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FLOOD DYNAMICS AND RISK MANAGEMENT AT THE GIANH RIVER ESTUARY: ARE MEASURES ABLE TO REDUCE RISKS SATISFACTORILY?

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Abstract. Flood risk has always been one of the most significant challenges for sustainable territory planning, particularly in the context of climate change and urban growth. The Gianh River's estuary, located in central Vietnam, is regularly exposed to floods, causes significant damage to humans and material. The scientific background is crucial to improve flood risk management and propose measures to mitigate these risks. This article aims to analyze the causes of the worsening risk of flooding with two main steps: 1) applying hydrodynamic models to simulate flooding in 2013; 2) socio-economic field surveys conducted in 2020. The results underline the economic transition policy since 1986 has led to rapid urbanization. The coastal plains in Vietnam in general and in the study area are significantly affected by urbanization. This transition will have severe consequences on people and assets and the effects on hydrological characteristics. The speed of flow between the urbanized and agricultural zones in two communes: Quang Phuc and Quang Thuan (>0.5m/s and from 0.2-0.5 m/s). In final, the results also presents a flood hazard assessment under the climate change scenarios, used to assist decision-makers in urban planning and agriculture and reduce vulnerability. These studies can serve as a theoretical framework for flood risk management in other metropolitan regions worldwide.

Keyword: flood, Gianh River, urban, land use

1. INTRODUCTION

Today there is a consensus of scientists about the changes in the climate of our planet. The indicators of climate changes are the increase and multiplication of extreme weather events: flood, droughts, precipitation, etc. (Hirabayashi et al., 2013; van der Pol, van Ierland, & Gabbert, 2017). Among the extreme weather events, floods are considered one of the most dangerous disasters in the world because of its impacts on society and humans (P. Bubeck & A. Thieken, 2018; P. Bubeck & A. H. Thieken, 2018; Hu, Zhang, Shi, Chen, & Fang, 2018; Ward et al., 2017), from 1900 to 2016, there were 4,630 floods, or about 40 events each year. According to Pilon (Pilon, 2002), from 1981 to 1990, more than 147 million people were affected by the floods and this figures increased, reaching 211 million people from 1991 to 2000. CRED estimates that 3.6 billion people were affected during a little more than a century, out of which about 7 million died, and nearly 723 billion euros of economic losses are considerable. Simultaneously, approximately 61% of estimated financial losses are in Asian countries (H. D. Nguyen et al., 2021). Due to its geographical location, Asia is hit by major floods in very densely populated areas such as Thailand, Vietnam, China etc. (Avand et al., 2020). Between 2006 and 2016, this regions experienced more than 748 significant floods, including the flooding caused by the catastrophic HaiYen, Wutip and Nari in 2013. Flood risk is a critical land-use issue, and hazard in given territorial conditions determined by the organization of this area by human societies. To guarantee the cohesion of the national territory called into question by a large-scale flood, the legislator has defined a number of risk management tools.

Like many other countries in the world in general and Asia, Vietnam is deeply affected by natural hazards that cause human and material damage to the country's economy (Lemke et al., 2007). Floods and typhoons account for more than 85% of the total cost of damage due to natural hazards in Vietnam (Dutta & Herath, 2004; Smith, 2003), i.e., 10 billion euros from 1900 to 2016. Besides, emerging regions, such as the coastal region of Central Vietnam, where there are high densities of population, are the subject of several studies, especially since 1986, when the country's policy of renewal was enforced (H. Nguyen, Ardillier-Carras, & Touchart, 2018). Due to its geographical location, this watershed is favorable to habitation and industrial growth. This leads to a phenomenon of conversion of agricultural land into urban land, and consequently to additional risks due to submersion. The Gianh River in Quang Binh Province is representative for the physical and human characteristics of the Central Region of Vietnam, and the estuary represents a specific situation in Vietnam, which faces several challenges, i.e., ecological, demographic, and socio-economic. However, the Gianh River has not been particularly studied. Therefore, water management in general and flood risk in particular are essential for Vietnam. Several questions can be asked: Have current economic activities changed the hydrological behavior? Are facilities able to reduce the risks on the river or not?

