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Methods of Management in a Tropical Floodplain and Hydrological Modelling, the Case of Gianh River (Vietnam)

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***Abstract*—*Problems associated with flood risk definitely represent a highly topical issue in Vietnam. The case of the lower Gianh river in the Central region of Vietnam with an area of 353 km² which is regularly subject of flood risks, whose the scientific question is strongly linked to flood risk management to limit its risks. The flooding analysis and management in this area requires a basic understanding of the hydrology in the River. The paper presents the hydrological modelling for the hydrological analysis and the flood management to orientate the risk prevention policy, as well as to help decision makers develop a floodplain for urban planning, to reduce vulnerability of the area which are based on the risk map and the flood hazard it through hydrodynamic modeling. In this article, we gave proposed structural and non-structural methodologies for flood management in the study area.*

***Keywords*—*Hydrology, Modelling, Flood risk, The Gianh River.*

I. INTRODUCTION

In recent years, natural disasters have caused many risks in the world. Flooding is one of the major disasters that causes the greatest human and material damage in the world (Garnier, 2008). Natural hazard exposure is inherent in many territories (Tiberghien, 2008). This is particularly the case in Vietnam, where two thirds of the territory are in the littoral zone (Source: Atlas Vietnam 2010), which are always affected by typhoons. On approaching the coast, typhoons cause marine surges and heavy rains. These phenomena cause flooding in coastal areas.

The Gianh River catchment in central Vietnam has been subjected to flooding in the last decade, with unprecedented economic and social consequences in Vietnam. Each year, four to six typhoons affect Quang Binh province, two of which directly hit the province (for example, in 2013, typhoons Wutip and Nari, considered to be the strongest in the province's history, caused heavy flooding). "For the risk of low-level flooding, it is a hydro-meteorological hazard (cumulative rainfall most often) causing large floods leading to an overflow from the minor bed or a rise of the water table, and A flood" (Jousseaume, 2004). This phenomenon is recurrent every year. Thus, people do not deprive themselves of occupation and develop these territories subject to recurring natural hazards (Ngo, 2014). "Hydrological forecasts and evacuation plans also reduce flood damage in sparsely populated areas where property values do not warrant other means of protection and where loss of life can be avoided through Rapid evacuation"(Kamal, 1990). Therefore, this article presents the basics of river hydrology, as well as flood hazards in the catchment areas, in order to enhance risk management and to provide policies for people and property protections.

The first part of this article presents the characteristics of floods and their consequences in the watershed. We will then use hydrodynamic modeling to simulate historical flooding in the watershed. Lastly, we will propose alternatives to study flood management, including flood risk prevention plans based on the risk map for development in the watershed and structural construction.

II. FLOODING IN THE GIANH RIVER WATERSHED

The Gianh River watershed is located in the northern part of Quang Binh Province, central Vietnam. It is the largest river in the province; the main stream is 158 km long, with an area of 4680 km² (58% of the province's surface). It originates in the mountainous Copi region, northwest of Quang Binh province. The topography of the Gianh River watershed is very complicated, with three distinct topographical features: mountains, valleys and plains.

This mountainous area includes the Copi mountain range to the west as well as to the Truong Son mountain range. The valleys have an altitude of between 5 and 20 m, with a width of 1 to 3 km, while the plains vary from 0 to 4 m of altitude with approximately 10 km of width (Source: Atlas Vietnam, 2010). During rainy seasons, this region is always confronted with flooding because of the overflowing of Gianh River. Moreover, upstream of the Gianh River, the slope of flow is high (more than 6%) over two-thirds of the river's length and then decreases in the delta. On the other hand, the slopes are low downstream (minus 2%), therefore during floods, the flow velocity is less.

The Gianh River is characterized by a very dense hydrographic network with three major tributaries: the Rao Tro River which is 68.5 km long, the Rao Nam River of 86 km long, and an 84-km-long Son River. The total flow rate is more than four billion m^3 / year for the Gianh River and nine billion ^{m3} / year in the watershed. Precipitation exceeds 2,500 mm to 2,800 mm per year upstream and 1,500 mm to 1,800 mm downstream. The very dense hydrographic networks associated with high precipitation are factors aggravating the risk of flooding (Deffossez, 2010).

