Adaptability and transformability of socio-ecological system: Exploring the resilience of Mulavukad panchayat in Ernakulum district of Kerala

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Abstract. The functioning of our community is dependent on the social, economic, environmental & physical components and the interplay between them. Disruption of one component can affect the others and can damage the functioning of the entire system. The variations in damage caused by stress, shocks etc depends on the ability of the social, physical, economic, ecological and institutional capacities to absorb them. This paper focuses on the theory of adaptive cycle and the adaptations & transformations underwent in Mulavukad panchayat is overlaid on the adaptive cycle to envisage and collate the occurrences. Mulavukad panchayat lies a few kilometres from Kochi city, which is the most urbanized city in the state of Kerala. The panchayat comprising of Bolgatty and Vallarpadam Islands has a total area of 19.25 Sq. km with a population of 21833. The introduction of Goshree Bridge in 2004 brought dramatic changes to the community that resonated in all sectors. The study shows that the social, ecological and economic system in this panchayat underwent adaptations and transformations in relation to the changing scenarios.

1. Introduction
Every disaster, devoid of its type and magnitude affects the society in several ways and it affects the social, economic, environmental and ecological components in varying degrees and scales. Disruption of one component can affect the others and can damage the functioning of the entire system. These damages range from mild disturbances to loss of properties, infrastructure or even human life and these variations in damage depends to a great extend on the amount of disturbances a community can absorb or how equipped the community is to face and overcome the disasters whether short term or long term. This capacity of the community named ‘resilience’ is dependent on the social, physical, economic, ecological and institutional capacities that are either tangible or intangible. The tangible capacities include population, physical infrastructure, environment and biodiversity etc. and the intangible capacities include social network, cultural identity, information, knowledge, communication etc. The strength and quality of these capacities determine resilience, which can be measured and enhanced [1] to approach a phase of rejuvenation and revitalization.

The aim of the paper is to study the process of resilience and explore the community’s absorptive, adaptive and transformative resilience in the context of dramatic shifts in socio economic ecological realm and its future challenges. The authors here uses the heuristic model of adaptive cycle which is
useful for envisaging and collating the occurrences both deliberate and natural and further suggest strategies for sustainable and resilient development of the study area.

2. The concept of resilience and its importance

The etymological roots of resilience stems from the Latin word “Resilieo” meaning “to bounce back”. The early literature on resilience renders that in 1950’s the term was majorly used in Anthropology, Child Psychology & Social research [2]. In 1973, the Canadian ecologist C S Holling introduced the concept to social sciences, which often is cited as the origin of modern resilience theory. Holling’s resilience of ecological system was then used across a wide spectrum of fields including natural and disaster risk management, climate change adaptation, public health, financial management, Urban Planning etc [3]. From 1990’s the socio-ecological resilience was considered as an important tool to measure sustainability and from 2000 onwards it has been widely used in urban related issues [2].

Asia with its unremitting urbanization, which being the paramount source of global climate change, the livelihood and the eco systems will duly get altered. This non-uniform process will affect the vulnerable more as they have the least resources and therefore the least capacity to adapt. Hence, a shift to either build a resilient community or initiatives to enhance the resilience of the community becomes important [4] particularly in developing countries. Resilience is said to be one among the guiding principles that makes a nation safer [1].

Resilience can be viewed from multiple angles [5]. Though disaster resilience is the most ‘in demand’ concept, it is only one of the many situations where resilience is applied. The scale of application varies spatially and temporally. It is not only limited to urban areas, but to peri-urban areas and rural areas too. It also varies from infrastructure resilience, social resilience, environmental resilience, economic resilience to institutional resilience. Ijiomah has quoted Folke, cited in [6], that resilience can be classified into two types - General and Specific. The former refers to resilience of a particular component of a system with known disturbances and stresses and the latter refers to resilience of the whole system, to all known and unknown disturbances that still provide essential services.