The issue has been addressed in scientific and professional literature since the 1980s on three viewpoints; first, the assessment of the flood, to determine the reasons for the occurrence of this disaster; second, the reduction of their frequency and associated risk; and third, the reduction of risk with the appropriate measures. The traditional methods are mainly based on infrastructure, i.e., dam networks, or dams (Balica, Dinh, & Popescu, 2015; Rasid & Paul, 1987). However, population growth is driving the demand for land, and dam networks are not enough to deal with the flood risk (Mustafa et al., 2018). In this case, population growth reflects the increase in the probability of occupying the risk zone (Larsen, 2009). According to Visser et al. (Visser, Petersen, & Ligtvoet, 2014), the damage is linked to the increased exposure due to the growth of population and economy in the region. In addition, the change of land use influences the hydrological processes, which determine the flood risks (Wheater & Evans, 2009). Therefore, the question of risk prevention, beyond the work carried out on the floods, invites us to question the strategies carried out by the local authorities, on the presence of the floods in the city (Gralepois & Guevara Viquez, 2015; Schanze, 2006; Vinet, 2008). Moreover, the transformations of flows linked to the change in land use, make it possible to deal with the reconfiguration of knowledge and inter-professional relationships within the city's design (Gori, Blessing, Juan, Brody, & Bedient, 2019; White & Greer, 2006). In addition, land use planning constitutes the framework for the action, mainly the urban project led by local governments (Klijn, Kreibich, De Moel, & Penning-Rowsell, 2015; Zaalberg, Midden, Meijnders, & McCalley, 2009).

From the literature review, there is much research on the risk of flooding. However, these analyses are mostly local, and mainly focused on the natural causes, while the socio-economic causes aggravate an risk, are poorly addressed. Therefore, it is necessary to combine between the two and build up the theoretical framework for the management of river works in Vietnam and other developing countries where massive urbanization occurs in the context of climate changes. In this article, we aim to analyze in detail the consequences of this situation and the possible elements of improvement using several integrated methods of analysis, including hydro-dynamic modeling in conjunction with the analysis of anthropic effects. We focus only on the "risk of floods", related to localized rainfall and typhoons.

2. STUDY AREA

Gianh river watershed is located in Quang Binh province, the central region of Vietnam; its area is 4462 km^2 with the 158 km length, originating from CoPi mountain with 2017 m height belonging to the Truong Son range, flowing in the Northwest - Southeast direction entering the East Sea via the Gianh river estuary. The annual average precipitation in the river basin varied in range of 2000 mm – 2500 mm. Rainfall is mainly concentrated in September and October, accounting for 50% of the total annual rainfall during the period of large floods in this area. There are places where precipitation intensity reaches 600 – 700 mm during a 48-hour interval. Due to the steep terrain and heavy rainfall intensity, the time of concentration of the watershed is short, and the flood intensity causing huge human loss for communities along the river and downstream the river basin.

The approximately 116 km of coastline expose the region to several environmental disturbances linked to hydrography (floods, tropical storms etc.). Nationwide, Quang Binh province is the most exposed to extreme weather events (Nhu, Thuy, Wilderspin, & Coulier, 2011). For example, during the October 2010

floods, the two provinces most affected were Ha Tinh and Quang Binh. In the case of Quang Binh, during the hurricane season in 2013, the Gianh river watershed was strongly affected by super typhoon Wutip and then by typhoon Nari, causing great floods in this region. The rain was also heavy for 2-3 days with precipitation of 200 to 600 mm per day. The province lost about 8,000 billion Vietnam dong (about 300 million euros).

