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Flood Resilience based on GIS Analysis: The case study of Chum Saeng district, Thailand

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Abstract

In Thailand, river floods can occur suddenly and have been increasing severity. Floods still cause substantial damage and many people have tried to reduce the impact of flooding. Therefore, to understand the problem, we turn to manage flood risk by a new concept like urban resilience for development in the city.

This research aims to study the resilience capacity indicator of communities and analysis flood resilience with GIS. The study have been used nine indicators; human capital, preparedness and hazard awareness of household, infrastructure and services, emergency plan, aid from other areas, evacuation plans, physical, economic and social for analysis resistance capacity, absorption capacity and recovery capacity in each community. Secondly, the indicators that three sets of capacities with respect to different level of availability the communities has before, during and after flooding processes, which are marked from 0, the requirement is not provided to 4, the requirement is fully provided. Each capacity contributes to the evaluation of the resilience capacity indicator (RCI) for the community. The research found that the community has the highest of the RCI (7.75), the resistance capacity has medium scale (2.333), the absorption capacity and recovery capacity have high scale (2.583 and 2.833).

Finally, the RCI represent a tool for developing to assess community disaster resilience. Therefore, it is important to map the geographical patterns of community resilience. The use of such maps will need the use of GIS-based technology.

Keywords: resilience; resistance capacity; absorption capacity; recovery capacity

1. Introduction

Floods are natural disasters that can occur suddenly and have been increasing severity. These situations require a new approach to achieve integration by bringing knowledge and understanding about the urban resilience applied to the management of floods. That is preparing to absorb with the impact and reduce the damage in order to contribute to the recovery as soon as possible after the flood (Choosumrong *et al.*, 2014).

The resilience is a very new method, especially with the administration and agencies to hazard awareness reduce the damage that may occur in the future or initiatives to increase the capacity of system, communities and cities. In fact, the community has the ability to resilience to a certain extent, but if that are confronted with serious disasters or unexpected situations the ability may be still not be enough. Therefore, it is necessary to stimulate, support and develop in order to maintain their lifestyle and activities to be under changes.

This research aims to study the resilience capacity indicator (RCI) of communities and analysis flood resilience with GIS, and goal is to improve the flood risk management to a better and reduce the damage to a minimum by manage the issues of risk and vulnerability to hazards of area flooding. The first analysis must assess the preparedness to absorb with disasters for increase efficiency their operations. This judgment software will be based on GIS, because it provide to manage or analysis, accuracy, redundancy and relationships between information including querying and updating data. GIS was a logical tool for integrate the necessary information

or identify critical infrastructures in normal period, to prepare or aid for emergency plan during disturbance and after flood, this tool will be used to relief or recovery.

In the first part of this paper present resilience concept to achieve more understand the importance of this concept in the management of flood risk. The second, the indicators are assessed to analysis resistance capacity, absorption capacity and recovery capacity in each community, which different levels are showed from 0, the requirement is not provided to 4, the requirement is fully provided. Each capacity contributes to the evaluation of the resilience capacity indicator (RCI). Rating scales corresponds to very low, low, medium and high resilience community. The urban or community has the resilience capacity from a disaster is high; it has the ability to accept and adapt to the incident as well. Thus, the indicators should take into account the importance of acting system dysfunction, the severity of physical damage to the system and the duration of the functioning with unusual.

Finally, the RCI is the first step that represents a tool for developing to assess community disaster resilience and currently still under development, demonstrating the benefits of GIS to show that such tools will help improve the resilience of the city.

2. Resilience Concept

In the past, the concept of resilience is used to engineering, ecological, social or psychological. But over the past year, the resilience has become widely known as the human and development such as reducing the risk of disaster, climate change, city planning or ecosystem management etc. Although there are many definitions of resilience from different disciplines, but generally can be divided into three aspects (Carpenter *et al.*, 2001);

- About the speed of recovery after a disturbance.
- About the severity of the situation, as compared to the absorption of system before the structural changes by changing the process and parameters.
- About the ability to learn and create new things from the situation and adaptation.