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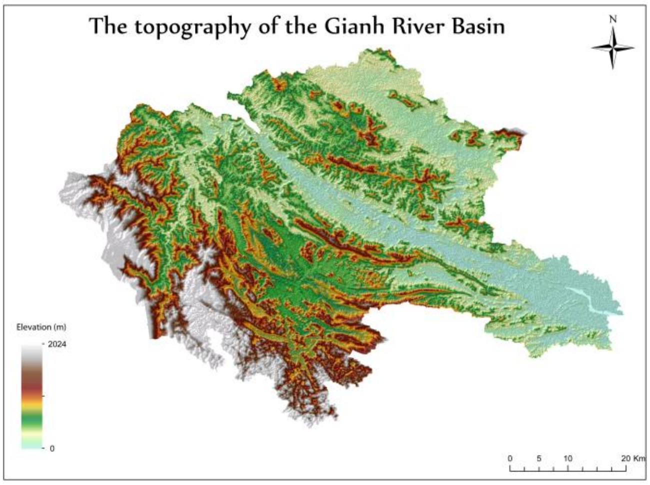

Fig. 1. Geographical location and the topographic of the study are.

The flooding of the Gianh River watershed takes place during the months of September to December. According to statistics from the Provincial Geometeorological Department, between 1961 and 2005, more than 46 floods occurred during the month of September, 62 in October and 16 in November. Several years ago, the floods were mostly between June and August and rarely exceeded to December. The annual average flood level of the Gianh River is 3.2. We can explain seasonal flooding by precipitation and typhoons.

When the typhoons arrive at the coast, they cause increased rainfall, resulting in floodings of the watershed. From 1970 to 2013, 106 typhoons hit the watershed. From August to November, these mainly affect the central part of Vietnam. It is noteworthy that 4 months of the year stand out from the rest, peaking in October, followed by September, which recorded more than 40 typhoons during the period from 1945 to 1998, then November and August. After the month of November, the number of registered typhoons decreases. Each typhoon is accompanied by rains, causing torrential flooding in the upper basins and also floods (Pham, 2008 and Ngo, 2014).

The precipitation study will be based on data from stations along the river since 1970. Seasonal precipitation on the watershed is shown in figures below. They show monthly precipitations of Dong Tam stations upstream, and Ba Don in the river delta, which are strongest from August to November. The majority of the floodings take place during this season. Rains often take the form of a typhoon or a storm, and are therefore intense. "The heavy rains associated with the passage of a tropical cyclone associated with gusts of wind and very low atmospheric pressures can have disastrous consequences during torrential floods" (Lorion, 2006). Altogether, they make the risk in the watershed worse.

At the Gianh River basin level, the results are more mixed: the two stations were analyzed and showed that the annual cumulative precipitation between 1980 and 2012 indicates a downward trend in the watershed, but with an increase in the number of days when the rain is strong. According to population surveys and interviews with municipality officials and provincial departments, precipitation in Quang Binh province in general and the Gianh River catchment in particular have decreased in recent years. However, precipitation increased in short-terms and during flood sequences, or during the passage of very large-surface, which increases the risk of flooding.

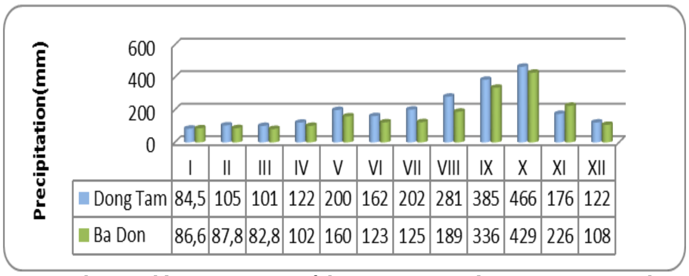

Fig. 2. The monthly precipitation of the Dong Tam and Ba Don station in the Gianh River watershed.

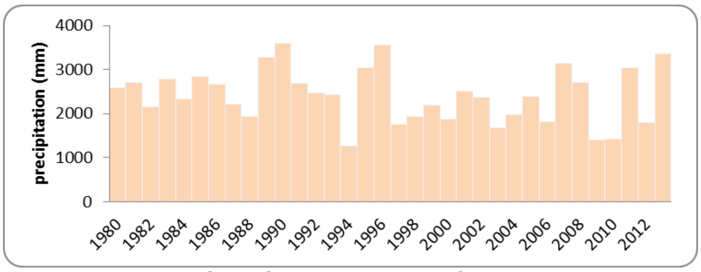

Fig. 3. Average annual cumulative precipitation at the Dong Tam station in the upstream.

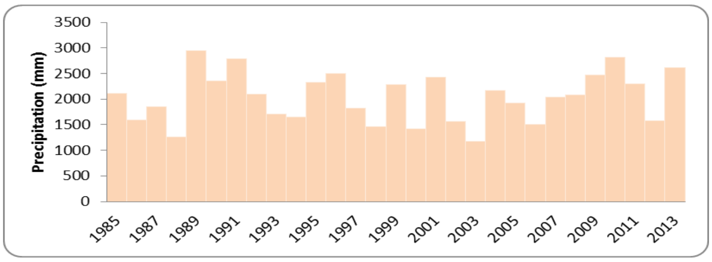

Fig. 4. Average annual cumulative precipitation at the Ba Don station in the downstream.

