Contruction of a flood risk map on Dinh river's downstream, Ninh Thuan province in service of rescuing and disaster prevention

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• **Abstract:** The downstream of Dinh river is in Ninh Thuan province, with a large surface slope. In order to assess the impact of floods in addition to the factors of flood depth, inundation time, the velocity of flow during flooding must be included. Up to now, in flood studies, when making flood risk maps, there are often clearly factors such as depth of flood, duration of flood, flow velocity, etc. In order to have a general view to serve practically the rescue operation, flood prevention, we present a new method of flood mapping when incorporating two factors: (i) flood depth and (ii) flow velocity of flooded areas..

• **Key words:** Dinh river, Ninh Thuan, flood risk, flood depth, flow velocity.

1. Introduction

The downstream of Dinh river is in Ninh Thuan province, Dinh river flows into the sea in Phan Rang - Thap Cham city, the Dinh river basin is mostly in Ninh Thuan province, a small part of Khanh Hoa province, with the total catchment area is about 3,279 km². This is an area where the climate is probably the most severe in the country, sunny, fiery, with the lowest annual rainfall in the country, often affected by natural disasters such as drought, desertification, heatwaves, storms, floods caused by heavy rains...

Although the floods are not as frequent as droughts, their impacts are significant. The historic floods in 2003, 2010 and 2016 have caused great damage to the local economy, especially the coastal districts and towns with the highest population. The frequency of occurrence of floods is not high, but due to the relatively steep terrain and low-lying areas in the downstream, the focus of flooding is quite fast, about 4-5 hours and the vast space causes floods in large area.

Due to the steep slope, the velocity of the flow when the flood returns is quite large, according to the actual observations of recent floods (November - December 2016) and the hydraulic calculation results show the flow velocity on the main river and on the spillway reach Vmax > 4m/s, making it difficult to travel on the river, specially in the flooded area in the south of the Dinh River.

To minimize the flood damage in Ninh Thuan province, develop an effective plan to respond to natural disasters, handle emergency situations when floods occur, and serve other planning requirements: land use, infrastructure construction, etc., the team calculated a flood risk map for the downstream of Dinh river in Ninh Thuan province, which incorporates both elements: flood depth and velocity. This paper will present a summary of the theoretical basis and some results of mapping.

2. Research methods and theoretical basis

2.1 Research scope

Flooding in the downstream area of Dinh River is mainly caused by floods from upstream, therefore, the study scope covers the entire Dinh river basin with a total catchment area of about 3,279 km² in Ninh Thuan province and a small part of Khanh Hoa province.

With topographic features of Ninh Thuan province, gradually lower from the Northwest to the Southeast, with three main types of terrain: mountainous areas, accounting for 63.2%; semi-hilly hilly region, accounting for 14.4% and coastal plains, accounting for 22.4% of the province's natural area, floodplains are concentrated in the downstream, hence, the paper will focus on this area.

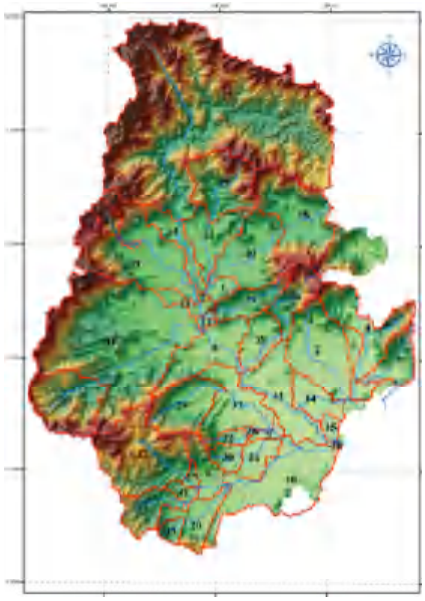


Figure 1. Research scope

2.2 Research methodology

Flooding depends on many factors such as rain, flow, tides, topography, regional infrastructure... and these factors have a close relationship with each other. Thus, to achieve the required results in the study, several main methods were used as listed:

Inheritance method: This study is inherited and partly refined from the results of the overall study on hydrology and hydraulics for the entire Dinh river basin in Ninh Thuan province, conducted by the research team..

