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The flood risk in the floodplain of watershed of Gianh River : Causes and consequences

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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 caused in the increased risk of flooding: The variation of precipitation and the flow of Gianh river due to precipitation, As well as the economical development, The activities of human Such as River bed management, deforestation, urbanization River bed management, deforestation, urbanization... have made the changes of the flow of Gianh river become the important factor that aggregates the risk of flooding. In this article, we gave proposed structural and non-structural methodologies for flood management in the study area 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.**

Keywords—Hydrology, Flood risk, Precipitation, Deforestation, The Gianh River.

I. INTRODUCTION

Natural disasters have recently caused many risks in the world. Floods are one of the disasters that result in the most human and material damages (Garnier, 2008). This is particularly the case in Vietnam, where two thirds of the territory is in the littoral zone and has been still affected by typhoons. On approaching the coast, typhoons cause marine surges and heavy rains which make flooding in coastal areas.

The Gianh River catchment in central Vietnam has been subject to flooding in the last decade, with unprecedented economic and social consequences in Vietnam. On average, four to six typhoons affect Quang Binh province every year, two of which directly hit the province (for example, in 2013, the typhoons Wutip and Nari, considered to be the strongest ones in the history of the province, caused heavy flooding). Since 1986, the country has embarked on a process of transition and development, which is parallel to the urban growth. This leads to an increase in the risk of flooding in the watershed.

Moreover, the river Gianh is very poorly known, there has been no researches on this river. The objective of this article is to analyze the causes of the increase in the risk of flooding in the catchment area for better management of development on this river, as we will propose the risk map in this basin in the year 2020 for the development of urbanization and the reduction of vulnerability.

The first part of this article presents the characteristics of the floods and their consequences in the watershed. The causes of increasing risk of flooding will be analysed in the second part and finally we will propose a study of flood management, including flood risk prevention plans to base the map, the risk for watershed management and structural construction.

II. CHARACTERISTICS OF CATASTROPHIC FLOODING IN THE GIANH RIVER WATERSHED

The Gianh River watershed is located in the north of Quang Binh province in 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 area). It originates in the Copi mountainous region in the northwest of Quang Binh province. The Gianh River watershed has a rich and complex hydrography system in a mountainous area where precipitation reaches between 2,500 mm to 2,800 mm per year. The Gianh River has three major tributaries: the Rao Tro River which is 68.5 km long, the Rao Nam River 86 km long, and the Son River 84 km. The total flow amounts to more than four billion m3 per year in the Gianh River and nine billion m3 per year in the watershed (Nguyen and al, 2016).

The topography of the watershed of the Gianh River is very complicated and presents three distinct topographic forms: the mountains, the valleys and the plains.

This mountainous area includes the Copi mountain range to the west and the Truong Son mountain range. The valleys have an altitude between 5 and 20 m, while the plains vary from 0 to 4 m of altitude (Source: Atlas Vietnam, 2010). During the rainy season, this region still faces flooding because of the overflowing Gianh River. Moreover, upstream of the Gianh River, the slope of flow is high (more than 6%) over two-thirds of the length of the river and then decreases into the delta. On the other hand, the slopes are low downstream (minus 2%) therefore during the flood, the flow velocity is less.

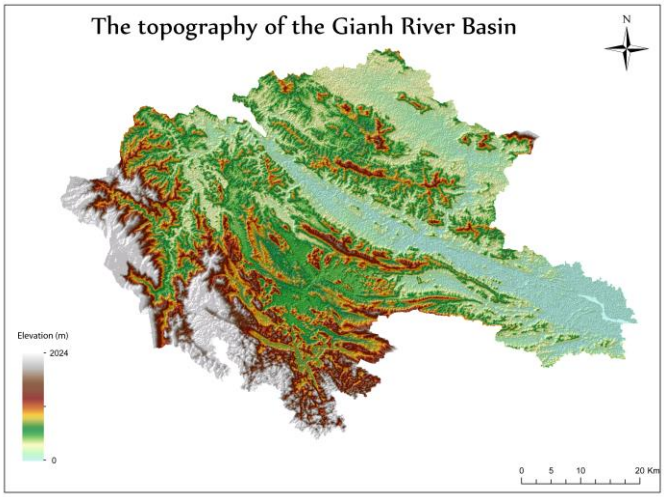


Fig. 1. Geographical location and the topographic of the study are.

The rich river system and the topography of the watershed are factors that aggravate the risk of flooding in the watershed. During the period from September to November, the floods occur more frequent and more dangerous, they make the fluvial overflows. The dangerous floods depend heavily on the water flow and the violence of the wind. To reduce the impacts of these risks, the provincial People's Committee built the reservoirs and dykes, and even the most sophisticated ones can not. There are stories of civilizations in the watershed often encountering these risks. This causes severe damage in the dense area. Due to the topography and the steep slope the force of the water is very strong from upstream to downstream, which associated with irregular rainfall and rising sea level during the typhoon. Therefore, if there is no serious containment, much of the basin is destroyed, including rice crops (Gourou, 1936).

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 but rarely appeared in December. The average annual flood level of the Gianh River is 3.2.

The typhoon has always represented increasingly serious problems in Vietnam in general and the Gianh River watershed in particular. The latter particularly affects the inhabitants and causes significant economic losses (destruction of production resulting from the primary sectors, destruction of infrastructures, slowing of intra- but also extranational exchanges, etc.). Typhoons, which are part of natural disasters, have the most significant global impact each year, due to their strength and their excessive climate, typhoons can cause significant damage to anything in their trajectory, particularly, when they hit low coastal areas. Vietnam, which is part of Asia monsoons, is marked by heavy precipitation and relatively frequent typhoons. They often strike from June to July in the northern part of the Vietnamese territory while the central part is affected from September to December. "They generally occur in the South China Sea offshore and move to Vietnam where the rains are stronger, as well as the winds, sometimes they can reach up to 300 km / h (Ngo, 2013). When they reach the coast, they cause increasing rainfall, resulting in flooding of the watershed. Each year, there are an average of 5 to 6 storms in the country (several years ago, the number of annual storms was over 10), and 4 of them directly affected central Vietnam (1 to 2 storms strike the Gianh river catchment each year) (Central Commitee for Flood and Storm Control, 2014).