The break point in 1994 for annual maximum flows can be verified on the graph below: on average, the maximum flow rates are lower for the second period than for the first. However, the number of years when the higher flows are more often in the second period than the first. This is one of the factors that causes the worst flood damage in the watershed.

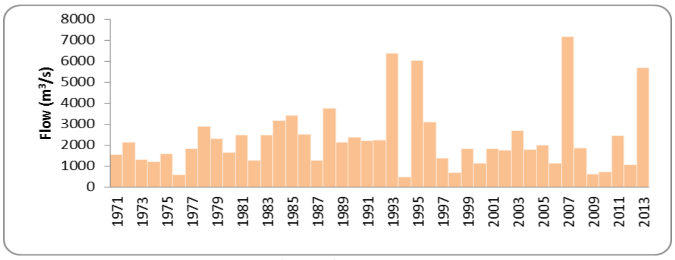

Fig. 5. The maximum annual flows for the Dong Tam station in the Gianh River from 1971 to 2011.

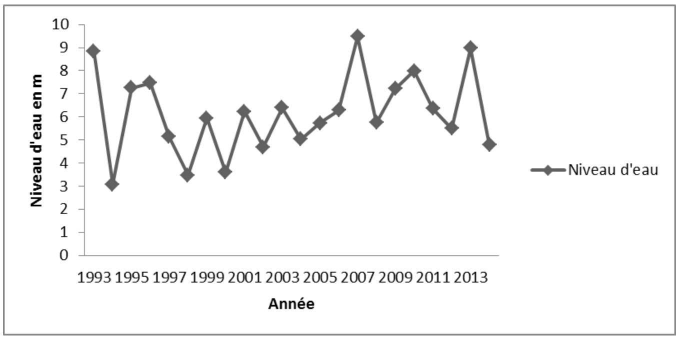

Fig. 6. Evolution of peaks in water levels at the Mai Hoa station of the Gianh River (1993 -2014).

Two figures 5 and 6 above show the maximum flows and peaks of water levels at the Dong Tam and Mai Hoa stations above the Gianh River. Flow rates can reach 7000 m^3/s and peak water level may go over 8 m as in the floodings of 1993, 1995, 2007 and 2013, during which precipitations exceeded 600 mm/day. This, associated with rich network hydrology, causes large floods in the watershed.

In the study area, there is no flood map and risk map for risk prevention and help with land use planning. Thus, we will use hydrodynamic modeling to simulate flooding history to help with flood management.

III. The Hydraulic and Hydrological Modelling under Mike Zero

A. The Database

The topography data: In this research, DTM is created using 10m of contour line. DTM is processed through ArcInfo and ArcView. This processed topographic data is provided as an input to hydrodynamic model MIKE 21 to determine the flood plain (Ahmad, 1999). The cross sections were issued from the Natural Resources and Environment Department of Quang Binh Province: 20 cross sections on the Gianh River, 10 on the Son River, 4 on the Rao Nan River and 6 on the Rao Tro River. They are used in the one-dimensional model MIKE 11.

The hydrologic data were obtained from the Ministry of Natural Resources and Environment in the 8 hydrometric stations (Tan My, Ba Don, Phuong Lap, Tan Lam, Mai Hoa, Rao Nam, Dong Tam and Tuyen Hoa). Only 2 stations (Dong Tam and Tan Lam) measured the flow. In fact, we only have the flow data on Gianh River from Dong Tam station from 1960 to 1980; and Rao Tro River from Tan Lam station from 1970 to 1980. Based on rainfall data from the hydrometric stations, using GIS, we can calculate the rainfall of floodplain on Gianh River. Also, using rainfall and evaporation data, we can calculate flow using hydrologic model “MIKE NAM” in order to use them as boundary conditions for the one-dimensional model of MIKE 11. The flows at Dong Tam station on Gianh River from 1960 to 1980 and at Tan Lam station from 1972 to 1980 on Rao Tro River are used to validate this model. Furthermore, using this model, we can reconstruct data of the flow at each station to accommodate our research.

A partir des données de précipitation à ces stations, nous pouvons calculer les précipitations sur la zone inondable dans le bassin versant pour servir par exemple les conditions aux entrées avec la modélisation hydrodynamique.