3. The Process of Resilience

The coping capacity, adaptive capacity and transformative capacity are the three critical dimensions of resilience and each of them leads to different outcomes: persistence, incremental adjustment and transformational response, which can be linked conceptually to various intensities of change or shock. When the ‘absorptive’ or 'coping capacity’ is exceeded, the community will exercise ‘adaptive capacity’ which refers to the various adjustments people make in order to continue functioning. Eg. Adopting new farming technique, diversifying livelihood base etc. These changes can be made at multiple levels involving multiple groups (groups, intra household, ward level etc) and can have multiple implications too. Adaptation at one level can affect or reduce the adaptation at another, but it is a continuous incremental process though people or societies may not be even aware of how they adapt to changes and people generally do not adapt to one specific stressor, but to a broad combination of changes. In due course, if changes are immense and beyond the adaptive capacity of the community or the eco system then transformation happens resulting in individual or communities primary structural and functional changes. The risk associated to these changes increases when transformative resilience takes place. According to Christopher Bene cited in [7] “It costs more to transform a system than to maintain it as it is, or to rebuild it as it was”.

In addition to resilience responses, it is seen that the same change or shock can give different responses to different groups or communities and a large number of these occurs across scales from local to global. Therefore, in order to strengthen or enhance resilience, interventions are required to strengthen all the three components of resilience namely absorptive, adaptive and transformative resilience and this should take place at multiple levels. (Individual, household, communities and regions)
Subsequently three ideas developed within ecology are: engineering resilience, ecological resilience and adaptive resilience. Engineering resilience is the time taken for a system to return to equilibrium after a shock, where the speed determines the quality of resilience [8]. This theory emphasizes minimizing changes by enhancing resistance [9], [10]. Ecological resilience refers to a system's capacity to reorganize under change to reach a new equilibrium while retaining the same essential functions. The emphasis here is the amount of disturbance a community can take, how long it can persist in the critical thresholds [11]. This approach entails a more dynamic and flexible system as safety thresholds is taken into consideration. Initial stressors and shocks are absorbed with minimal damage and loss [8]. Retaining the basic structure and functions becomes important while transition to a new equilibrium state may be experienced [9]. Adaptive resilience is the ability of a system to undergo anticipatory or reactionary organization of form and/or function so as to minimize impact of a destabilizing shock.

Ecological Resilience is more of a process rather than an outcome [1], [12]. This part of theory is an extension of adaptive cycle of ‘Ecology’ stream, which is extended, to the urban system, which continuously goes through four distinct phases namely exploitation or growth (r), conservation or consolidation (k), release or creative destruction (omega) and reorganization or renewal (alpha) [13]. The adaptive cycle suggests that the socio ecological system is never in a state of equilibrium but is in the process of continuous change and adjustments. In the exploitation phase ‘r’ the resource gets developed with a rising level of diversity and connections and this growth period is marked by high resilience. In Conservation phase ‘k’ the growth slows down; system gets less flexible and gets vulnerable to external disturbances. This change occurs slowly and takes a long time and is predictable too. This stage is characterized by stability and certainty, at the same time reduced flexibility and resilience. In release phase (omega) there is release of accumulated capital, the bound up resources or the accumulated structure collapses. This is the phase of uncertainty and resilience is very low and finally the reorganization phase (alpha) which eventually leads to another growth phase. This is the phase of restructuring and innovation along with greatest uncertainty and high resilience (refer Figure 3). Sharifi and Yamagata, [9], state that the changes from release to reorganisation experience a chaotic change, which is highly uncertain and also takes lesser time.