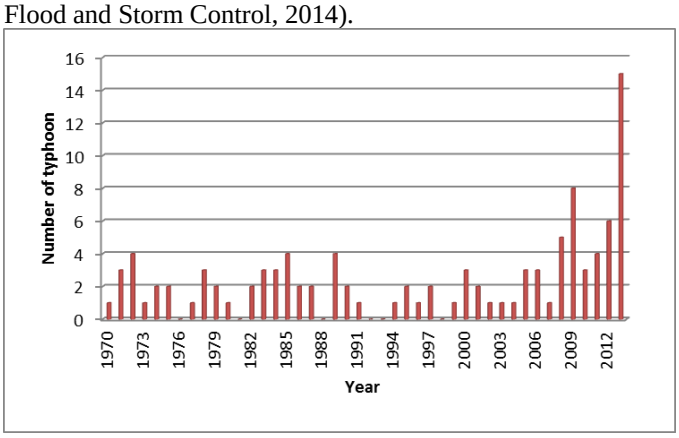


Fig.2. Number of typhoon in the Watershed of Gianh river from 1970 to 2013

Like many other countries in the world in general and Asia in particular, Vietnam is exposed to natural hazards that result in economic and human damage and the problem of food shortage in the country (Ujjie, 2001).

According the OFDA/CRED international Disaster Database : The Flooding and typhoons account for more than 85% of the total cost of damage due to Vietnam's natural hazards, ie 10 billion euros from 1900 to 2016, with agriculture the most affected after a flood. By the geographical location of Viet Nam in general and the Central region of Vietnam in particular, it has a tropical monsoon climate, and often struck by the typhoon which is accompanied by major flooding. The table above shows that the Northern Plain region, the Central region and the Mekong basin are the regions most affected by the storms and floods in the country. We can note some floods in the Central region of Vietnam in 1999, 2010, 2011, 2013, 2016. In the case of Quang Binh province with a history rich in natural catastrophic events, in the 20th century, Quang Binh province was repeatedly affected by flood damage.

Note some typical floods:

- The battle of the October flood in 1950: more than 137 people were killed, more than 1,000 houses destroyed, 1,000 buffalo and cows killed or washed away and 80% of the crops were lost.
- Flooding on 26th of October in 1983 which is considered one of the biggest floods in the Province. Rainfall was increasing in the Gianh watershed at May Hoa station, precipitation was estimated at about 450 mm per day, at its peak the flooding at this

station was 8 m deep and Ba Don was 3m. From 7am on October 29th to 7am on the first of November, the rain fell heavily for three days. At the Tuyen Hoa station, rainfall measured about 600 mm per day, suggesting the great flood in the province. These floods have caused major damage in the province in general and the Gianh River watershed in particular. Above all, they influence the problems of food shortages in the region. More than 252 people were killed, 50% of houses destroyed and 90% of houses lost their roofs in the flood zone, more than 10 000 tonnes of agricultural products were lost in 1983, or 30% of agricultural production.

- Flooding on October 1, 1985 killed more than 7 people, and 59 people were lost, 1,191 houses were completely destroyed, 44,770 houses were flooded, about 26,000 ha of agricultural land were flooded and several of the irrigation and drainage networks were destroyed. After two weeks, on October 16, 1985, the typhoon struck the province that accompanied the great flood, 702 people were killed, 128 people were missing, 67,664 houses were destroyed and 70,000 ha of agricultural land were flooded. The networks and irrigations, drainages were destroyed, making life very difficult for cultivation in the following years. These floods caused the lack of food in this province. So the governments of the country, the neighboring countries have supported with food to the population.
- The flood in 1993 caused 7 deaths, 2 people were lost, 489 houses were destroyed, and 3,000 ha of agricultural land destroyed.
- In 1995 the central region and the province of Quang Binh in particular suffered a great flood with rainfall of 800 to 1,100 per day and the flood peak at Mai Hoa station of the Gianh River was 9.5 m and Ba Don 3.5 m deep. The water level raised about 6 m above the Gianh River and 3 m downstream. It caused great loss of life and material damage.

Even in the 21st century, floods have resulted in material losses and significant agricultural production in the Central Region and Quang Binh Province.

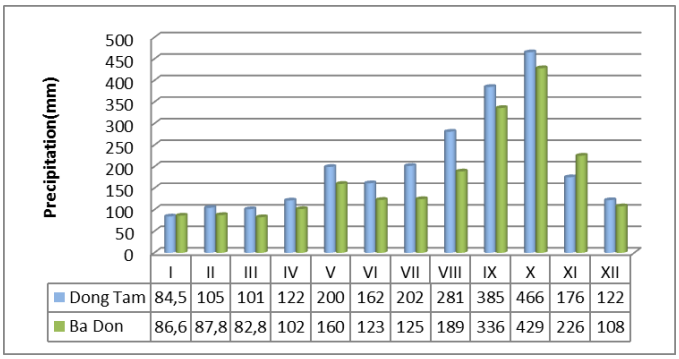
- The flooding in 2007 in the province, so the watershed of the Gianh River is the area most affected by this flood. 16 people died, 3,655 houses and 7,500 ha of rice were destroyed. This flood caused total losses of over 810 billion VND (about $ 36 million).
- Typhoon Wutip and Narie hit the coast of Vietnam on October 1 and October 16, 2013, causing flooding in the north-central region of the country. These typhoons caused a great flood in the province more than 6m upstream of the Gianh river and more than 3m downstream. Agricultural sectors were the most affected by these typhoons. After the floods, the food safety problems were in the alternating situation.
- Flooding in 2016 caused rainfall over 920 mm per day with a peak flood at the May Hoa station of the Gianh River was 9.3 m. It caused 35 deaths, 9 people were missing, 92,192 houses were flooded, a great damage on the agricultural sector. After the 2016 flood, Quang Binh province in general and the watershed in particular was in a food shortage situation, especially in the mountain region. After the flood, the government supported the food like rice, noodle, and rice seed to cultivate in order to ensure food security in the province.

III. INCREASED RISK OF FLOODING: THE CONSEQUENCES OF THE SHARE OF NATURAL AND ANTHROPOGENIC

a. Natural Factors

- **Precipitation in the watershed**

The Gianh River is characterized by a very dense hydrographic network and a very complicated topography. Moreover, the watershed concentrates heavy precipitation. The precipitation study will be based on data from stations along the river since 1970. Seasonal precipitation on the watershed is shown in the figures below. They show the monthly precipitation of the Dong Tam stations upstream and Ba Don downstream of the watershed which is stronger from August to November. In fact, the majority of the floods are taking place during this season. Indeed, the rainfall often has the character of typhoon or storm, and therefore of strong intensities. So all this makes the risk worse on the watershed.



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Dong Tam	84,5	105	101	122	200	162	202	281	385	466	176	122
Ba Don	86,6	87,8	82,8	102	160	123	125	189	336	429	226	108

Fig. 3. The monthly precipitation of the Dong Tam and Ba Don station in the Gianh River watershed

At the level of the Gianh River basin, the results are more contrasted: the five stations were analyzed and show that the

annual cumulative precipitation between 1980 and 2012 indicated a downward trend in the watershed and a number of days when the rain is heavy (Nguyen and al, 2017). According to population surveys and interviews with officials of the municipality and the province department, precipitation in Quang Binh province in general and the Gianh River catchment in particular have decreased in recent years, however , precipitation increased in a short period of time or during flooding sequences and during the passage of the typhoon with a very large surface area, which increases the risk of flooding.