Table 1. An example of resilience concept

References	Categories	Definitions
Wang and Blackmore (2009)	engineering	that threaten the stability of system engineering which is linked with low probabilities of failures or rapid recovery to normal levels of operation.
Holling (1973)	ecological	as the system's ability to absorb disturbances and still persist.
Adger <i>et al.</i> , (2005)	social-ecological	ability of the system to absorb with external pressures and disturbance, for sustainable living.
Kim <i>et al.</i> , (2004)	psychological	ability to recovery from stress. And a genetic point of view, the resilience is set up of quality in order to protect individuals at risk for a genetic affected by these problems.
Neil <i>et al.</i> , (2006)	humanistic-psychology	ability of the individual to flourish, even with the stress. The people are resilience, not only to cope with the disorder or stress but also increasing the learning and development opportunities as well.
Bodin and Wiman (2004)	mathematics	the time required for the system to return to equilibrium again.

Since the work of Holling, 1973, the concept of resilience has been learned and more acceptable. And currently, this concept applied in many fields, especially as a concept for understanding and managing systems to connect people with nature (Klein *et al.*, 2003). The first to use this concept is Timmerman, 1981 has defined "the measures or the capacity of the system to absorb and recovery from dangerous situations". And then in the last three decades, there are many definitions of the resilience concept from the risk and disasters, which mainly consists of two properties (Mayunga, 2007);

- The ability to resist and absorb with disturbance.
- The ability to manage and quickly recovery.

In general, the definition resilience from a disaster is a long-term recovery process after the disaster that is the resilience can be measured in terms of time spent in recovery or return to normal. The disaster resilience concept, not only has the time is indicator, but also has the ability to learn, preparedness, absorption or adaption to the risks. Therefore, in this study, the resilience means to the capacity of systems or functions to preparedness for resistance, absorption and quickly recovery from the disaster impact.

The theory of resilience has been applied to the communities by focusing on the ability to absorb with the impact from the disaster and manage while disturbance for defend infrastructure, processes and reflection. Lhomme *et al.*, 2010 defined urban resilience "the ability of a city to absorb disturbance and recover its functions after a disturbance". That means urban resilience can be determined the capacity of city to proceed the patterns have deteriorated (absorption capacity) and to recover functions when disturbed (recovery capacity; Lhomme *et al.*, 2013).

The urban flood resilience has defined the ability of the city to resist flooding in order that prevent death or injury, and to maintain its social and economic emergency. That evaluate from levels of flooding or criterion of city can be absorb, which based on set of variables that reflected in many aspects such as security, livelihood, economic efficiency or rapidly changing social and economic of the city etc. (Adger, 2000) For these reasons, the resilience has known quickly in terms of the key concepts in the management of flood risk. By using a

systematic approach to analysis urban flood crisis which discern economy, population, environment, governance, network and house crisis (Lhomme *et al.*, 2010). In principle, the urban systemic model demonstrates the functions, structures and components which can be explain the working system in various fields, or show the relationship between parts of the system that could affect the other parts.

Therefore, the urban flood resilience is ability of the system, community or social to confront with danger and adapt by resisting or changing in order to maintain an acceptable level of functioning and structure. That is determined by the level of social systems to increase the capacity of resilience from learning disasters of the past to prevent damage and improve measures to reduce the risks that may occur in the future (UN-ISDR, 2004). This framework will need to be adjusted to more reasonable in order develop and evaluate the methods to manage flood risk. The resilience aims to protect the city as a whole and recover from the effects of severe flooding. The defence will be the following;

- Adjustment criterion of the system in relation to changes in response to the flooding.
- To determine the level of the system has the capacity to organize.
- To determine the level of the system has ability to create or increase learning and adaptation.

Moreover, the concept of resilience ecology is also a suitable framework for managing flood risk because is modeled from the real situation with a focus on practical living (Adger, 2000). And it is very useful for flood risk that occurred between the river and the transformation of the city. But the resilience of the ecosystem is not necessary to determine the factors that will help in its implementation which opposite of the urban has to be a pre-condition to ensure the right level of functionality (Batista *et al.*, 2013). Thus, the urban resilience was based on several factors such as population, social, cultural, economic, political, types of natural disasters or topography etc. However, these factors may vary according to the level of analysis.

3. A framework for analysis flood resilience of the community

The study of flood resilience requires three main issues for analysis: resistance capacity, absorption capacity and recovery capacity.

3.1. Resistance Capacity

Prevention measures and flood management is trying to learn and understand the impact of floods on the community, society or economy of people living in the watershed and floodplain. The flood risk consists of two components: the dangers and the impact that causes damage and social disruption. Traditional strategies in developing countries have largely focused on the management of risk with the aim of preventing floods that consider from resistance capacity.

