strategy is remediating any kind of land contamination in the coastal area. This strategy can be achieved by treating the landfill site by using phytocapping and bioremediation (see objective 1 in Figure 4). The second strategy is reducing coastal erosion and its impact on East Beach site. This strategy can be implemented
by protecting and managing the sedimentation (see objective 2 and 3 in Figure 4). The last strategy is establishing resilient community and settlement. This can be done by accommodating the inundation and flooding problems in the existing settlement (see objective 4 in Figure 4).

**Objective 1: Landfill site treatment**

Considering that excavation of the night soil is expensive and takes time, phytocapping is an alternative solution to deal with this landfill issue. This is a relatively new method to reduce contamination from landfill site. This can reduce water infiltration into the landfill site by using vegetation to keep rain water. This is beneficial to minimize pollution (leachate and methane) from the landfill [10].

The use of vegetation is not only beneficial for avoiding pollution from the landfill, but also useful to stabilize the sand dunes, break storm wind and increase bio-diversity in this area. The plants’ roots can protect the dunes from erosion caused by both wind and waves. The presence of vegetation in this site also has a function as wind breaker to protect the residential area from storm wind. Norfolk Island pines are one example of site specific vegetation that is resilient to storm wind. Furthermore, this trees may facilitate some species to reclaim this area and increases bio-diversity there.

However, phytocapping suggests a single type of vegetation namely, Norfolk Island Pines. This response does not create diversity and can be a weak resilient solution. There are several types of indigenous vegetation that can be use in Phytocapping such as Tea Trees and Marram Grass [11].

Moreover, phytocapping does not remediate the night soil site. Other solution such as Bioremediation can be an alternative long term solution complementing phytocapping (see Figure 5). This enables contaminated land to degrade and self remediate [12].

![Objective 4: Inundation Flooding Accommodation](image)

**Figure 4.** The mapping of the suggested solutions

![Bioremediation](image)

**Figure 5.** The concept of Phytocapping (left) and Bioremediation (right) [13] [14]
Objective 2: Dunes Protection

Coastal erosion is caused by wind and wave that affect sand dunes. East beach does not have any barriers that can protect its dunes from wind and strong wave. This area has been eroded by roughly 10 meters in 2009 - 2014. A sea wall was established in this area to address this issue. However, this existing solution is not an effective solution because it is just protection and there is no effort to accommodate the storm waves. Artificial reef is one solution that is more effective than sea wall. It does not just protect the dunes from erosion but also can create a new habitat for some fish and a new diving attraction. This offers protection as well as ecological and recreational advantages.

There are several designs of artificial reef that use prefabricated materials such as concrete. This material is relatively less expensive than natural rocks or volcanic rocks [15]. Artificial reef has been installed in South Beach to protect the dunes from strong waves. The design of this artificial reef can be varied based on the need of the site. There is a possibility for community to involve in the process of designing this reef.

![Figure 6. Artificial reef can be used for reducing erosion as well as creating new habitat for fish [15]](image)

However, artificial Reef consists of similar moulded concretes that lacks of diversity and aesthetical value. Furthermore, if it is poorly designed, it may be collapse during severe storms and become trash that pollutes marine ecosystem [16]. Its installation also may damage existing natural habitat and it enables concentration of fish unnaturally that may create imbalance ecosystem [17][18]. These problems can be addressed by utilizing natural material for wave breaker such as timber and stones. However, artificial reef is still possible to be successfully implemented as long as planned well. This offers many social and ecological benefits. Additionally, the reef design can be modified as sculptured statues. This may create new attraction in East Beach and attract local artists to contribute to the design.

![Figure 7. Wooden Poles and Sculptured Artificial Reef [19][20]](image)

Objective 3: Sedimentation Management

Port Fairy has a significant training wall, the Moyne River Training Wall, that was built in the nineteenth century in order to facilitate the navigation for vessels. However, this wall has an impact on the amount of sedimentation on East Beach. The erosion at East Beach is approximately 3.000-4.000
m3 per year in the past 150 years [9]. This problem occurs because the training wall block the transportation of the sand from the river to the bay. This has created a substantial sediment accumulation on the wall and this has an influence on the erosion on East Beach. The amount of sand brought back to the beach has been decreasing continuously in the last hundred years. Therefore, this training wall should be redesigned to improve the sedimentation on the bay. Simply removing the wall is not a solution because this training wall is listed in the Victorian Heritage Register. It is considered as a historically significant building that represents a nineteenth century regional port infrastructure in Victoria, Australia. Furthermore, removing the wall will affect the vessels’ navigation.

This problem may be addressed by using sand by-pass system. This technology has been developed in Gold Coast, Queensland, Australia since 1980s. This system pumps the sand trapped in the training wall system, to the bay. This system may replace the natural movement of sand from the river to East Beach. This system usually consist of several jet pumps located in approximately 11 meters below the sea level [21]. Sand by-pass system is relatively more effective than coastal reclamation.

Objective 4: Inundation Accommodation

The inundation affecting the housings in East Beach can be addressed by constructing flood resilient home designs. Nowadays, there are various kinds of design that enable the housings to accommodate severe flood events. It is important to design a house that is not just resistant to a particular level of flood, but the design must ensure that the house can accommodate any levels of flood. Most modern flood resilient house designs use the concept of traditional elevated house. However, this type of design is limited to a certain level of flood. Practically, people cannot predict exactly the maximum level of flood. Therefore, a kind of elevated house that is able to inflate in a case of a great flood is needed. This kind of design has been developed in Netherland because more than half of its settlement is below the sea level [22] (see Figure 8). Besides, educating the community to be ready for any storm surge and flooding is also important.

Figure 8. Wooden Poles and Sculptured Artificial Reef [22]

5. Conclusion

The existing engineering approach implemented in East Beach, Port Fairy cannot effectively address the complex environmental problems that occur there. The existing solutions mostly focuses on short-medium term and does not address the root problem. The community also has not been engaged in the implementation process. Community should be actively involved in solving the root problems and enhancing diversity in both short-medium and long term scale. The creativity of the local community should be accommodated to develop eco-tourism and enhance the economic sustainability in East Beach particularly and Port Fairy in general.

This study provides recommendations that aim to overcome the limitations of the existing approach implemented in East Beach. Landfill site should be treat by using natural-long term method such as phytocapping. The dunes should be protected by installing beautiful artificial reef that designed by local artists. This can protect the dunes as well as creating a new tourist attraction in this area. Furthermore, the sedimentation problem should be tackled by adding a sand by-pass system. Lastly, the inundation problem should be addressed by implementing a kind of floating house construction especially for the dwellings located near the shore.
The lesson learned from this study can be used to improve the condition of coastal settlement in Indonesia. The problems occur in East Beach are also common in Indonesia. The strategies mentioned to address coastal erosion and inundation in East Beach can also be adopted with modification in Indonesian coastal town such as Jakarta, Semarang, Makassar and Denpasar.

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