Modeling method: Mathematic modeling method is the main method used in the overall

study. The models applied in the calculation of MIKE include: NAM model (Rainfall - Runoff) calculates the flow from rain for the whole Dinh river basin; Models MIKE 11 (HD, AD), MIKE 21, MIKE FLOOD calculate changes in flow, water level, flood in rivers and low-lying areas along the river.

GIS method: In this study, GIS method is used to build input data (topography) for calculation models, combined with calculation results of hydraulic model to build flood maps. flood (flood water level, inundation depth, flow velocity in flooded areas, flood risk map ...).

Expert method: The main result of this research is to develop a flood risk map, this is a new issue so during the implementation of the research group, the research team consulted and received plenty of opinions from domestic and foreign experts.

3. Calculation results and discussion

3.1. Case study selection

In order to assess flood risks in service of rescue and response to emergencies within the limited scope of the paper, the research team will develop the case of floods, overflow of reservoirs in the whole basin corresponding to the frequency P = 1.0%, the tide level outside the river mouth corresponds to the frequency P = 1.0% in the present conditions. and periods of climate change, rising sea level.

The calculation scenario is based on the current status of irrigation constructions and the scenario takes into account the planned constructions, especially Song Cai Lake, Tan My Irrigation System, Song Dinh Dam, dike south of Dinh River and others that have been approved according to the planning. Some of the main changes of the planning conditions compared to the current situation include: (i) Phan Rang city area is expected to expand, raise the ground level, plan new urban areas in the Northwest region, East and Northeast; (ii) Upgrading the dike system along the Dinh River bank, starting from Dao Long 2 bridge to An Dong bridge with an elevation of +6.0 ÷ + 6.3m; (iii) Some upstream reservoirs will be built such as Phuoc Hoa lake, Than river lake ... (iv) Sluice gates to prevent salinity downstream Dinh river will be built and put into operation.

No.	Scenario names	Scenario descriptions	Rain	Tide	Flood
1	HT	Current topography, flood 1%	P1%	P1%	P1%
2	HT+BĐKH2050	Current topography, 1% floods take into account climate change 2050, scenario RCP4.5	P1%	P1%	P1%
3	QH	Planning terrain, flood 1%	P1%	P1%	P1%
4	QH+Cống	Planning terrain, taking into account the 1% Dinh flood estuary construction	P1%	P1%	P1%
5	QH+BĐKH2030	Planning terrain, 1% flood, taking into account climate change 2030, scenario RCP4.5	P1%	P1%	P1%
6	QH+BĐKH2050	Planning terrain, 1% flood, taking into account climate change 2050, scenario RCP4.5	P1%	P1%	P1%
7	QH+BĐKH2100	Planning terrain, 1% flood, taking into account climate change 2100, scenario RCP4.5	P1%	P1%	P1%

3.2. Inputs for flood risk mapping

In this study, the results of calculation of flood depth and velocity are calculated from MIKEF LOOD model results for the entire downstream area of Dinh river. MIKE FLOOD model was built from 1D MIKE11 hydraulic model for all main river branch, tributaries of Dinh river connected NAM flow showers distributed evenly along stream branches and 2D models and MIKE21FM for the entire low-lying area of the lower section of the river.

The model has been calibrated and verified with real measurements of flow and water levels at hydrological stations on the Dinh River. After adjustment and testing of the model used to calculate hydraulics for the entire study area.