B. Hydrological Modelling Rainfall-Debit

In the watershed of Gianh River, there are 8 hydrological stations, including two stations on the tributaries of Gianh River. However, there are only two stations on Gianh River to calculate its flow. Unfortunately, they do not work anymore, so we have to use "Mike-Nam" hydrological modeling to calculate the flow of the river. Dong Tam station’s flow from 1960 to 1980 and Rao Tro River’s flow from 1972 to 1981 were used to validate this model. Using this model, we restored flow data at each station to complete the research, as well as to understand the hydrologies in order to analyze and manage floods (Hafezparast, 2013).

The MIKE 11-NAM model is used to estimate daily runoff for the Gianh River watershed. The calibration period was from 01/01/1971 to 31/12/2013 and the validation period was from 01/01/1971 to 31/12/1981. Following the self-calibration procedure for NAM model, the NAM parameter of the model is calculated and then the simulated discharge is compared with observations. Considering the structure of the NAM model, it appears that the final calculated values of the model parameters represent hydrological (source: Hafezparast, 2013).

To calculate flow of the river, precipitation data per day at Dong Tam station upstream of Gianh River are used (because on the Gianh River we can not ask the Ministry of Natural Resources and Environment).

The final values of NAM parameters that were added during/into the calibration process are shown in the table below:

TABLE I. NAM parameters determined during calibration.

Parametres	Description	Final value
Umax (mm)	Maximum water content in surface storage	10
Lmax (mm)	Maximum water content in root zone storage	101
CQOF	Overland flow runoff coefficient	0.9
CKIF (hr)	Overland flow runoff coefficient	277.6
Ck1,2	Time constant for routing overland flow	25
TOF	Root zone threshold value for overland flow	0.11
TIF	Root zone threshold value for interflow	0.258
TG	Root zone threshold value for GW recharge	0.139
CKBF	Time constant for routing base flow Lower base flow	1168

The figure 7, 8 shows the results of the Nam model for the periods 1971-1981 at the Dong Tam station with the coefficient of Nash is 0.806 and 0.92 for the Tan Lam station.

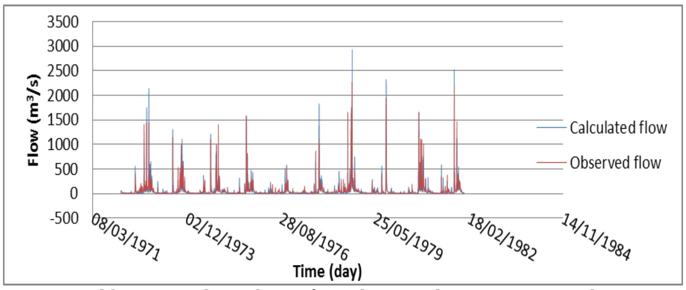

Fig. 7. Calibration under Mike 11 from the period 1972 to 1981 at the Dong Tam station on the Gianh River (Huu Duy, 2015).

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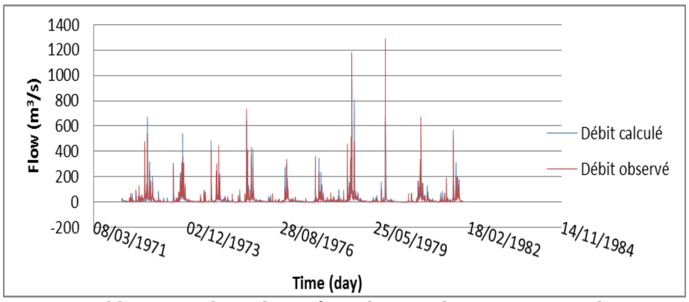

Fig. 8. Calibration under Mike 11 from the period 1972 to 1981 at the Tan Lam station on the Gianh River (Huu Duy, 2015).

C. The Hydraulic Modelling under Mike Flood

Application of 1D modelling: "The MIKE 11 is an implicit finite difference model for one-dimensional unstable flow computation and can be applied to loop networks and quasi-two-dimensional flow simulation on floodplains. The model was designed to perform detailed river modeling, including special treatment of flood plains, roadside roofs, culverts, door openings and drills. A complementary geographic information system (GIS) module provides an interface for displaying the results of river modeling for floodplain management" (Admad, 1999 and Kamel, 2008). The hydrological networks in Gianh River watershed are described in a hydraulic diagram which includes Gianh River with 20 cross sections, Rao Tro River with 6 cross sections, Rao Nan River with 4 cross sections and Son River with 10 cross sections (Nguyen, 2016).