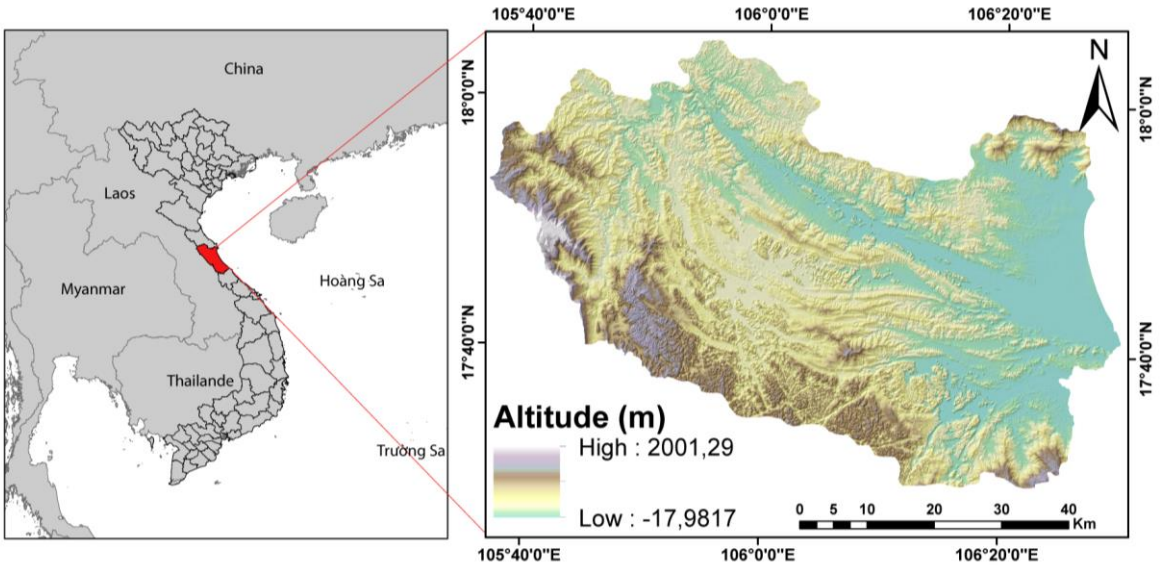

Figure 1. The location of the study area

3. METHODOLOGY

3.1. Hydrodynamic Modeling

In this study, the flood plain region located downstream was then modeled in MIKE 21 and linked with MIKE 11 through MIKE FLOOD. The 2D computational domain modeled was bounded by Mai Hoa gauge and Gianh estuary with an area of 181 km^2. A flexible mesh was generated by dividing the computational domain into 60362 elements with 30644 mesh nodes. The size of cell is in range of 70 – 100m. The development detail of this model has been presented in (H. D. Nguyen, Touchart, & Ardillier-Carras, 2014).

3.2. Socio-Economic Data

In order to understand the core concepts, opinions and analyses of the actual damages perceived by the local residents (especially household heads) about floods in general and Narie typhoon in particular, a household survey was conducted, using face-to-face interviews based on structured questionnaires. The main contents of the questionnaire were grouped in 5 main parts: 1) knowledge about flood risks; 2) memories of historically hydrological events; 3) concepts and actual damages under Narie typhoon; 4) opinions about the management and regulating flood risks measures implemented before and after floods, in relation to the prevention and protection strategies; and 5) concepts and opinions about the local planning of the flooded area. For the survey, 160 households were simple-randomly chosen in study area in 2020, frequently affected by floods in Quang Binh province, and 147 responses were collected. After data checking and validation, 140 responses were finally selected for the next step, i.e., processing and analysis, while 7 responses were not considered due to lacking necessary information and/or providing illogical information.

4. RESULTS

4.1. A Diagnosis Of The Gianh River Estuary: A Space Weakened By Floods

4.1.1. A Weakening Zone By Economic Activities: Have Current Economic Activities Changed The Hydraulic Behavior?

The different uses of water and anthropogenic activities, such as gravel extraction and deforestation, negatively impact the change of the flow of the river and worsen the risks related to water. The natural water system has been modified for centuries of human intervention in the effort to control water for the development of these fertile lands (Vörösmarty et al., 2004). The water management in these areas has a partially contradictory objective: to avoid surplus water during high water periods.

Rural settlements are made up of villages that can accommodate several thousand people, traditionally located on natural levees. In the downstream part, closer to the sea, the topography is more regular and the villages can also be installed in the lower areas. The population density is naturally higher where the agricultural potential is the best. This coastal area enjoys a strategic geographical location on a road between the North and South of Vietnam, connecting the two most important cities of the country: Hanoi in the north and Ho Chi Minh City in the south. In 2005, the two major seaports of Hon La and Gianh were developed by the Vietnamese authorities. This port development allows for economic exchanges and movement between the coastal region and the rest of the country, but also with neighboring countries such as Laos and Cambodia. Port cities are essential and strategic communication hubs in Southeast Asia. As centers of economic development, they lead in their wake the development of many industrial and craft activities. This is how, for a few years, we have seen the landscapes change at an impressive rate. Traffic routes were either reinforced or created.

The investments made in these areas are very important. One can also imagine the intense land speculation that exists around these changes in land use. The price of a parcel is multiplied during the establishment of a new axis of circulation, and some insiders take advantage, but rarely the farmers who initially owned these lands, since they are not necessarily the best informed about large infrastructure projects. An important scientific question is about this change: Have current economic activities changed hydraulic behavior?

4.1.2. Changing The Speed Of Floods

Land-use changes directly impact the genesis of floods since urban development and risk development are inseparable (Lehner et al., 2011; Metzger & D'Ercole, 2011; November, 1994). The demographic pressure causes the change in land use and increase in the number and / or value of exposures to hazards. This changes the flow conditions. Floods related to cyclonic events act differently on the modified estuary. This element is justified by the map of the speed of flood between two zones, one urbanized and the other not urbanized.