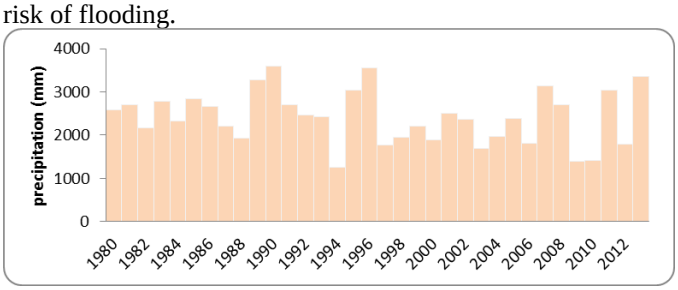


Fig.4. Average annual cumulative precipitation at the Dong Tam station in the upstream

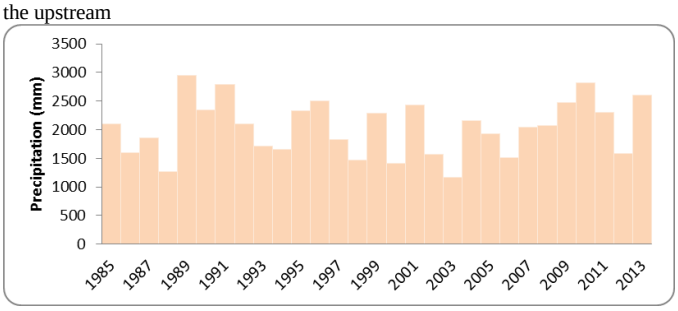


Fig. 5. Average annual cumulative precipitation at the Ba Don station in the dowstream

Four years stand out on all stations with a stronger positive anomaly: 1990, 1996, 2007 and 2013, these years correspond to the highest floods recorded in the Gianh river catchment. This indicates climate change is also affecting precipitation in the Gianh River watershed.

- **Variability of the flow of the Gianh River**

The Hubert segmentation allows us to confirm this date of rupture and to determine phases in the time series. The year 1993 is considered a breaking point. During the first period, the average flow rates are higher (70 m3 / s). It can be seen that the average flow of the second period (1994-2013) is lower (64 m3 / s). However, in the second period, there are some years where the average annual flows are stronger. This is related to precipitation, as we have analyzed above, which decreased upstream of the river. However, it was raining stronger during the typhoon or flooded a wide territory.

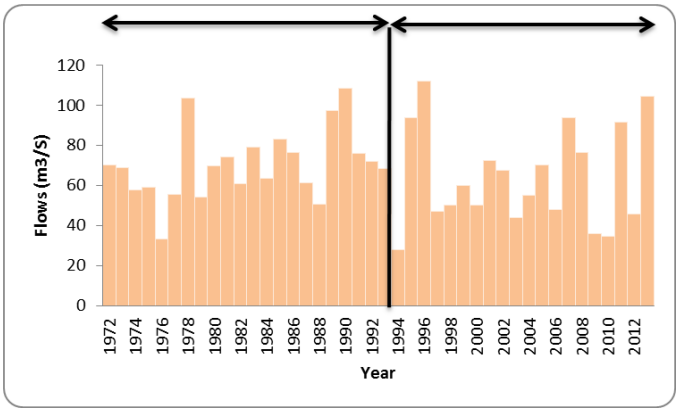


Fig. 6. Hubert segmentation applied to the chronicle of average annual flows for the Dong Tam station on the Gianh river from 1971 to 2013

The breaking point in 1993 for the maximum annual flows can be verified on the graph below: the maximum flow rates are lower on average for the second period than for the first. However, the number of years when the higher flows are more in the second period than the first period. This is one of the factors that causes the worst flood damage in the watershed.

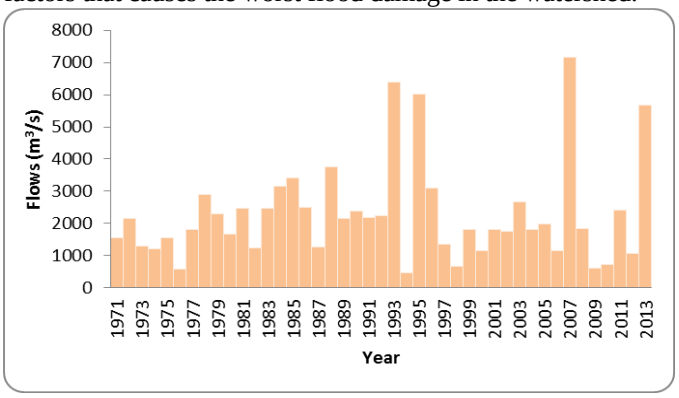


Fig.7. The manimum annual flows for the Dong Tam station in the Gianh River from 1971 à 2013

From these highlighted dates, it can be shown that there is an evolution in the variability of the average monthly flows and the monthly frequency of the maximum annual flows

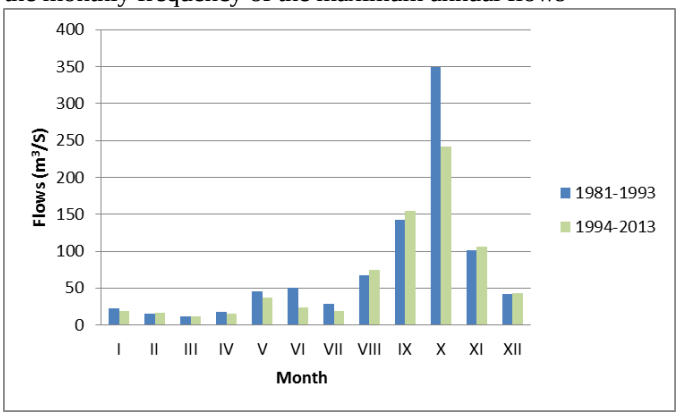


Fig. 8. Change in monthly average flows at the Dong Tam station on the Gianh River from 1981 to 2013

There is a change in the monthly distribution of average flows: Higher in September, October and November from

1981 to 2013. The month of November is under represented in the following period where the highest average flows are in September and November. This is the period of flood and typhoon of the study area. The figure shows that the month of October, the flow of the river from 1981 to 1993 is higher than the year from 1994 to 2013.

b. Human Factors

1. The causes related to the man

The Gianh River plays an important role in the lives of the inhabitants of the watershed. It is used for people transportation, water supply and agriculture ... The Gianh River catchment catches more than 50% of the surface of the Province. At the time of the census in 2013 the population was 553 604 inhabitants. The population density is low upstream, but very high downstream in the watershed. The inhabitants use the river daily for their water supplies, fishing, growth economy as well as electricity.