Thus, in the context of the concept of resilience, resistance capacity can be considered as the starting point for the implementation of adaptation that protects the area from the impact of floods. Damage analysis of the system need to be aware of the damage that can occur to the system can absorb the failure and recovery. In addition, this approach can also help improve performance during a flood.

In fact, both absorption capacity and recovery capacity depends on resistance capacity, because if have the ability to absorb with emergency situations very well, then it would have caused less damage and recovery can be performed more quickly. Therefore, the resistance capacity should be analyzed by a dysfunction of the elements considered by complementing each other.

3.2. Absorption Capacity

The flood management is a continuous process, not only because floods occur every year, but also because of the nature and the impact of floods can be changed at anytime, resulting in a need to be adaptation strategies to absorb with the flood situation regularly. Also flooded each time, it is also an opportunity to make learning how to absorption capacity of communities that is efficient enough or improve defects to adapt and survival when the situation has intensified.

The criteria used to divide absorption capacity of the community identified two ways: first, if the damage is too severe, and second, if the disaster without violence. The response of coping is not enough to manage with the consequences of the risks and disasters, the cumulative effect of the condition prior to the incident and characteristics of the event. Overall, the local effects are mitigated by the community has the absorption capacity with the disaster itself.

The use of the response plan is an emergency plan in many ways to absorb the floods. Flood response plan to be successful will depend on the planning and coordination between local authorities with the people, it also depends on the time after the alarm. Therefore, the analysis of absorption capacity, it should be focused on that the study evaluated redundancy and distribution of each component.

3.3. Recovery Capacity

The context of disaster, recovery capacity means that all elements of society to the state before the disaster (De Bruijn, 2004). In other words, recovery is defined in the form of repairs to return it before the disaster,

including in the form of daily life for households affected by the disaster, and may improve resilience from events occurring in the future. But in some areas, still lack knowledge and decision making, and management was limited, reflecting the failure of policies to deal with the disaster, the plan to provide aid in a fair and timely or secure the negative impact of household such relocation etc. (Chandrasekhar *et al.*, 2013).

In general, recovery capacity is consistent with the ability and the time needed for the recovery of damaged components, which means if elements much damage, recovery elements will need more time. The duration of the recovery will depend on the impact, both directly, such as property damage and illnesses, and indirectly, such as stress or indirectly concerned with the situation. Of course, if there is little recovery capacity, the resilience will have to take a long time.

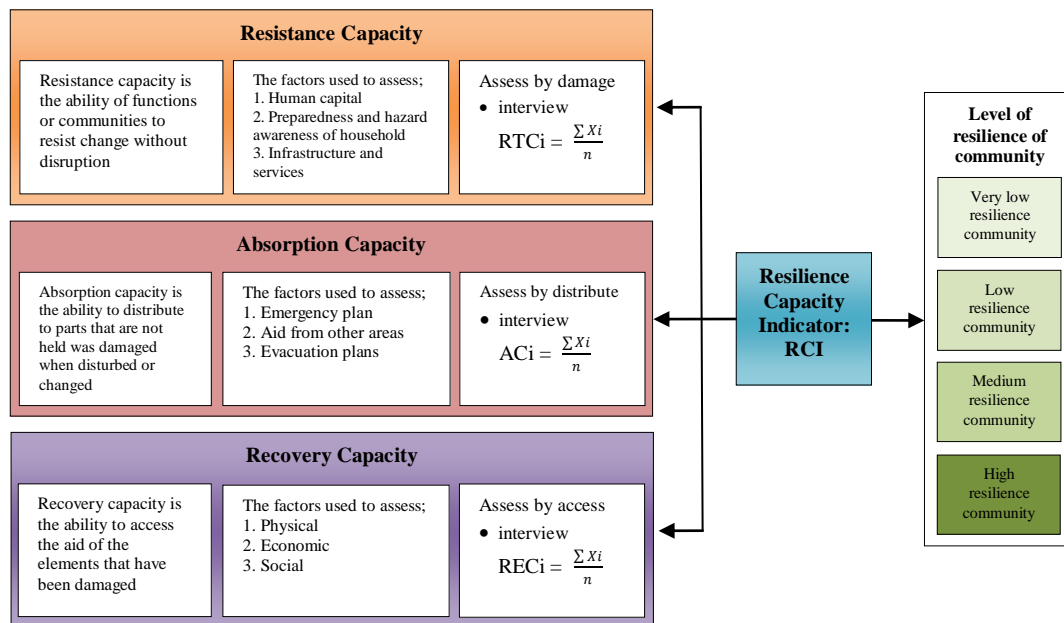


Fig. 1. A framework for analysis flood resilience of the community

From this framework, all elements were analyzed for urban planning disaster management, for administrator through people to be aware of ways to prepare together. To accept the fact that the disaster of the floods cannot be edited, but can mitigate the damage which will require the development of this concept continues to adjust strategies to absorb with the disaster is becoming severity and variability in the future.