Application of 2D modelling: "The tool used for 2-D hydrodynamic modeling in this study is MIKE 21, developed by the Danish Hydraulic Institute. MIKE 21 is a complete modeling system for 2D free surface fluxes and can be used for the simulation of hydraulic and related phenomena in rivers, lakes, estuaries and coastal areas where stratification can be neglected. Typical areas of application are modeling of tidal hydraulics, currents generated by winds and waves, storm surges, flails and flood waves" (Admad, 1999). The limit of flood plain is determined by the topography map associated with the documents on the historic flood, in order to cover the entire flood plain. The topography data is processed through ArcInfo and ArcView. The topographic data are provided as an input to the hydrodynamic model Mike 21. Boundary conditions are fully taken into account by the 1D model.

According to the report characterizing the hazards, the stakes and the vulnerability on the Douvenant valley: Coupling the 1D and 2D models**:** MIKE FLOOD is used to couple the 1D and 2D models. According to the reports from DHI in 2015, coupling these two models allows us to use the best qualities of each, avoiding or reducing disadvantages encountered if they are used separately, and MIKE FLOOD offers the opportunities:

- To represent the runoff in a minor river bed by a 1D model perfectly suited to topographic cross sections type of data;
- To represent the overflow of a minor river bed to flood plain by lateral links
- To represent the runoff in a flood plain in a 2D model by providing a detailed description of the fields of speeds and flooding heights;
- To generate mapping directly under a GIS.

Data from Mai Hoa and Ba Don stations from Wutip and Nari typhoons are very important in comparing calculated water levels and observed water levels to validate the model. In this model, the coefficient NASH is 0.759 in comparing from Mai Hoa hydrometric station.

Moreover, the model was calibrated and verified using field control data (on the flood heights measurements), and on interviews with the community and local councillors (140 measuring point and inerviers) from a realistic program in 2015. The highest level of the flood calculated in the model matches the measurement and interviewed data. Also, according to the data interviewed from the community, counsellors and reports from Quang Binh Province's Center of Flood, Storm Control and Rescue, in October 2013, there were 2 floods resulting from the Wutip and Nari typhoons. In consequence, regarding the compared data above, we can validate the model.

D. Results

Dans cette étude, nous avons simulés deux inondations qui proposaient par le typhon de Wutip et Narie. Deux inondations sont plus grandes dans l'histoire qui ont proposés les grandes dommages sur matériel et humaines.

On 30th September and 16th October 2013, Wutip and Nari typhoons, accompanied by huge rainfalls in this province resulted in a terrible flood on Gianh River and Quang Binh Province. This disaster caused 15 deaths and 250 million euros of damages. They were considered the two worst typhoons ever in this Province. Water in Gianh River flooded the watershed community.

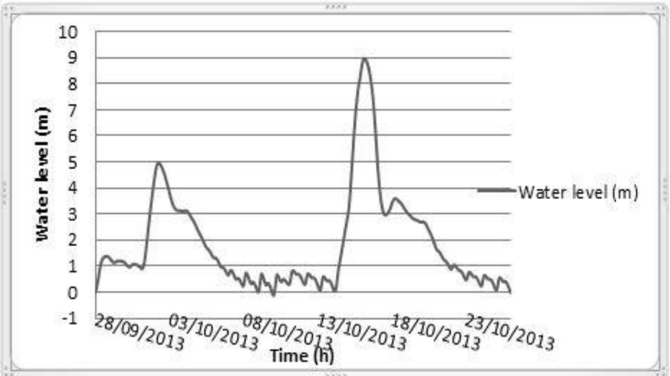

Fig. 9. The Water level at Mai Hoa station in the upstream (Huu Duy, 2015).

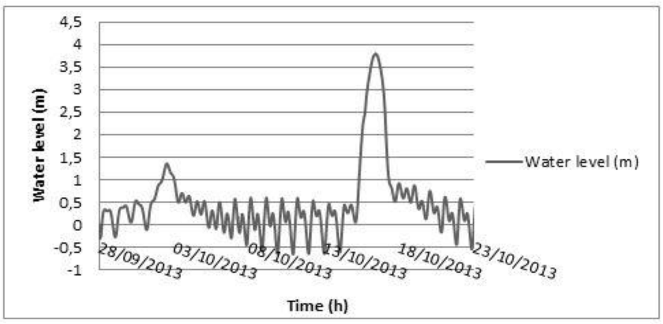

Fig. 10. The Water level at Ba Don station in the upstream (Huu Duy, 2015).

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- At Mai Hoa station, there were 2 peaks caused by Wutip and Nari typhoons. According to the peak's model, the flood's peak occurred at around 16:00 on 16^{th} October 2013 due to the Nari typhoon. The water level calculated at Mai Hoa station (on the upstream) was 9 m (Fig. 9).