4. Profile of Mulavukad Panchayath
Bolgatty Island and Vallarpadam Island together form the Mulavukadu panchayat (the area being 19.27 sq.km with a Population of 21833), which is lying very close to Kochi city, the urban centre of
Kerala. Though lying adjacent to a metro city it doesn’t exhibit an urban character. Mulavukadu has a tropical humid climate with hottest months in March, April and May with a maximum temperature of 31.4 degree and minimum temperature of 23.2 degrees. The annual rainfall is 3233 mm. Mulavukad region comes under the tidal deposit (fluvio marine) and hence the soil is saline. Mulavukad panchayath is well connected to the Ernakulam district by roads and water network. Main accessible roads are Goshree Bridge and International Container Terminal road. The Mulavukad panchayat is well linked with Ernakulam, Vallarpadam and Vypin through the Goshree bridge and NH 966A. The national highway - NH – 966A (before known as NH-47C) passes through Mulavukad to Vallarpadam International Container Transhipment Terminal in Kochi. Figure 2. shows the Mulavukad panchayath administrative boundary and existing Master plan.

5. Existing Socio-Economic-Ecological scenario of Mulavukad panchayat

Until the construction of Goshree Bridge in 2004, the local body was accessible only by boats which plied to and forth frequently, subsequently the number of boats reduced from 13 to one. People depend on mainland for most of their services, the primary occupation of ‘pokkali’ farming (specialized form of Agriculture in low-lying areas) and fishing along with the secondary occupation of boat making and repairing diminished subsequently.

The administrative boundary comprising of two islands, the proximity to metro city, the low lying land encompassing wetlands and mangroves, the gargantuan investments like Vallarpadam transhipment terminal and Grand Hyatt convention centre and hotel, the historically important Bolgatty palace, the nuances of multiculturalism with its in and out migration are the features that make Mulavukad panchayat unique [14]. Tracing the history and evolution of the panchayat, the series of important events that contributed to the growth and transformation of the panchayat (See Table.1)
Table 1. Growth and Transformation of Mulavukad panchayath

| Year | The milestones                                                                 |
|------|-------------------------------------------------------------------------------|
| 1524 | Vallarpadam Church was built                                                   |
| 1744 | Bolgatty palace was built by the Dutch                                         |
| 1973 | An outer ring road was built to save Agriculture of the Panchayath             |
| 1976 | Bolgatty palace owned by KTDC (Kerala Tourism Development Corporation)         |
| 1981 | 400 acres of land was reclaimed to built tanker birth at southern part of      |
|      | Vallarpadam                                                                   |
| 2004 | Goshree bridge connecting the panchayat to main land opens                     |
| 2011 | Vallarpadam becomes the first transhipment terminal in India                  |
| 2018 | Mega commercial establishments like Grand Hyatt and Bolgatty                   |
|      | convention centre opens in Panchayath                                         |

The study of land use of the Mulavukad panchayat shows that there is limited scope for development in future in a sustainable manner. The environment of the panchayat has been gradually deteriorating due to improper or lack of waste management practices. There has been a severe depletion in the amount of agriculture like ‘pokkali’ that has been practiced in the study area. The amount of Industries is very low, with the existing ones being related to vehicle maintenance. There is a significant dearth of commercial spaces with no commercial nodes. The commercial spaces are limited to small provisional shops. The public amenities are more or less distributed equally. There is a need for organized Parks and open spaces for recreation. The town has moderately good road network, but the local roads in the panchayat are very narrow and characterized by poor geometry and surface quality. The strength of the area is its strong water-based transportation, which links it to the Mainland. The area has a large amount of coconut cultivation. The panchayat also comprises of large amount of inland water bodies, which once were the prime location of ‘pokkali’ farming. While the farming practices have gone down in the recent decades, the water bodies still exist with contaminated water, most of which has become unfit for aquaculture. There also exists large network of submerged lands in the study area that has variety of species of mangroves.

6. Discussions
A thorough study of the social economic ecological dimensions and the major investments for the last four decades has been studied. The implications of these leads to understanding the process of resilience as shown in Table 2.