The way in which human societies manage their environment sometimes greatly alters the hydrological functioning of watersheds. Besides the voluntary and planned actions to control floods, other human activities may have unintended and uncontrolled consequences.

This is why the objectives of this study concerns the consequences of human activities on floods, such as river bed development, demography, fish farming or deforestation ...

2. Riverbed planning

Since the years 1986, the policy of renewal and economic liberalization have made it possible to revive the policy of industrial growth and urbanization. This allowed a lot of changes in land use. (Bernier et al., 2007, p.1). The Gianh River plays a more important role in the development of hydroelectricity system in the province of Quang Binh. The table below shows the hydroelectric center on the Gianh river.

Tab. 1. The number of hydropower centers on the Gianh River

The Name	**The River**	**Flv (km^2)**	**Q_0 (m3/s)**	**Nlm (MW)**
La Trọng	Ngã Hai			18,0
Ngã Hai	Ngã Hai	63,0	3,45	4,0
Rào Cái 2	Rào Cái	155,0	8,50	2,5
Khe Nét	Khe Nét	160,0	9,45	5,5
Rào Trổ	Rào Trổ	550,0	41,61	7,8
Thượng Trạch	Cà Roòng	106,0	6,18	5,0

In fact, at the dawn of 2020, six hydropower stations will be completed on the Gianh River with a capacity of 19.3 MW. It will have a great effect on the river Gianh for example, the flow of the river.

Dams are used to limit flood flows during the flood season and can make changes to the watercourse in three variables: intensity, duration and frequency of flows ... and induce significant changes in Hydrodynamic, hydraulic and morphological characteristics of the channel due to changes in water and sediment transfer ... and water losses by increasing the evaporation surface are also reservoir-related effects. Water losses depend on several factors, such as the location of the structure, climate, vegetation cover and technical characteristics of the reservoir (Pinto Martins, 2008).

In addition, dykes are built for flood control during the flood season, however, dykes induce changes in flow conditions (acceleration of currents, increase in slope, etc.) (Grivel, 2012) . In addition, dykes cause hydraulic disconnection between the minor bed and the major bed, which may increase the risk of flooding downstream (Malavoi and Bravard, 2010).

Hydro projects lead to changes in settlement areas, including for remote areas, including deltas. This spatial and temporal spreading of the modifications led to a late awareness of the changes. The impacts of these changes are many, including salinization, changing water quality and changes in some management systems. The most significant of these are dykes, interbasin transfers and dams), their duration of view is relatively long (Bethemont, 2000).

From satellite images of 1989, 2003, 2013 with the help of GIS, we can calculate the morphological evolution of the river beds in the Gianh river. Figure 12 shows the morphological changes of the minor bed upstream of the river causing a change downstream of the river.

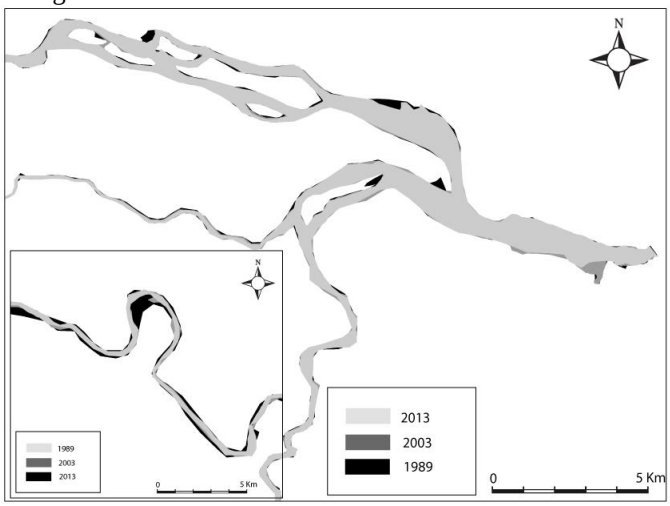


Fig. 9. Morphological evolution of Gianh River from 1989 to 2013

The river bed is characterized by a decrease in the length of its flow axis over the period 1989-2013. Between 1989 and 2003, the evolution is less marked with -0.005% per year. The change in sinuosity concerns mainly in the period between 2003-2013. This fluvial change over a relatively short period of time is explained by the installation of aquaculture zones on the active strip (about 500 m wide)

Tab. 2. Evolution of the length of the Giang River from 1989 to 2013 (Huu Duy, 2015)

Year	Length of axes (km)	Evolution of length of axes (% par an)
1989	185,55	
2003	185,42	-0,005%
2013	183,95	-0,07%

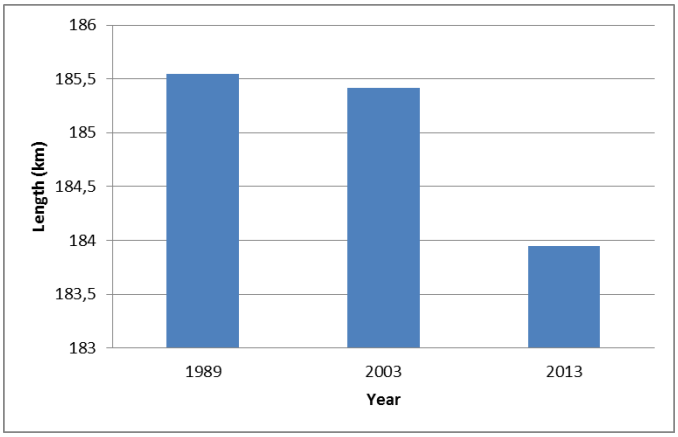


Fig. 10. Evolution of the length of the Giang River from 1989 to 2013

Moreover, the width of the active band tends to increase, mainly between 1989 and 2013. It can be seen that from 1989 to 2003 downstream of the Gianh river, the active band tends to decrease due to the development of urbanization, and fish farming. And from 2003 to 2013, the bandwidth decreased, as it is the period of growth and urbanization, as well as fish farming grows in the province of Quang Binh. That is why it has decreased considerably. On the other hand, upstream of the Gianh river, the minor bed is subject to erosion problems, the reason may be related to the flood. These geomorphological facts reflect the possible modifications of the main flows in the deltaic plain, which could have negative influences during periods of floods.

3. The role of land use in flood disasters in the Gianh River watershed

The disasters are linked to natural and human factors. Urban growth, clearing of forests, and fish farming are the main causes of floods getting worse. Reduction of the capacity to regulate and retain lakes, which is directly related to land use, is a crucial factor in the intensification of flooding.

From the satellite images of 1989, 2003 and 2013, using geographic information systems and remote sensing, we can determine the evolution of land use in the flood zone of the catchment area. First of all, the original development was designed mainly for rice growing, whereas today these areas are more dynamic (growth of urbanization, industrial, demographic, etc.). The table below shows the evolution of land use in the flood zone of the watershed from 1989 to 2013.