- On the downstream, at Ba Don station, during the Wutip typhoon, rain started in the morning of 30th September with over 250mm/ day. On 15th October, rain was measured 200mm/day and went up to 550 mm/day during the Nari typhoon. The flood's peak was calculated at 3.7m at around 21:00 on 16^{th} (Fig. 10).

At the level of flood in 2013, upstream of the river, in general, it flooded from 2 to 3m, however, there is the area where flooded up to 6m, for example the communes of Duc Hoa and Phong Hoa due to low relief. In the downstream, the communes of Ha Trach and Bac Trach are flooded stronger up to 3m.

We simulated the historic flood in 2013 to understand the characteristics of the flood, this able to assist in the development of the flood zone in the watershed. However, thanks to the same hydrodynamic modeling, we can also simulate the floods of 2010 and 2011 which were of an annual return frequency. We can distinguish two types of flooding: exceptional flooding and annual flooding.

As discussed above, the flood season in the study area starts from September to December, so the two floods in 2010 and 2011 took place during this period. However, the massif causes a flood in October. For the 2010 flood, rain started on 2^{nd} October with 68mm per day, and increased to over 400mm on 3rd October 2010 at Dong Tam station in the upstream of Gianh River. Meanwhile, the flood in 2011 affected the watershed of Gianh River from 14th to 17th October with precipitation of 200 to 300mm per day.

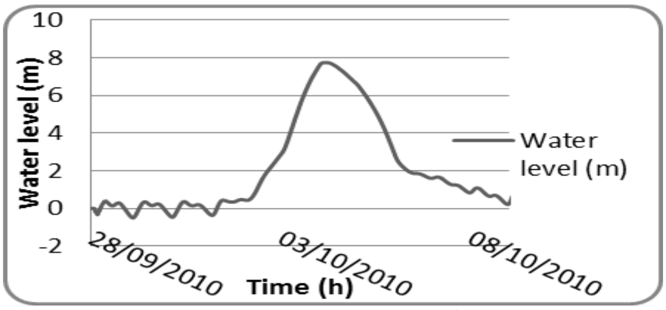

Fig. 11. The Water level at Mai Hoa station by the flood in 2010 (Huu Duy, 2016).

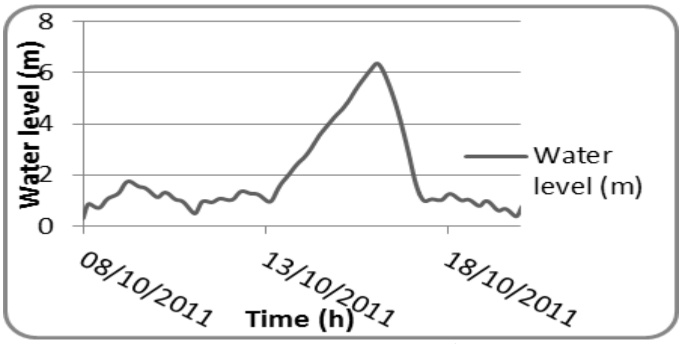

Fig. 12. The Water level at Mai Hoa station by the flood in 2011 (Huu Duy, 2016).

- Figures 11 and 12 show that the flood peak was 7.8m and occurred at 4 am on 4th October 2010, whereas the peak in 2011 was 6.4m at 1am on 16th October 2011 at Mai Hoa station. This flood peak in 2010 and 2011 was less 1.2m and 2.5m than the flood in 2013.

In this section we will not show the flood map of 2010 and 2011 because in the 2013 flood map, we covered all flood level cases in the Gianh River watershed. The communes of Duc Hoa and Phong Hoa in the upstream, which were flooded at the height of 4m to 4.5m in 2010 and from 2m to 3m in 2011, are affected by the worst floods each year. In the downstream, municipalities located by the sea have been flooded stronger, from 1m to 2m in 2010 and 0.5m to 1m in 2011.