4. Result

The indicators that three sets of capacities respect to different level of availability which are marked from 0, the requirement is not provided to 4, the requirement is fully provided. The resistance capacity, absorption capacity and recovery capacity was calculated and classifications that are represented in a map.

The results from three capacities in each community of Chum Saeng district, Thailand, contributes to the evaluation of the resilience capacity indicator (RCI) that has the total value from 1 to 12. Communities are very low resilience with a total of 2 accounted for 4%, communities are low resilience with a total of 24 accounted for 48%, communities are medium resilience with a total of 22 accounted for 44% and communities are very high resilience with a total of 2 accounted for 4% which the average value of 6.7 and a standard deviation of 0.4.

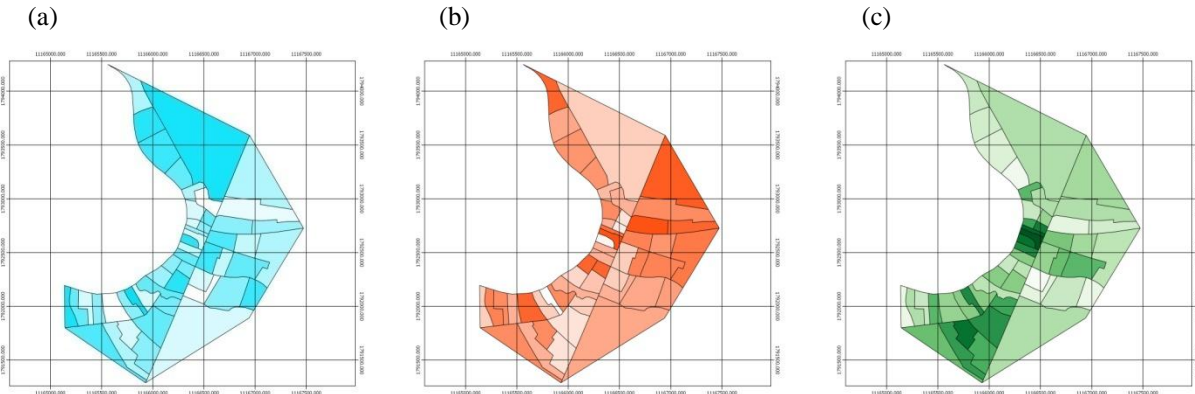


Fig. 2. Map of the resistance capacity (a), absorption capacity (b) and recovery capacity (c) of communities in Chum Saeng district

The RCI is a presentation format with the standard deviation which rating scales have been calculated and classifications in four levels. This way focus on the average of data, which each group of data is distributed sporadically from the average by the standard deviation. Within the standard deviation is indicative of the amount of data contained in each group as a proportion of the normal distribution. Community with the RCI least equal to 5.5 and the community with the most equal to 7.75.