Tab. 3. Evolution of occupation in the floodplain of the Gianh River watershed

	Year					
	1989		2003		2013	
	Ha	%	Ha	%	Ha	%
Urbanized	1656,55	9	2894,66	16	4453,67	24
Agricultural	8259,94	46	9305,23	52	8520,62	46
Fish	178,31	1	703,24	4	947,48	5
Fruit trees	1691,56	10	264,93	1,89	243,06	1
Forest	2905,92	16	1889,09	10	1354,12	7

In the economic and political context, demography plays an important role in the dynamics of land use in the Gianh River catchment, as well as the distribution of the population between the communes in the region such as local migrations. The town of Ba Don in the delta has a population density of about 4500 inhabitants / km², whereas it is 9.9 inhabitants / km² in Ngu Hoa upstream). Due to demographics and geography situation of the study area (proximity to the provincial capital) have resulted in an urban expansion. By 2020, the municipality of Ba Don has seen its rice-growing landscape completely retreated and given way to an urban landscape, as well as in Quang Thuan and Quang Phuc in 2030. There will be a beach development project in order to promote the tourist development of the area.

In the upper delta, demographic pressures have led to a migration of the inhabitants to the deltaic areas, which are the lowest, topographically (mangroves, for example). These mangroves have been partially destroyed by human activities, whether clearing (in the delta of Bengal or the Mekong for example), as well as the increasing evolution of tourism which has led to a development on the coastline. These fragile areas also face natural hazards (typhoons, cyclones). These mangrove and marsh areas nevertheless play an important role in protecting the coastlines, as they limit maritime erosion and the impact of waves during cyclones and tsunamis (Sylvie Fanchette, 2014).

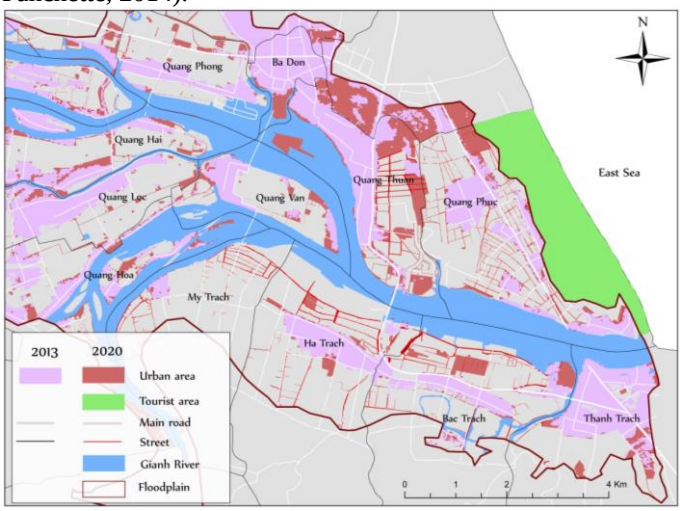


Fig. 11. Projects of urbanization to 2020 (Huu Duy, 2016)

During our field expedition in 2015, we interviewed 140 people living in 8 communes in the Gianh River Delta and 80 people in the upstream. To the questions that urbanization still has indirect consequences on the urban extension and then plays a primordial role like the pollution, the aggravation of the risk of flooding ...: 71 people (50.7%) answered "yes" "Versus 69 respondents (49.3%) who answered" no ", while upstream, 13 respondents (16.25%) responded" yes "to 67 respondents (83.75%) who answered" no "

The increase in urbanized area, whose impermeable surfaces have increased due to habitat requirements and construction which has led to an increase in storm-water run-off. This greatly limits the possibility of water infiltration. It causes an increase in water volumes in the Gianh River and urbanization contributes to an increase in flow velocities, especially during the peak flood. In the past, the occupation of the territories took the risk into account. From the field mission in 2015, we observed that the inhabitants settled outside the main bed, on the terraces or on the banks, whereas the construction of the dykes can (as Pinto Martins 2008) induce significant changes in the hydrodynamic, hydraulic and morphological characteristics of the channel due to changes in water and sediment transfers. "These constructions modify the characteristics of the river flow such as the depth of the wetted section and the velocities (Malavoi and Bravard, 2010)". And according to the head of the construction department, the phenomena of anarchic installations in the major beds of the Gianh River exist. All this aggravates the risk of flooding.Because of its favourable geographical location, each year the basin is affected by the floods and linked to tropical storms. It is heavily exposed to the risk of river flooding by combining heavy rainfall and rising sea level with the passage of typhoons which has tended to increase since 2005.

Fig. 12. The development on the Gianh river minor bed (Photographie : Huu Duy, 2015)

The photos are taken downstream of the Gianh River in 2015, they show us the phenomenon of the constructions on the minor bed of the river. This phenomenon is not uncommon downstream of the river, the residents settles there to maintain their boats. If we go a little further downstream towards the sea, the fish farmers also build the housing on the minor bed to keep their fish farms.

Then, due to demographic changes, for the purpose of construction and trade the inhabitants practice the illegal exploitation of sand from the Gianh riverbed. This is one of the causes of a very serious process of erosion of the dam and which modifies the flow of the river, thus increasing the risks of flooding.

The illegal exploitation of sand from the Gianh River is carried out according to two types of extraction. For the first type, companies have an operating license with a deadline date and therefore with precise figures on the volumes or tonnages that can be extracted each year, but the second type of exploitation is illegal. These are uncontrolled extraction and the cost price is lower. According to the interview with the populations and with the officials of communes, the illegal exploitation of sand at the upstream of the river causes one of the modifications of flow of the river. The head of the Typhoon and Flood Control Center in Quang Binh Province said that upstream of the river in the Tuyen Hoa district there was a lot of illegal sand mining.

Fig.13. Illegal farms above the Gianh river (Photographie : Huu Duy, 2015)

But in 2012, the Population Committee of Quang Binh province banned, arrested people and businesses that exploit the sand, which reduced such illegal practices.

The flooding of the Gianh river catchment area is aggravated by poor land use because the floodplain construction has not been controlled by the population. The same can be said with the authorities of the communes and the growth of urban planning. In fact, 100% of respondents are not aware of the protected areas and the problem of anarchic installations in the major beds of the watershed. This growth is associated with the problem of deforestation which leads to an increase in the risk of flooding.

4. Deforestation

Vegetation cover plays an essential role in protecting soil against the risk of erosion as well as to prevent the runoff of rainwater. In the watershed of the Gianh River, forest areas provide effective protection, curbing flood flows and speed from upstream to downstream. "Degradation of mangrove forests reduce wetland protection functions such as shoreline stabilization and protection against storms and typhoons, thus increasing the risk of flooding" (Tran and Shaw 2007b and Luong, 2012) in the rainy and stormy seasons.