IV. The Management of Flood in the Floodplain of the Gianh River

A. The Structural Method

For communities residing in high-risk floodplains or where the developments of these areas justify the cost of protections, flood control is essential to reduce damage to an acceptable level. The key element of any monitoring device is to ensure that water level of the river does not exceed predetermined safety ratings, in order to avoid submersion. Such control should also apply to flow velocities and damages to bed and river crossing structures (Kamal, 1990). Dikes, protective walls: in Quang Binh province, there are 280.2 km of dikes including 20,8km seawall, the rest being river dikes. However, the dike system in Quang Binh province is ancient, mainly along major rivers (Ron, Gianh, Ly Hoa, Le Ky, Nhat Le, Kien Giang) and according to the Department of Resource Natural and Environment of Quang Ninh Province: the river dyke network also plays an important role in countering floods and thus protecting agriculture and the inhabitants. The network of dikes in Gianh River catchment is about 70,381 km long and ranges from 1.5 m to 3 m with widths between 2 m and 3 m. The dike system in Gianh River catchment area was erected to combat flooding and saltwater infiltration, to develop agriculture, aquaculture, and to protect the lives of the population and to foster economic developments. Due to its location, the delta is often hit by typhoons from the eastern sea in the period from August to December. As the dike systems were old, they were damaged, which led the Quang Binh Provincial Committee to create a reinforcement budget to fight against floods and erosion: in 2013, the province prepared more than 3,200 bags of sand, 617m3 of stones, 45 000m ^{3} of crushed stone, 40m $^{3, of}$ sand, and hundreds of steel mouths .... to improve these networks. In addition, the Vietnam Committee has allocated € 4 billion to strengthen water networks in the Central Region from 2012 to 2020.

Flood protection tanks are effective means of reducing peak flows in some sections of watercourses. A reservoir built upstream of the area to be protected will retain part of the flood flow in order to clip the maximum flow at or below a level that does not present a danger of overflowing or submersion of structures. The location of such a reservoir depends on the characteristics of the floodplain that control the length of the dam and other possible sites that are more heavily encamped upstream of the protected area (Kamal, 1990). In addition, the People's Committee are building 57 reservoirs in the watershed, for a total volume of 153.023 million ^{m3} to reduce the risk of flooding.

Flooding is a common occurrence in rainy conditions, as the rainwater drainage system is often obstructed by household waste, which has negative effects of increasing disease cases and their ease of spreading. To meet the demand of urban growth and the needs of the people, Quang Binh Provincial Committee is planning an investment of 14 million euros from 2010 to 2020 to build and improve drainage systems. They are aimed to improve agricultural activity and to fight against flooding. As well as the Provincial People's Committee and the Department of Agriculture has give agricultural development strategies to adapt the difficulties in the region to ensure food security in the context of area reduction and increasing the number of typhoons and floods.

B. The No Structural Method

Human’s adaptation to flooding is very important in the study area. Summarizing this approach, Hoyt and Langbein write: "Floods are as much part of the landscape as hills and valleys. These are natural elements with which we must coexist, events that require some adaptation on our part.” One of the most effective means of adaptation is to avoid the indiscriminate development of activities and facilities in flood-prone areas, or in other words, to control "floodplain development" through the study of flood risks corresponding to various levels of probability. According to an interview with the head of the Typhoon and Flood Control Department of the province, the province's People's Committee has propagated and guided the staff on the risks and methods of fighting destrutctive storms: allocations of personnel and verifications of preparations to fight against typhoons. Before, flooding often occured from September to December; however, since 2005, flooding can occur earlier or later. Due to irregular flooding and typhoons, the committee must have a typhoon and flood warning system, as well as plant a forest system.

The provincial committee has planned and developed the coastal and river protection forest systems. But every year the typhoons grow stronger, so many forest trees have fallen and broken. Currently, the area covered by forests has decreased. In particular, the development of land use must ensure the fight against natural disasters such as storms and flooding. Areas that are often affected by floods or typhoons such as the Gianh River watershed must be developed. Since one of the important causes that increases the risks of flooding in the region which are land use planning where are not incompatible. There are many people who are settled along the river where reliefs are very low, so they are always influenced by the flood. In addition, land use planning is not yet concerned about the environment, for example deforestation. The forest area covered 224,870 ha in 2010 in the catchment area, but this area will have increased to 379,250 ha due to the forest plantation project for flood control.

Then, according to the head of the department of flood control and typhoon of the province, Quang Binh province does not yet have a typhoon and flood warning system, so the installation of these systems is the priority, but because of the irregularity of floods and typhoons, these systems are struggling to be entirely effective. The provincial committee must also build new and improve existing harbors so that boats can take shelter from typhoons.

The province has also invested in the construction of metrological stations to measure rainfall in areas where flooding and erosion occur frequently, thus helping to improve the erosion situation along the river.

Maintenance of banks and river bed: "Actions on the river include recalibration of beds, stabilization and/or remodeling of banks, the maintenance of the bed and the banks, and restoration of the ripisylve. They act mainly on the flow of the watercourse. During floods, these changes in the watercourse are intended to facilitate the flow of water. It takes place more quickly and contributes to the rapid evacuation of flood waters "(Deforssez, 2010). The river beds and banks of Gianh River are never cleaned after the floods.