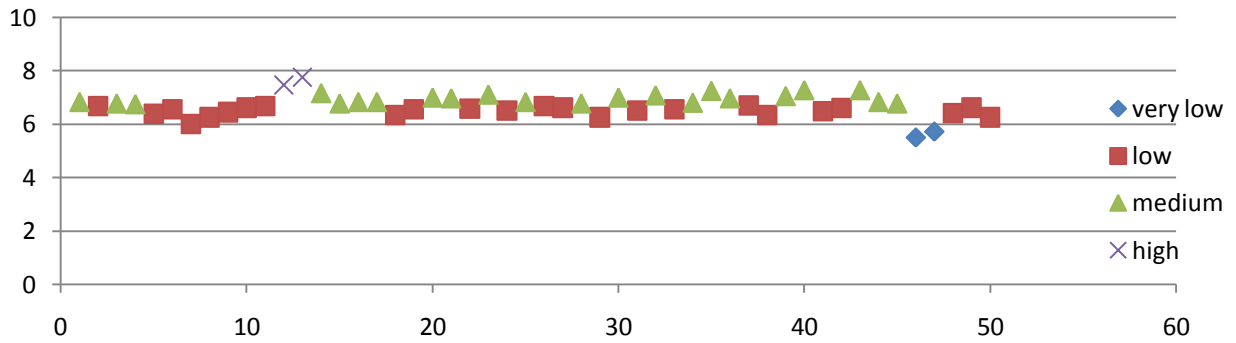


Fig. 3. Scatter diagram of the RCI of communities in Chum Saeng district

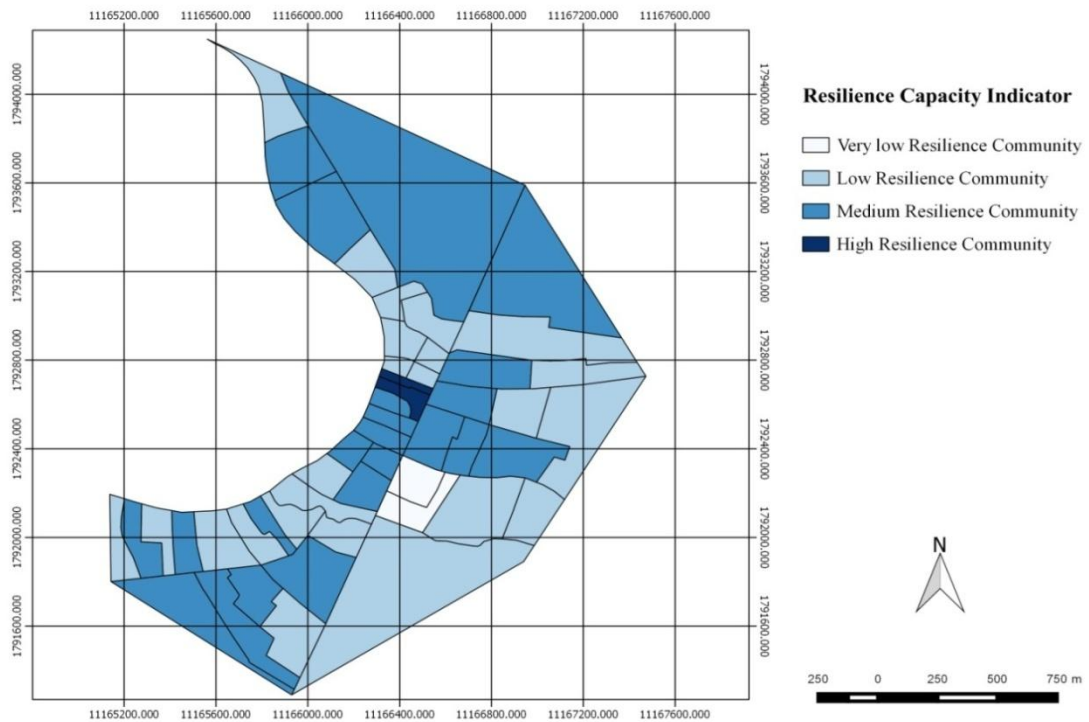


Fig. 4. Map of the RCI of communities in Chum Saeng district

5. Conclusion

The urban flood resilience is used to adjust to living on the flood. This approach will improve the existing urban structures and building systems to absorb with the damage to a minimum by having a focus on preparedness in many aspects such as the physical, economic or social etc.

This paper, indicators reflected that the procedures before the disaster to mitigate the danger or preparedness of emergency plan, which before disaster should be considered with recovery capacity. The RCI represents a tool for developing to assess community disaster resilience, demonstrating the benefits of GIS to show that such tools will help improve the resilience of the city. This focus on the two elements;

- Knowledge and understanding about the resilience represents the knowledge to applied and incorporate with the planning and management to create approach to absorb flooding. The stakeholders must participate in role and must have a common understanding.
- Processes of analysis by incorporate various factors, until steps implementation.

The resilience is essential process to have the ability to increase adaption. So when the resilience has improved, the system's vulnerability is reduced. Each district has a process to learn to live with variance or changes of the economy, social and environmental responsibility in the current situation. But confrontation with the flood situation in the future, which is not predicted, must be adapted effectively to be able to maintain the lifestyle and activities under to the changes. Therefore, the system must have the ability to resilience in order to be resistant to change and can be recovery a cause of adaption and sustainable development.

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