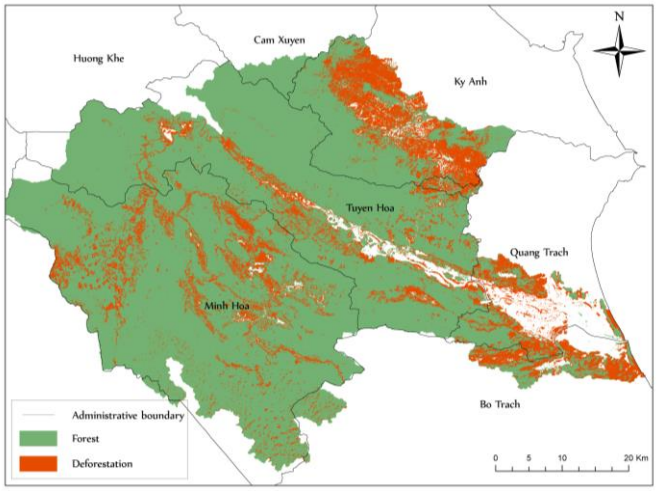


Fig. 15. Deforestation of the Gianh River watershed from 1989 to 2033 (Huu Duy, 2016)

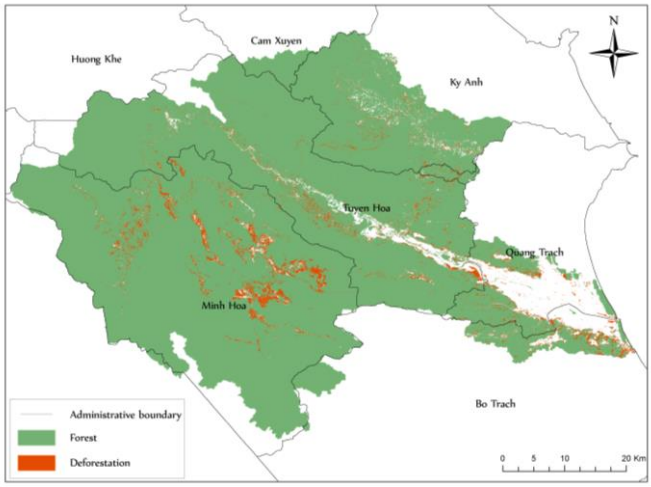


Fig. 16. Deforestation of the Gianh River watershed from 2003 to 2013 (Huu Duy, 2016)

One thing is clear: the forest area has decreased considerably from 1989 to 2013. The land-use map in 1989 is the extent of the forest zones, which covered 276 960 ha in the catchment area. In 2003, the forest covered only 259,029 ha. Subsequently, the forest area increased to 267 792 in 2013. This development can be explained by the management policies and the bad management of the forests and the wild clearing for the acquisition of new lands denounced. According to Claude Cosandey in 2008, if irrigated agriculture constitutes the largest water consumption, other human activities can modify more indirect and balance the flow of the rivers as it is the case for the changes in vegetation. Among these activities, afforestation and logging operations have an impact on flow, which is all the more sensitive as water resources, especially summer water, are indigent and the increase in flow resulting from deforestation. So deforestation can be demonstrated as an aggravating factor of flooding.

Thus, the decline of forest covers in the basin of this great river and the weakening of its regulatory effect which leads to increasingly frequent floods. Sometimes of catastrophic magnitude, especially three years ago in the deltaic plain in October 2013, it was very menacing. Vietnam pays a heavy economic and human price for the deforestation of its uplands.

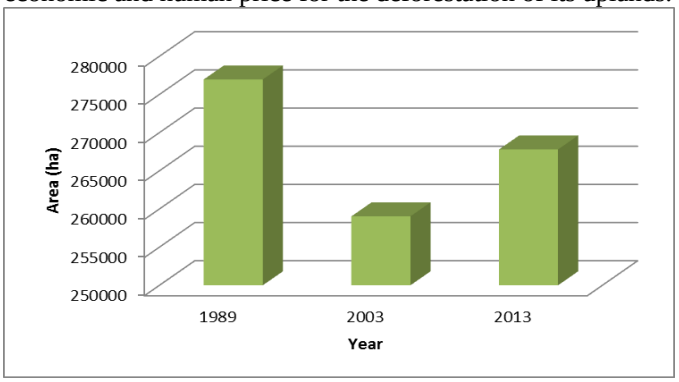


Fig. 17. Evolution of the forest area of the watershed of Gianh river (Huu Duy, 2015)

What are the causes of deforestation in the Gianh River basin?

In addition, the total area of the mangrove in the catchment area is 22.1 ha, while 20.9 ha in the Quang Trach district and 1.2 ha in the Bo Trach district. However, the decline in mangrove area that affects Vietnam in general and the Gianh River catchment in particular is largely due to the development of aquaculture since 1989, State on the protection and development of aquaculture, in order to increase the income of the population. New techniques have increased the yields of aquaculture. This resulted in the destruction of the mangrove for replacing it with aquaculture. The interviews with the population mentioned, for 30% of the respondents, that the wooded areas have decreased due to the exploitation of fish farms.

According to the inhabitants in these communes, mangroves are cultivated by the government, however, they are smaller so cannot be protected. Moreover, every year the typhoon arrives breaking much of the mangrove surface.

In fact, mangroves are playing a more important role in the fight against the typhoon to protect the inhabitants. At the moment, downstream of the Gianh River, there are 33.9 km of dyke, but only 9.1 km are protected by mangroves.

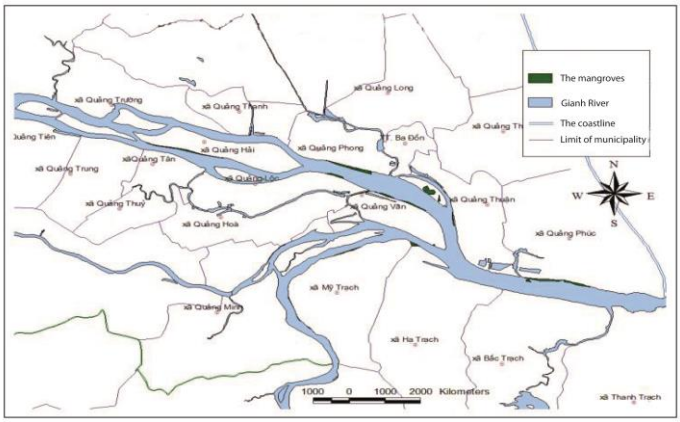


Fig. 18. The mangrove situation of the Gianh River watershed (Huu Duy, 2015)

Agricultural clearing is the main cause of deforestation affecting Vietnam in general and the watershed of the Gianh River in particular. Since the promulgation of Resolution No. 10 of 1988 by the Secretary-General of the Communist Party for the Management of Innovation in the Agricultural Economy of Vietnam, the national agricultural policy aims at both intensifying Production of rice fields and the use of uplands for perennial plantations and livestock development (Bui and Nguyen, 2002). The distribution of forests to households was the last step in the land use rights changes that accompanied the Doi Me (renovation) Vietnam reforms. In a context of declining agricultural and food productivity shortages, the cooperative system was undergoing a major crisis. A dual system of production has developed, along with work managed collectively in rice fields, supplemented by work managed individually on the hillsides (Sadoulet et al., 2002). Although "persons" (in other words, the State, article 19 of the 1980 Constitution) formally belongs to all the land, sloping land has not been integrated into cooperatives. For this reason, sloping land continues to be grown according to the rules of free access, providing additional income for many households. In times of scarcity, farmers focused on the private economy, increasing the area cultivated on the slopes, leading to significant deforestation in the northern regions (De Koninck, 1999; Castella et al. 2002).