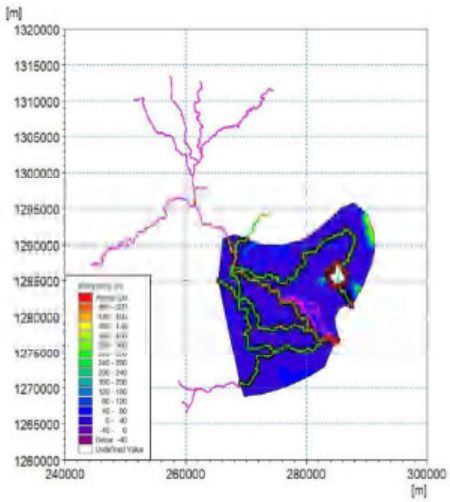
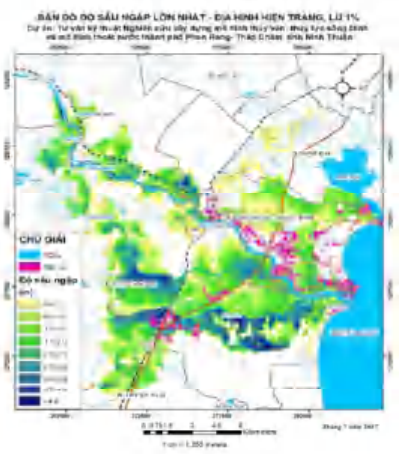
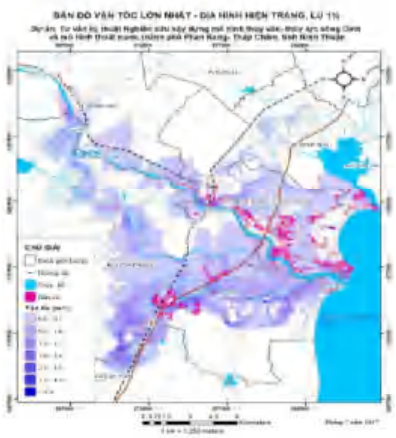


Figure 2: MIKE FLOOD hydraulic model for the downstream area of Dinh river

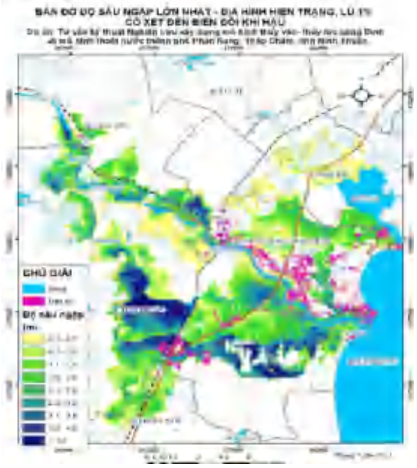


Map of the largest flood depth

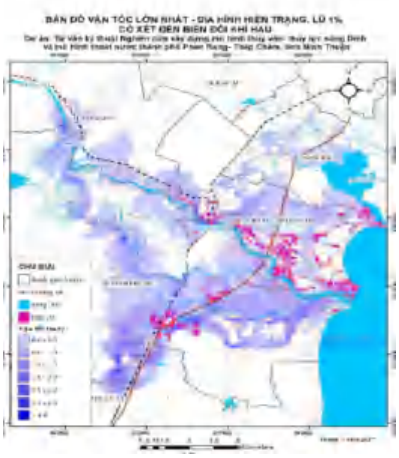


Map of the largest velocity

Figure 3: Bản đồ độ sâu ngập và vận tốc dòng chảy lớn nhất cho kịch bản hiện trạng



Bản đồ độ sâu ngập lớn nhất



Map of the largest velocity

Figure 4: Bản đồ độ sâu ngập và vận tốc dòng chảy lớn nhất cho kịch bản hiện trạng + BĐKH

3.3. Calculation and discussion results

The results of the model used to build flood risk maps are flood depth, flow velocity which will be exported as Raster data and numeric data, then will be calculated and processed by GIS to develop flood risk maps for scenarious.