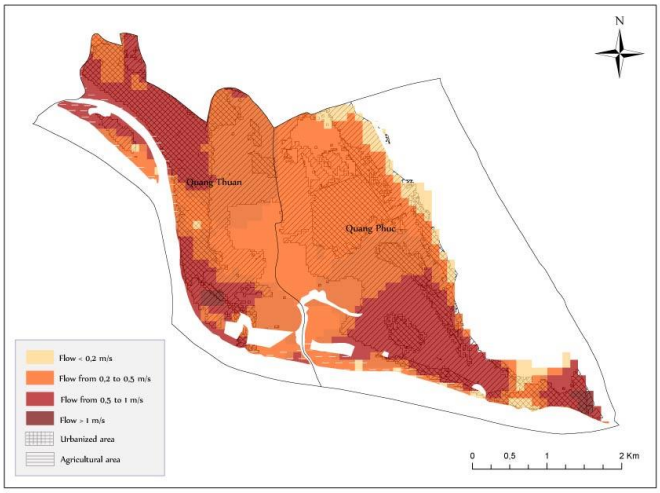

Figure 2. The flood rate in the urbanized zone and in the agricultural zone

Figure 2 shows the speed of flow between the urbanized and agricultural zones in two communes: Quang Phuc and Quang Thuan. Runoff is faster in the urban area (more than 0.5m/s). Interviews with residents downstream of the Gianh River confirm this fact, as "... the water level is rising faster and faster, so we do not have time to move the goods ...". Among the questions asked, one dealt with urbanization: "Does it still have indirect consequences for agricultural activity and is it therefore a major cause among the causes of pollution, the increased flood risk?" 71 people (50.7%) answered "Yes"; meaning that urban planning has indirect consequences, worsening the risk of floods because there are many problems related to the development or improvement of roads. For example, the drainage networks are not developed, so when the rain is heavy, the water cannot be evacuated, causing floods and dispersion of waste throughout the municipality. 69 people (49.3%) answered "no", meaning that urbanization has no consequences for the flood problem, since their plots and their houses are located on higher terrain. In addition, according to interviews with elderly people on the flood memory in Quang Thanh commune downstream of the Gianh River, floods occurring nowadays are faster than in 2007 and 2013, meaning that the water level rises faster

with high speed, causing difficulties for the inhabitants in protecting the property or moving. This causes great human and material damage.
The results show that the increase of impervious surfaces modifies the hydrological process and blocks the natural flow, eventually leading to floods. The poorly controlled urbanization causes a rapid rise in floods in the downstream sections. This increases the concentration of water and exposes neighborhoods to frequent flood risk. In addition, in the case of increased precipitation as analyzed in the previous section, the combination of heavy precipitation, saturated soils and impermeable soils highlights the potential for vulnerability in the urban area. (Yang et al., 2013). These cases are identified in several cities throughout the world where there is a strong urbanization, such as Chainnai in India or Atlanta in the United States (Debbage & Shepherd, 2019; Suriya & Mudgal, 2012). However, the priority of the Vietnamese central government remains the development of economy (Mottet & Roche, 2008).
The interpretation of all this information relating to land use, vulnerability and the analysis of their fluvial morphology allows for the presentation of a geomorphological map of flood fields and consequently the creation of risk maps. Infrastructure development in a fragile environment is combined with extreme climate change, which is then aggravating the risk of floods at the Gianh River estuary. What are the forecasts for future risks?

4.2. Flood Risk: What Are The Forecasts For Future Risks?

4.2.1. The Consequences Of The Floods Of 2013: Are The River Works Sufficient To Reduce The Risks Satisfactorily?

Floods are caused by a combination of extreme hydrological and meteorological patterns that can vary considerably in space. This is also reflected in the seasonality of floods. For example, the last major historical floods that caused extensive damage date back to 2013. This year marked popular memory because the flood exceeded the existing dikes and, as a result, breached some of them causing the flooding of large protected areas and significant material damage.

The Narie typhoon in 2013 was accompanied by torrential rains that caused floods at the Gianh River estuary. There were 300 000 victims, 22 dead and the damage amount to 320 million euros. The river submerged the dikes, flooding the neighborhoods of the study area.
Figure 3 shows the flood in October 2013, a historic flood of the study area. Some areas have been flooded for more than 3 meters, e.g., Bac Trach, Quang Phuc, or Quang Thuan. The flood caused great human and material damage.

From historical times to the present, and as has been the case in almost all countries of the world, the attention of policymakers and technicians has always been focused on the "hazardous" component of floods, and consequent attempts to minimize this hazardous component by structural measures. Dykes began to be built centuries ago. These containment actions have allowed the rivers estuary to accommodate such population density by giving, in the "normal" years, the means to produce rice in sufficient quantity to live.

In the case of the Gianh River estuary, two main categories can be distinguished, by decreasing vulnerability: inhabited areas and cultivated areas. Standardizing the level of protection by dikes actually had the effect of securing agricultural production, or, at the very least, of reducing the default likelihood. However, the level of dikes being still "low", in case of big flood these were exceeded, with consequences of thousands ofhouses were flooded. These figures indicate a bad management of land use planning and a large part of the population living in the area of high risk in the process of economic-social development.