Mountain hills are considered marginal in terms of food production potentially and more appropriate for forestry (Castella et al., 2002). However, mountain inhabitants have long relied on shifting cultivation in upland areas, either as a complement or as a substitute for the production of mountain paddies. During the cooperative period, the shortage of paddy rice forced many families to cultivate the uplands to achieve self-sufficiency in rice. The allocations of paddies paid to individual households in 1982 and the dismantling of cooperatives from the late 1980s have created incentives to invest in mountain paddy areas. Nevertheless, the comparative advantage of upland field productivity has led to an uncontrolled increase in the cultivation. The disappearance of forests and new policies in the 1990s motivated the farmers who could concentrate again on the rice fields. But the distribution process had left households with little or no rice fields, offering them little choice but to continue cultivating hillsides (Castella, 2002). Since the years 1989, there has been an intensive exploitation of wood for heating, cooking and selling charcoal, but in recent years, the phenomenon has subsided because they use gas and electricity.

Commercial legal and illegal logging is a factor that leads to a decrease in the forest area of Vietnam in general and in the Gianh River watershed. The phenomenon of wood smuggling is increasingly serious, especially the rare plants for example Erythrophleum fordii, cloves ... including several in the mountain of the watershed of the Gianh river. So the people cut them off for commercial purposes. According to a resident "Nguyen Van Hiep" who has lived in the commune of Phong Hoa for 60 years, he said that "at the moment there are not rare plants and big wood on the mountain because they are cut illegal by the Inhabitants "Lam Tac".

Fig. 19. Deforestation of the Gianh River watershed (Photographie : Huu Duy, 2016)

In addition, the limestone mining to produce the cement, for example the Song Gianh plant, was built in 2006 in the commune of Canh Hoa in the Tuyen Hoa district it is one of the factories that produce larger amounts of cement in the central region of Vietnam. This causes deforestation on limestone hills.

5. Fish farming

Population growth and above all the combination of urbanization and improved levels of development, life and income are the main drivers of increased demand for fish and other edible products from the sea and the development of fisheries. Demand has risen, the area of fish farming in the catchment area has increased steadily. However, fish growth also affects the physical environment. This is why the analysis of the changes of the fish surfaces in this study shows the relations between the physical environment, the risks floods and the fish activities.

Between 1989 and 2013, fish farms increased significantly from 178.31 ha to 849.72 ha. This may be linked to the strategy of the province, policies for the development and development of fish farms in this area by Decision No. 18 of 1989 by the State Council on the Protection and Development of Aquaculture. The creation of fish farms requires the release of land and, in effect, the destruction of wooded areas. In addition, this leads to erosion of the banks, changes in water flow and the weakening of larger areas in the flood zone of the entire Gianh River watershed. In fact, more than 15 ha of mangrove area are replaced by fish farming downstream of the Gianh river in 9 communes: My trach, Bac Trach, Thanh Trach, Ha Trach, Quang Phuc, Quang Thuan, Ba Don, Quang Phong , Quang Van. Among those surveyed, 8.5% said that mangrove areas have declined because each year the forest is destroyed by typhoons, as well as by construction and programs related to land use planning. In addition, people cut the forests for heating. Finally, the development of fish farming has led to deforestation to develop ponds or lakes.

Because of its geographical location, the watershed of the Gianh River is subject to the risk of flooding. Material and

human damage from flooding is aggravated by natural and human factors. These aggravating natural factors are: complicated topography, dense hydrological networks associated with heavy rainfall, and an increase since 2005 in the typhoon affecting the watershed. Human factors include upstream deforestation and the destruction of the mangrove downstream of the river as well as the development of the watercourse. Material and human damage caused by the flood affects food security in the study area and in Quang Binh province.

IV. WATERSHED FLOOD MANAGEMENT

a. Development of dykes and drainage networks

In its economic and social development process, the watershed of the Gianh River concentrates agricultural areas. Dyke networks have played an increasingly important role in the development of agriculture, and they have been built since the 14th century on the Gianh river during the Lê dynasty. These containment actions have made it possible to welcome many inhabitants, rice and urbanization has been developed massively in the country. During the colonial era, this process of containment in floodplains intensified (source: Béthemont, 2000). For example, since 1990, with the financial support of international funds, the networks have been increasingly strengthened. Throughout history, Vietnamese have consolidated and enhanced dyke networks (source: Eric Mottet and Yanne Roche , 2008) because the protection of the back of the coast is a priority for the inhabitants. Thus for centuries dyke networks have been built by allowing crops and human settlement. Indeed, many poor people who live in the countryside believe that agriculture must be developed to increase labour and increase food production. So the strengthening of the dikes seems to be very important.

In the province of Quang Binh, there are 280.2 km of dykes, 20.8 km of sea dykes, the remaining being river dykes. However, the system of dykes in Quang Binh province is ancient, mainly along the great rivers (Ron River, Gianh River, Ly Hoa River, Le Ky River, 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 the floods and thus protecting agriculture and the inhabitants. The network of dykes in the Gianh river catchment is about 70,381 km long and ranges from 1.5 m to 3 m and widths between 2 m and 3 m. In addition, the People's Committee is planning 57 reservoirs in the catchment area, for a stored volume of 153.023 million m3 to reduce the risk of flooding. The dyke system in the Gianh River catchment area has been erected to combat flooding and saltwater infiltration, to develop agriculture, aquaculture, and to protect the population and to foster economic development. By its geographical location, the delta is often affected by sea typhoons from the east during the period from August to December. As the dyke systems were old and damaged, which led the Quang Binh Provincial Committee to create a reinforcement budget to fight against floods and erosion: in 2013, the province has prepared over 3,200 sandbags, 617m3 of stones, 45,000m3 of crushed stone, 40m3 of sand, hundreds of steel mouths .... to improve these networks. In addition, the Vietnam Committee has allocated € 4 billion to strengthen the hydraulic networks in the Central Region from 2012 to 2020 (Nguyen and al, 2017).