The adaptability and transformability of Mulavulad during the last four decades is illustrated in the adaptive cycle in Figure 3, which is adapted from the popular heuristic model put forward by Holling, Walker, Gunderson (2002) and subsequently by many more. The digit ‘1’ in figure shows all the developments till 1980, which includes the construction of vallarpadam church, Bolgatty palace, ‘pokkali’ farming practice, Fishing activities, the development of Kochi and its subsequent repercussions, administrative growth etc. After the conservation stage, from release to reorganization there were efforts to protect the agriculture by constructing an outer ring road. Bolgatty palace was renovated and taken over by Kerala tourism Development Corporation and Greater Cochin development Authority (GCDA) was constituted for the planned development of Kochi city region, which is represented by the digit ‘2’ and ‘3’ consecutively.
| Year | Major Investments                                      | Affected sectors | Positive Implications      | Negative Implications                  | Process of Resilience                  |
|------|-------------------------------------------------------|------------------|----------------------------|----------------------------------------|----------------------------------------|
| 1981 | 400 acres of land reclaimed for Terminal              | Physical         | Land use Change            | Occupational shift                     | Adaptive capacity- Ecological resilience |
|      |                                                       | Ecological       |                            |                                        |                                        |
| 2004 | Goshree Bridge                                       | Physical         | Improved Connectivity      | Sustainable water transport neglected  | Transformative capacity                |
|      |                                                       | Social           | Rapid urbanization         | Loss of social capital                 |                                        |
|      |                                                       | Economic         | Improved marketing facilities | Traditional occupation less reliable |                                        |
|      |                                                       | Economic         | Local body own fund increased | Not beneficial to the local community |                                        |
|      |                                                       | Physical         |                            | Underutilized transportation facilities/ Traffic congestion in existing roads/ parking & related issues | Transformative capacity                |
|      |                                                       | Ecological       |                            | Disturbance in ecological system       |                                        |
|      |                                                       | Social           | CSR Fund utilization      |                                        |                                        |
|      |                                                       | Institutional    | Local body own fund increased |                                        |                                        |
| 2011 | International Transhipment Terminal at Vallarpadam   | Physical         |                            |                                        | Transformative capacity                |
|      |                                                       | Ecological       |                            |                                        |                                        |
|      |                                                       | Social           | CSR Fund utilization      |                                        |                                        |
|      |                                                       | Institutional    | Local body own fund increased |                                        |                                        |
|      |                                                       | Social           | Bolsters the identity of the place | Public access denied | Adaptive Resilience                  |
|      |                                                       | Cultural         | Conservation of heritage   |                                        |                                        |
|      |                                                       | Ecological       | Protection of Environment  |                                        |                                        |
| 2018 | Renovation of Bolgatty Palace                         | Institutional    | Local body own fund increased |                                        | Transformative capacity                |
|      |                                                       | Social           | Disintegration of identity |                                        |                                        |
|      |                                                       | Physical         | High land value            |                                        |                                        |
|      |                                                       | Physical         |                            | Disintegration of identity             |                                        |
|      |                                                       | Ecological       | Elevated road bisects the island isolating one side stretch | Transformative capacity/ Adaptive- ecological resilience |                                        |
|      |                                                       | Ecological       | Disintegration of wetlands, chances of flooding |                                        |                                        |
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Figure 3. The adaptability and transformability of Mulavukad panchayat depicted in Holling’s adaptive cycle framework [13]

7. Conclusion
The social, economic and ecological system adapts and transforms according to the changing scenarios. The impacts and implications of these, whether short term or long term, positive or negative majorly contributes to the growth or degradation of the area. The study covers all the factors that affect the lives of people of Mulavukad. An integrated approach reviving ‘pokkali’ farming and Agri-Aqua tourism, smart sewage treatment, development of nodes/ gathering spaces, electrified para-transit mode to ensure last mile connectivity, conservation and enhancement of mangroves and wetlands are the few suggestions to ensure Mulavukad panchayat on a path towards systematic and planned urbanization. The authors have tried to figure out the resilience capacity of the community with
respect to the major investments on land. To concise the paper, the study is limited to social and ecological resilience and hence disaster resilience and other classifications of resilience is not included.

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