According to the surveys, 75% of victims said that they had a very difficult life for 2 to 4 days following the storm. From the answers, we can understand that a large part of the population is settled in high-risk areas. This result cruelly highlighted the shortcomings of civil protection and logistical problems, e.g. difficulty in moving around the delta, absence of unsinkable roads allowing the distribution of aids, and insufficient and obsolete means of intervention. The poorest populations had to face the disaster by their own means (Zaninetti, Ngo, & Grivel, 2015). Moreover, the results show that the population lacks memories of the risks of flooding. Immediately after a flood, residents overestimate the risk of flooding. However, a few years after the worries are reduced, so the risk of flooding is underestimated. This results in a lack of preparation (Penning-Rowsell, 2003). Furthermore, urbanization significantly changes the social structure of the population of the delta. There is a very prominent land use conflict between urbanization and traditional farming. The populations currently residing in the most exposed areas depend on the river for their lives. They exploit the salt marshes through shrimp and fish harvesting. The development of new neighborhoods leads to an increase of the new populations, which do not know the memory of risk for this region. This situation raises questions about river management and risk prevention systems.

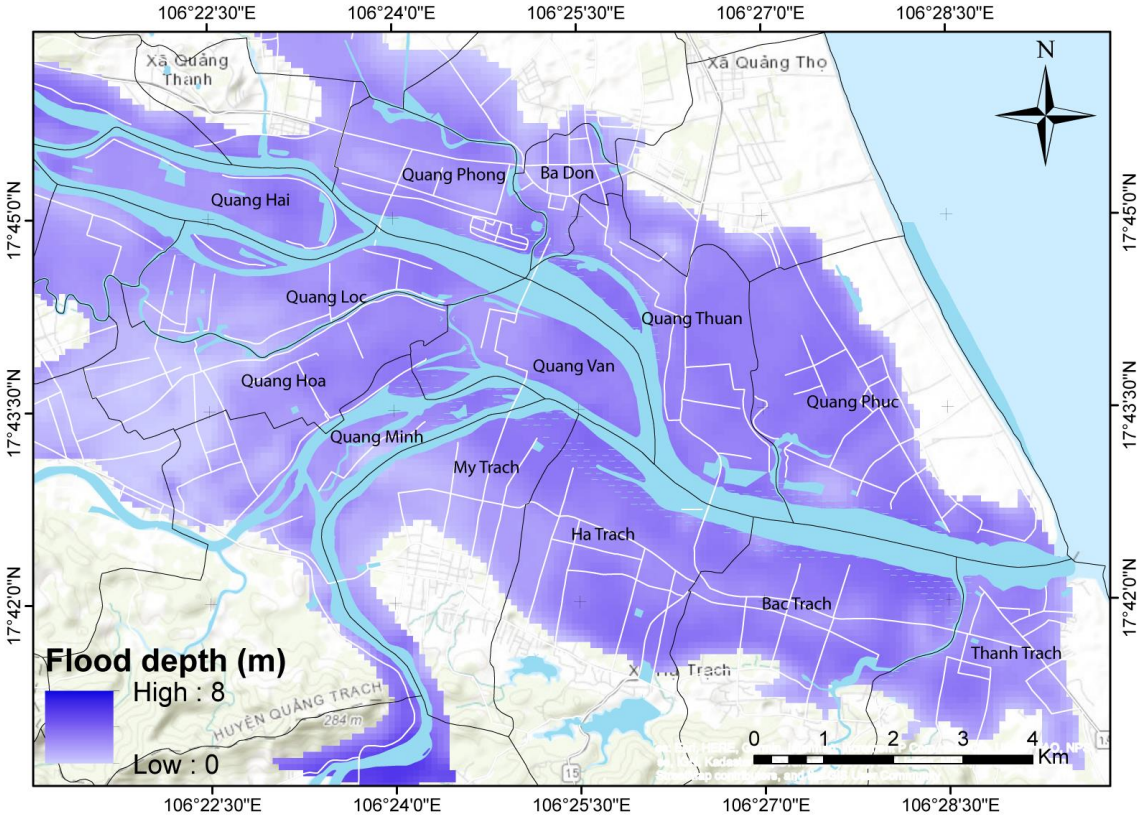

Figure 3. The flood map at the Gianh River estuary after the typhoon Narie 2013

4.2.2. Are Adjustments On The River Aimed To Reduce Risks Sufficient Or Not? Are The Prevention Systems In The Right Place And Adapted To The Situation?

Increased vigilance is an important step to improve the alert

Following the floods of 2010 and 2013, the management of the alert was strongly criticized in the Gianh River watershed. Investigating these events showed errors and the chain of alerts was missing. According to interviews with the inhabitants, the 2010 flood occurred during the night and people were not warned, so the disaster caused several deaths and material damage. In the case of the 2013 typhoon, a typhoon direction forecast highlighted the fact that the Gianh River watershed would not be affected by the typhoon. However, the typhoon suddenly changed direction and caused difficulty for the relief organization. Therefore, the effectiveness of the alert must be better in order to reduce damage in the watershed.