No	Scenarious name	Content	Flood risk	
			F (m^2/s)	% increase compared to status quo (HT)
1	HT	Current topography, flood 1%	0-11	0,0%
2	HT+BĐKH2050	Current topography, 1% floods take into account climate change 2050, scenario RCP4.5	0-17	54,5%
3	QH	Planning terrain, flood 1%	0-17	54,5%
4	QH+Cống	Planning terrain, taking into account the 1% Dinh flood estuary construction	0-15	36,4%
5	QH+BĐKH2030	Planning terrain, 1% flood, taking into account climate change 2030, scenario RCP4.5	0-18	63,6%
6	QH+BĐKH2050	Planning terrain, 1% flood, taking into account climate change 2050, scenario RCP4.5	0-19	72,7%
7	QH+BĐKH2100	Planning terrain, 1% flood, taking into account climate change 2100, scenario RCP4.5	0-18	63,6%

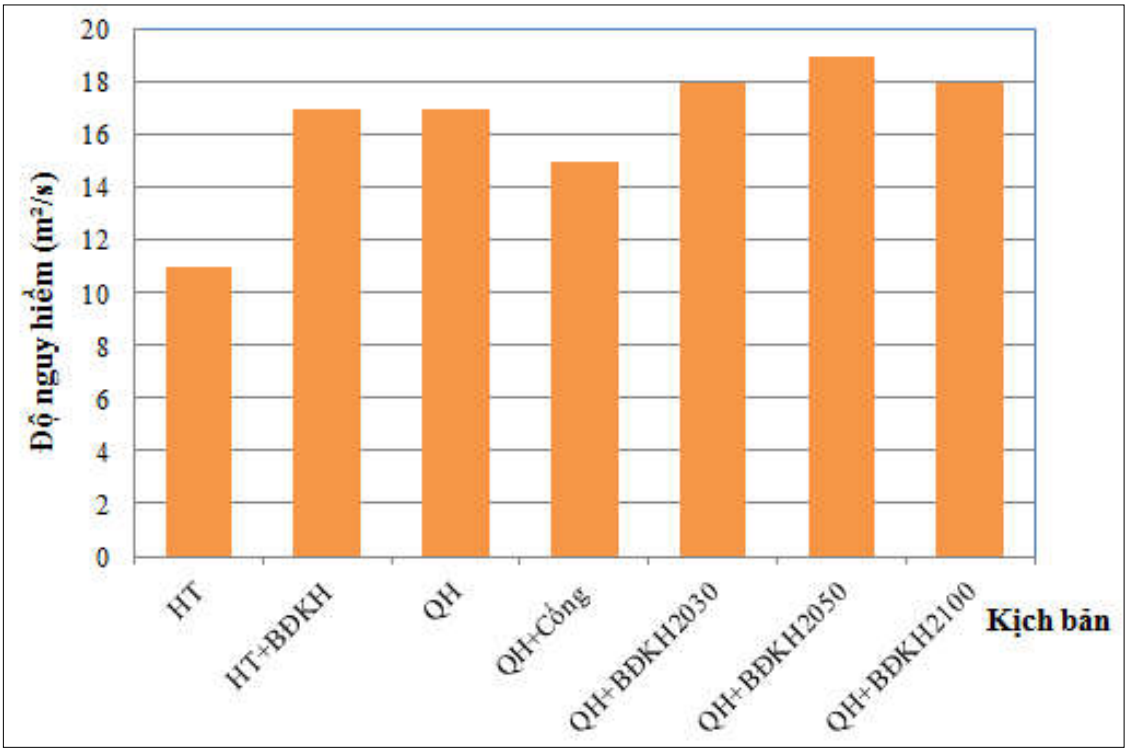


Figure 5: Extreme danger in calculation

From the scenarios, calculate the danger level (F) for each location and for the entire downstream area of Dinh river. The most dangerous level in the area is from 11-19 (m^2/s) depending on the calculation scenario. And of course it depends on the location (each point).