Viet Nam in general and the Gianh River catchment in particular have often been affected by catastrophic events over the past two decades that have led provinces to strengthen their flood control policy, in order to reduce the vulnerability of people and property. However, in Vietnam, there is not yet a risk map for flood prevention as well as for land use planning.

Therefore, one of the objectives of this study is to propose cartographic tools for the prevention of flood risk and to take into account the flood risk in land-use planning and development decisions. However, because of the difficulty obtaining data, we only carry out the risk map for seven communities in the upstream and 27 communities in the dowstream from hydrodynamic modeling (Nguyen, 2016).

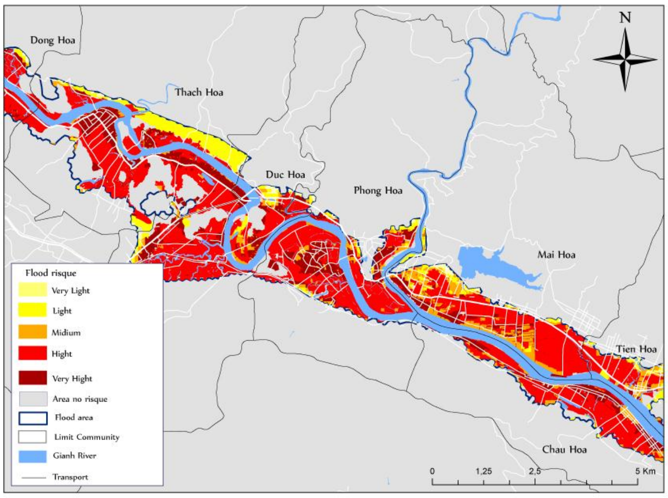

Fig. 13. Rismaps in the upstream of Lower Gianh River (Huu Duy, 2015).

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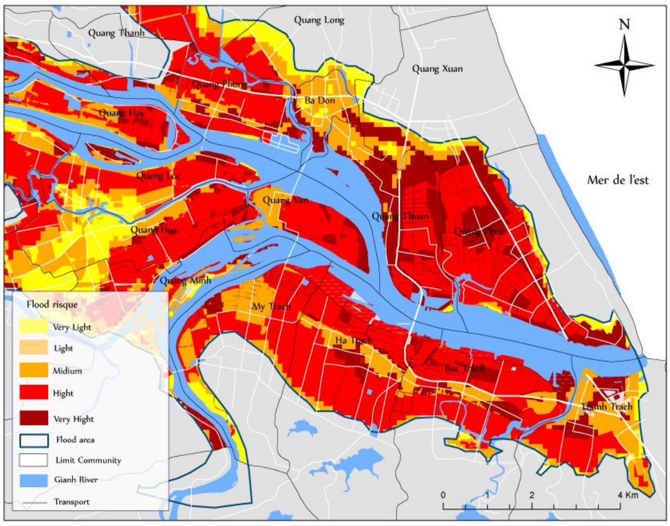

Fig. 14. Rismaps in the dowstream of Lower Gianh River (Huu Duy, 2015).

According to flood risk maps, we can delineate the areas where applicable prohibitions and preventive measures, protection and backup exist. In those areas where the risk is higher for the safety of human and property, the objectives are (Mottet, 2008):

- Prohibition of all new buildings
- Improving the safety of people and not increasing the number of people exposed
- Reducing the vulnerability of buildings and existing facilities by imposing new requirements

Those areas where the risk is low to medium can accommodate in urbanized areas, subject to compliance requirements or prevention, new construction.

Dans ces zones où le risque de moyen à faible permet d’accueillir dans les zones urbanisées, sous réserve du respect de prescriptions ou de mesures de prévention, des constructions nouvelles.

V. CONCLUSION

The watershed of Gianh River is often affected by floodings. Particularly, over the last years, floods have caused several human and/or material damages and the damages are becoming more and more serious.

Due to very dense topography and hydrology networks, the risk of flooding in the watershed is aggravating. Precipitations between 1980 and 2012 have a decrease both in the dowstream and in the upstream. However, from 1994 onwards, there is a strong increase in the number of days with heavy rains. Moreover, since 2005, the number of typhoons has had the tendency to increase. This is why the People's Committee has built concrete dyke and drainage networks, as well as forests and mangrove plantings to reduce the damages from this risk.

However, in the study areas, there are no flood risk prevention plans. That's why we added it in this article. It is an effective and necessary information tool for flood prevention and implementation of protective measures, including targets to reduce the vulnerability of people and property, as well as to assist in planning and development decisions such as prohibiting human settlements in the most dangerous areas, mastering urban planning, preserving flooding and flood expansion capacities.

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