In addition, the technical progress and complementarity of data processed in meteorology, hydrology, etc. allows for better flood forecasting. According to Stéphanie Defossez (Defossez, 2009), precise techniques exist, such as the satellites used by the USA that have a short delay between the forecast and the occurrence of the event. Moreover, with the poverty of the watershed and the populations living there, this has resulted in a lack of financial and human resources in the vigilance of disasters.

It is therefore increasingly urgent that land-use change decisions take into account these exceptional floods, which can occur as early as next year, or ten, twenty or one hundred years from now on.

Land occupation in exposed spaces

Obviously, human activities at the Gianh River estuary, especially a part of industrial, handcrafts, and agricultural activities, are located on flood-prone land. Thus, spaces known to have been impacted during past floods are still occupied by the populations. A precautionary approach to land use in particular is difficult to put in place. New buildings and industrial parks will be built in 2030 on the thousands of hectares of agricultural land of the Gianh River (H. Nguyen et al., 2018). The investments made in these new factories and workshops are very important, as the predominantly agricultural provinces of the coastal zone being currently attractive destinations for foreign investors because they enjoy both a favorable geographical position and a cheap young and abundant workforce. The Vietnamese government sees the establishment of these new business clusters very favorably since they make possible to create jobs on the spot and to avoid the rural exodus towards big urban centers and industrial complexes (Gendreau, 1993). According to the field surveys, 100% of respondents do not know certain risk areas. This leads to poorly controlled

urbanization. Although major improvements have been made to protect the new human activities, they failed to move within.

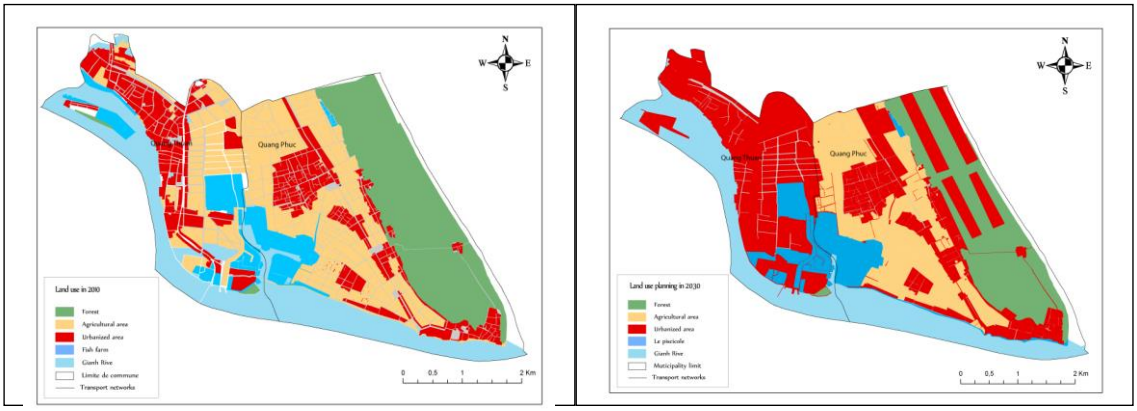

Figure 4. Changes in land use from 2010 to 2030 in the Gianh River estuary

Figure 4 shows the land use at the Gianh River estuary in 2010 and 2030 forecasted urbanization in the two communes of Quang Thuan and Quang Phuc. Urban areas in Quang Thuan commune will completely replace rice-growing areas, and part of the coastal forest will be destroyed to build a seaside tourism site. This change attracts new populations in the flood zone. The reinforcement of the dike network was carried out to protect the populations, but especially the elements of the vulnerability are forgotten when planning for the territory.

In Vietnam in general, and at the Gianh River estuary in particular, the attention of policy-makers and planners has focused mainly on the hazardous components of flood risk. This resulted in the implementation of structural measures such as dikes, reservoirs etc. However, this measure only responds to overflows. Nevertheless, in recent years, the low height of these structures and the poorly controlled urbanization allowed for a surplus of water in times of flood. When the dikes were exceeded in the case of major floods, this led to material and human damage. The reinforcement of the flood protection dikes is not a good solution; it is very difficult to end it forever with the floods and the stagnation of the waters. The higher the dikes, the higher the flood threat (Liu, 2004). So vulnerability cannot be forgotten in the land use management or protection of property and people. The readjustment of land use becomes a necessary and urgent measure, effective in solving the flood problems at the Gianh River estuary.