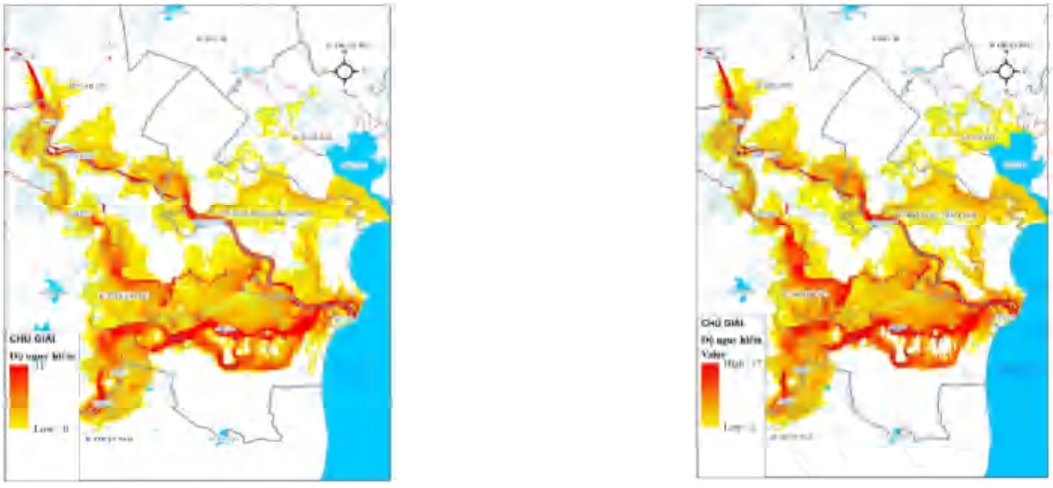
Calculation results closely reflect the reality, under the current conditions but under the impact of climate change (2050), the flood risk for the downstream area is quite high (about 54.5%) compared to to the status quo. In the case of the planning scenario, the risk of floods also increased by about 54.5%, which proves that the infrastructure construction in the upstream, urban development associated with the improvement of the foundation and infrastructure construction. traffic, irrigation, dykes prevent river floods in downstream areas, increasing and potentially flooding. Upgrading and strengthening the construction of dyke line north of Dinh river to protect the city area. Phan Rang - Thap Cham is synonymous with increasing flood risk for the southern part of Ninh Phuoc district, flood risk is directly proportional to the height of the Northern dike crest.

Currently, the dam to prevent salinity downstream of Dinh river has been nearly completed, put into use, the calculation shows that in the case of normal operation, the project has no negative impact on flood drainage, but a problem. It is also necessary to set out that if there is a problem of valve jams (1 or several of the 6 gates) cannot be opened when constructing the project, the risk of flooding will increase very dangerously. for the entire downstream region, especially the central area of Phan Rang-Thap Cham.

The calculation results show that the risk of flooding on the southern bank of Dinh river is much higher than that in the North bank area in terms of both flood and flood area. The high flood risk area lies to the southeast, especially the low-lying areas running along the Lu river to the sea and Ninh Phuoc town area.

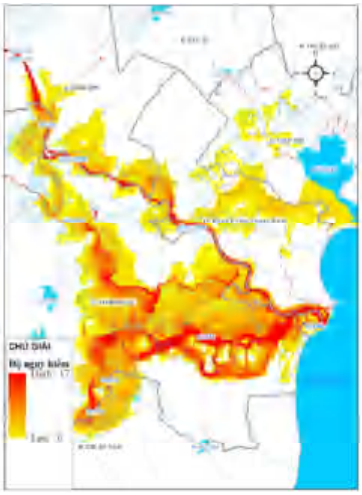
In the case of onstructions built according to the planning and conditions of climate change, rising sea level occurs, the risk of flood increases quite high, about 63.6% - 72.7% compared to the current situation. The comparison of flood risks between climate change scenarios across periods of not much change is about 10%.