Flooding is a common occurrence in rainy conditions, as the rainwater drainage system is often obstructed by household waste. This has a negative effect of increasing number of diseases and their ease of spreading. To meet the demand of urban growth and the needs of the populations, The Quang Binh Provincial Committee is therefore planning an investment of € 14 million from 2010 to 2020 to build and improve drainage systems to improve agricultural activity and combat flooding. As well as the Provincial People's Committee combined with the Department of Agriculture providing agricultural development strategies to tailor the difficulties in the region to ensure food security in the context of area reduction and increase The number of typhoons and floods.

b. The flood risk prevention plan

In Viet Nam in general and the Gianh River catchment in particular is often affected by catastrophic events over the last two decades these have led the state to strengthen flood control policy so that the vulnerability of people and property is reduced. However, in Vietnam there is not yet a risk map for flood prevention as well as for land use planning. According to the interview with the head of the Pilotage Centre, for the prevention and control of typhoons and storms in the province: It is very difficult to prevent typhoons because there is a lack of technology in typhoon weather warning systems, we follow the evaluation of typhoons on TV, but, there is only the metrological station for information. During the storm, they measure the precipitation and send to us the information. Before, thanks to experience, people can predict the times when storms will strike. But, right now, as I speak, the storm situation is very complicated so prevention is very difficult. During the storm season, the local people are prepared for the fight against the storms. Therefore, one of the objectives of this study is to propose cartographic tools for the prevention of flooding and to take into account the flood risk in land-use planning and development decisions and for Future developments of the watershed (in 2020). However, due to the difficulty of obtaining data, we only take into consideration the risk map for seven communes upstream and twenty seven communes downstream of the river.

According to the risk map in the 2020 period of 27 common downstream and 7 common upstream in the flood zone was caused in 2013: 2,138.54 ha of the territory will be in the very high risk zone, 5886.82 ha in the area Of high risk, 2766.16 ha in the medium risk zone, 1 369.83 ha in the low risk zone and 111.69 ha in the very low risk zone (Nguyen and al, 2016).

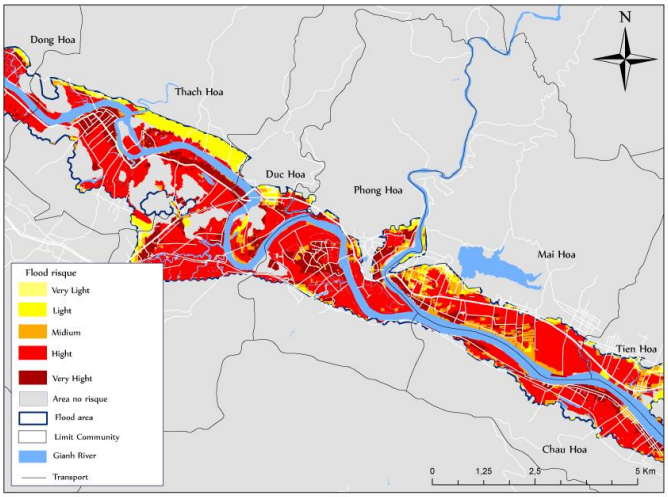


Fig. 20. Rismaps in the upstream of Lower Gianh River (Huu Duy, 2015).

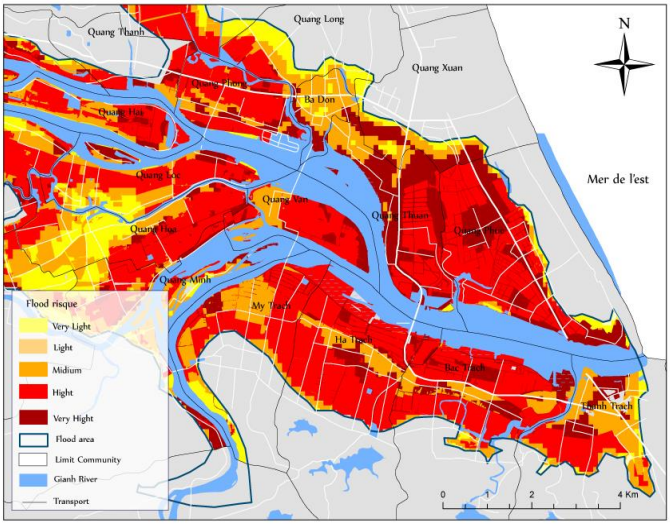


Fig. 21. Rismaps in the dowstream of Lower Gianh River (Huu Duy, 2015).

Through flood risk maps, it is possible to delineate areas in which prohibitions, homogeneous regulatory requirements, and prevention, protection and safeguard measures are applicable.

In these areas where the risk is greater for the safety of people and goods, the objectives are (2004 report in Rhône-Alpes):

- Prohibition of all new constructions
- Improving the safety of people and not increasing the number of people exposed.
- Reducing the vulnerability of existing constructions and developments by prescriptions, because in this area, it concerns the most exposed areas due to the water heights or speeds reached, as well as the fields of flood expansion.

In these areas where the medium to low risk makes it possible to accommodate new constructions in urbanized areas, subject to compliance with regulations or preventive measures.

V. CONCLUSION

The Gianh River watershed is often affected by flooding. Particularly in recent years, floods have caused a number of human and/or material damages, and the damages are increasingly serious in a context where typhoons have become more frequent since 2005. The increase in the risk of flooding is linked natural and human factors.

Due to the very dense topography and hydrology networks, the risk of flooding in the watershed is compounded. Precipitation between 1980 and 2012 had a downward trend in the upstream part of the watershed, while there was an upward trend in the downstream part. However, from 1994 onwards, the increase in the day of rain is strong and the number of years when the flows stronger in the same period. Moreover, from 2005, typhoons have the tendency to increase. This is one of the factors causing the worst flood damages in the watershed.

Since 1986, the country has embarked on a process of transition and development, which is parallel to the urban growth. In addition, in the context of population growth, impermeable surfaces have increased due to the habitat requirements and construction. This growth also reflects the problem of the illegal exploitation of sand on the river. The densification of built-up areas and the construction of numerous hydroelectricity centers have accentuated the stakes and the vulnerabilities to the risk of flooding. The forest ecosystem also seems fragile. Deforestation upstream of the river worsened between 1989 and 2003 due to agriculture and illegal logging, etc. All of these lead to a greater risk of flooding in the watershed. This is the reason why we have added plans to prevent flooding in the delta. It is an effective and necessary information tool for flood prevention and implementation of protection measures, including targets to reduce the vulnerability of people and property, as well as to assist in planning and development decisions. Territories such as prohibiting human settlements in the most dangerous areas, mastering urban planning, preserving flooding and flood expansion capacities.

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