4.3. Non-Structural Measures Are Very Important For Flood Risk Management

Populations and risk management: the protection of goods and people

The morphology of the Gianh River estuary has always been dictated by the topography of the territory, where water has always played an important role in daily life and wet rice agriculture. In order to protect against floods, settlements were initially located in areas known to the population to be historically out of the reach of water and, if necessary, partially backfilled (village-island), or on dikes, also serving as communication network (village-road) (Mottet & Roche, 2008). The inhabitants have gained experience in the fight against floods. With their experience, they have been able to implement several types of measures to reduce damage to people and property. During floods, the floors of dwellings are refuges, which allow for getting out through the roofs and escape from the water knowing that its height, more than 4 meters, frequently exceeds the ground floor. During the field missions, we were able to note the main reason why the inhabitants have to adapt their dwelling to the risk with an elevation of a floor: to limit the damage in anticipation of a flood.

According to an interview with a farmer in the town of Quang Phuc on the memory of risk, we can cite the role of the great floods of 1985 which caused significant damage to people and property. This led to a raised roof for safety. From the year 2007, several inhabitants have rebuilt buildings with floor to protect against floods. They raise the floor level of the ground floor by approximately one or two meters, with access by an external staircase and consolidate the house with shelters to limit the effects of floods. However, these changes only prevent small events. They are not effective for heavy floods (Porio, 2011; Porio & See, 2015). To reinforce protection facilities, consolidation measures for concrete houses have been put in place for walls and roofs.

Figure 5. The walk of an elevated house downstream from the Gianh River

In this house of Quang Phuc commune, the steps are raised about 1m and the house has been consolidated to reduce the influence of flood.

According to downstream survey statistics, 49 people (35%) live on their rooftop for two to three days during the flood, 52 people (37.1%) go to refuge in schools, and 39 people (27.9%) sought for refuge in a nearby concrete house in a higher position. The new land use model is less suitable for the flood risk than the previous one, although the new protection networks serve the new layouts. The new urban districts are more vulnerable because their rural population, aware of the risks will be displaced and replaced by a larger urban population placed under the very relative protection of the dikes disconnecting it from the river.

Land cover management from the risk map

During the urbanization process, because of the limited space, urban sprawl determines the transformation of adjacent natural or agricultural systems into urban areas (H. Nguyen et al., 2018; Petrisor, Ianos, & Tălângă, 2010), affecting the environment (Peptenatu, Draghici, & Merciu, 2012) and exposes the population to additional risks (Álvarez, Gómez-Rúa, & Vidal-Puga, 2019; Armaş, Toma-Danila, Ionescu, & Gavriş, 2017). This is why the establishment of the risk map is very necessary to help urban planning.

Construction projects around the Gianh River's Estuary do not have the necessary infrastructure support, such as adequate drainage, sanitation, and ronetworksork. The resulting floods become intense because they are not really suitable for housing or commercial or industrial use because they are mainly wetlands.