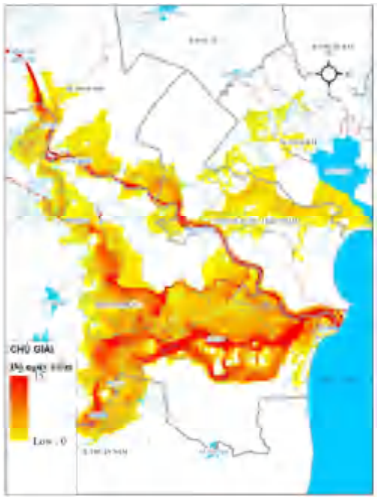
The calculation results also show that the risk of floods increases due to human impacts through the planning and construction of residential areas, construction of irrigation infrastructure, transportation... equivalent to the increase due to the variable. climate change and sea level rise until 2050 under current conditions.



Scenario HT *Scenario HT+BĐKH2050*

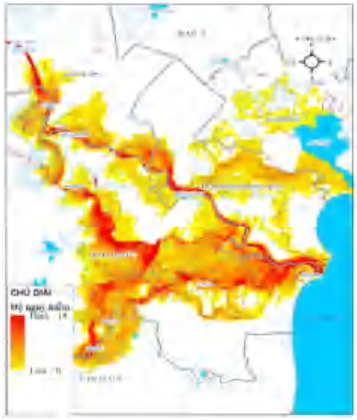
Figure 6: Flood risk map for the scenarios HT và HT+BĐKH2050

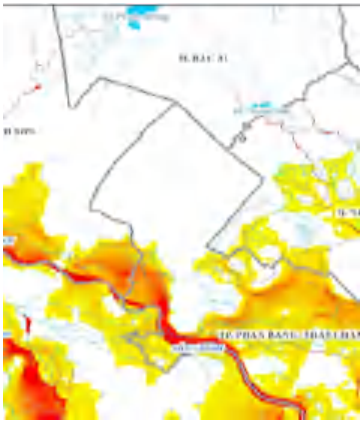




Scenario QH *Scenario QH+Cống hạ lưu sông Dinh*

Figure 7: Flood risk map for scenarios QH và QH+Cống





Scenario QH + BĐKH 2030 *Scenario QH+BĐKH2050*

Figure 8: Flood risk map for the scenarios QH +BĐKH 2030, 2050

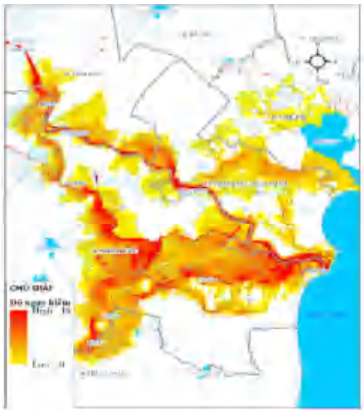


Figure 9: Flood risk map for the scenario QH +BĐKH 2100

4. Conclusion

The article presents part of the results from the research "Technical consultancy on building hydraulic and hydrological models of Song Dinh and drainage models of Phan Rang - Thap Cham city, Ninh Thuan province in relation to climate change, under the project Integrated management of water resources and urban development in relation to climate change in Ninh Thuan". According to the evaluation of the research team, the flood risk maps built in this study have great practical significance, can be applied directly to the prevention of floods, storms, natural disasters and rescue. rescue and develop scenarios, emergency response plans, and will be a reference in spatial planning, land use planning... for the downstream Dinh river, especially for flooded areas.

Normally, when building flood maps, it is only limited to a number of single maps, such as: depth map, flood level, flood time, flooding speed. In order to meet the practical requirements, the need to improve research work, the implementation team has developed a new research and calculation method in the construction of flood maps incorporating risk factors of flood flow including flood depth and flood velocity is added. In the next research direction, it will continue to develop higher when the flood risk map is integrated with other adverse and dangerous factors such as: flood retention time, socio-economic importance. , the culture of the flooded area.

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