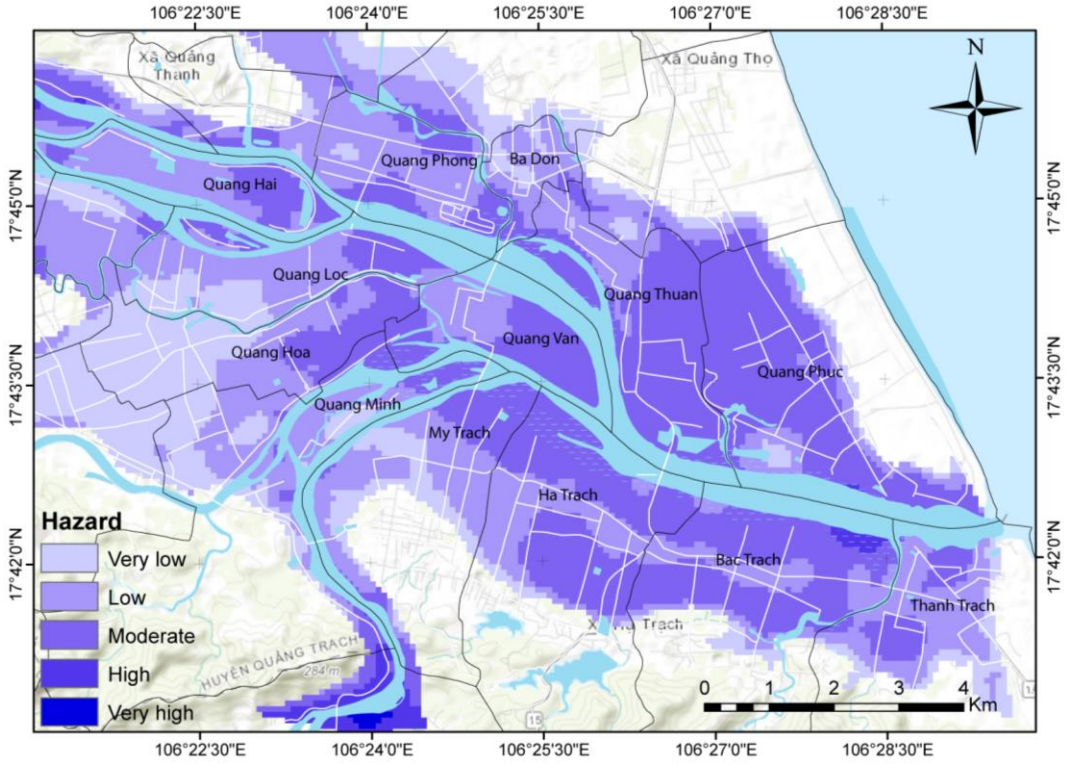

Figure 6. Flood hazard assessment in the Gianh river estuary

Figure 6 presents a flood hazard assessment under the climate change scenarios used to assist decision-makers in urban planning and agriculture, and reduce vulnerability at the Gianh River estuary.

From this map, we can offer some ideas for landscape planning in the area. Regarding the flood of the river estuary, we recommend not installing new buildings and reducing the number of inhabitants in areas where the hazard is strong, very strong, and extreme. In areas of low and medium hazard, where the risk is moderate, it is possible to keep the current number of the inhabitants. This map could provide the authorities a plan for the mobility of people exposed to floods. In addition, they can improve the organization of relief and rescue of victims.

5. DISCUSSION

Provided that the research on flood risks is increasingly developing in Vietnam, the present study assesses the combination of human and natural impacts, which has been insufficiently addressed, particularly at the local level. In this study, the Gianh River watershed was selected as the case study because this area shows significant natural and human characteristics for Vietnam.

Like in other cities of Asia, the "urban" status of a territory is the subject of an administrative decision. This territory may include portions of rural space. This growth increases the risk of flooding. Therefore, this study is an important tool for assessing the flood risk, including the topographic and climate factors, and human activities (urbanization). Flood events influence the populations and socio-economy of the study area directly. Flood risk management strategies can help reducing the damage and the effects of flood risk in the region. Before the floods, risk reduction actions can be carried out, and the population can be urged to go to the refuge if necessary. In addition, the flood risk map provides useful global information to prepare the local protection strategies. Besides, the study produced the geospatial databases and contributed to the theoretical framework for understaing urbanization of the flood zone, useful for other regions in Vietnam and other countries where urbanization needs to be addressed using hydrodynamic modeling and local knowledge. Our study has the potential of continuing to improve the process of flood risk reduction through land use change strategies. This represents a scientific, technical, political and social advance in the field of flood risk management.

The first objective of the Vietnamese government is to carry out a flood risk assessment and create a management framework for reducing the risk of human and material damages. With this objective, the local committee can draft tailored strategies to detect the main flood risks and locations. The objective of flood

risk management strategies is to improve the land use planning in the flood zone. For this purpose, several researches have used modeling with different risk prevention scenarios. For example, in the study by Kourgialas and Karatzas (Kourgialas & Karatzas, 2011), the authors tried to simulate a flood prevention scenario in the future to find out if anything can be change. Similarly, Tran et al (Tran, Shaw, Chantry, & Norton, 2009) built up a flood risk map for risk management purposes.

As it can be seen, there are techniques, analyses and studies allowing for different simulation scenarios, and the identification of risk zones. In addition, the recommendations for different land use management techniques aim to increase the water storage capacity. Therefore, the integration of local knowledge and analyses of the effects of urbanization in the management of flood risk can improve the quality of the protection strategy against floods by contributing to decision-making with a more global perspective of the different aspects of disasters and role of local populations and regional planning. This study can be used in different fields and other countries. The main conditions are for the local authorities to accept the approach and recognize that the process of urban planning must take into account the flood risk.

6. CONCLUSION

At the Gianh River estuary, natural environmental conditions are particularly conducive to flood processes. This environment is more sensitive as the violent rains are concentrating in only four months. The urbanization also aggravates the consequences of floods. This article highlighted all the dynamics of floods and risk analyses. These tools are related to the physical characteristics of the territory, economic growth, demographic, and the history and culture of the country. The management of flood hazards must take into account the current needs and requirements related to the protection of the environment. The solutions suggested at the end of this article could limit the damage due to submersions and typhoons. This is one of the objectives of this work, and we understand that suitable answers are more complex.

The country's economic, industrial and technological development will undoubtedly bring new means and solutions to adapt to the constraints associated with floods. However, the psychological and social changes coming with it, including urbanization, population density, memory loss of risks, etc., make normal floods extremely dangerous when the protection rings collapse. Therefore, Vietnamese gouvernment should focus on reducing the vulnerability of the population to floods.

Modern methods exist today to facilitate thinking and help making wise choices, but many efforts are still needed to ensure that both technicians and policymakers learn to take these elements into account and change the way how they integrate the flood risk in rational development policies.

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