FLOOD RISK INDEX ANALYSIS
FOR CUHA RIVER BASIN, TIMOR – LESTE

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ABSTRACT

In order to reduce flood damage by conducting appropriate structural and non-structural measures, it is essential to understand flood risk of the area. In this study, flood risk in the Cuha river basin in Timor Leste was analyzed by using Rainfall-Runoff and flood inundation Model (RRI Model) which is a two-dimensional model capable of simulating rainfall-runoff and flood inundation simultaneously. In this river basin, observed hourly rainfall data is not available. Then, centralized hourly design rainfall for the target river basin was assumed based on rainfall intensity curves of different return periods such as 10, 25, 50 100, 200 return periods. Using assumed design rainfall, flood inundation simulation was conducted by RRI model. Next, in order to show flood risk in the area in more comprehensive way, flood risk index were proposed from the viewpoint of human safety by using thresholds value of the inundation height considering the measured height of a typical house such as the average first flood level and roof-top level. Finally, flood risk rank (A, B, C and D) of each area was obtained from flood inundation depth calculated by RRI model and shown on the Google earth map. Flood risk index analysis could be used to identify the area at risk and give suggestions on necessary countermeasures in the area.

Keywords: RRI Model, flood Inundation mapping, risk index analysis.

INTRODUCTION

Timor Leste, is located in the Southeast Asia country and it lies at Longitude of 123^0 E and Latitude of 9^0 S. It has divided into the Districts, Sub districts, Sucos. Study area, District viqueque is located in Cuha river basin with catchment of 267 KM^2 as shown in Figures 1 and 2. Since time in memorial, human beings have been suffering from the harms of flood and floods have brought a lot of death, loss, and damages in Cuha river basin. Flood in Viqueque district of Timor Leste occurs as flash –flooding when the heavy seasonal rain converges into tributaries as it descends, resulting in the rapid rise of discharged water. LA Nina which brings heavy rainfall, causes an increase in flood. Floods are now mostly considered as the threat to human beings with the expansion of human activities. The number of floods has increased since 2001 and recorded flood damage has also increased since 2013 in the areas where water accumulates in float terrain and upland flood plains where river banks area are insufficient. In 2001 and 2016, at least 44 people were killed by floods according to the emergency events database by United Nation For Risk Reduction (UNISDR).
In order to solve the problem due to flood risk in the Cuha river basin, this study aims to analyze flood inundation process in the basin by RRI model, to develop flood inundation maps for identifying the most flood prone areas, and to assess flood risk in the basin by risk indices for suggesting appropriate countermeasures for flood prone communities.

Figure 1: Location of study area.

Figure 2: Cuha river basin.

METHODOLOGY

Figure 3 shows a flow chart of the study. In this study, flood risk in the Cuha river basin in Timor Leste is analyzed by using Rainfall-Runoff and flood inundation Model (RRI Model) . RRI model is a two-dimensional model capable of simulating rainfall-runoff Inundation simultaneously (Sayama et al., 2012), Sayama). The model deals with slopes and river channels separately.

In this river basin, observed hourly rainfall data is not available. Then, centralized hourly design rainfall for the target river basin is assumed based on rainfall intensity curve in Bogor district in Indonesia because its climate is regarded to be almost similar to Timor Leste. Based on the rainfall intensity curves in Bogor district, centralized design rainfalls for different return periods such as 10, 25, 50 100, 200 return periods return period are assumed. Using this design rainfall data, flood inundation area is identified by RRI model simulation.

Next, in order to show flood risk in the area in more comprehensive way, flood risk index from the viewpoint of human safety is proposed based on the measurements of a typical house in the area. Four risk ranks (A, B, C and D) were proposed using thresholds value of the inundation height which are determined by the measured height such as the average first flood level and roof-top level of a house. Flood risk rank for human safety in each area is obtained from flood inundation depth calculated by RRI model and shown on the Google earth map. Finally, necessary countermeasures in identified high risk area are discussed.

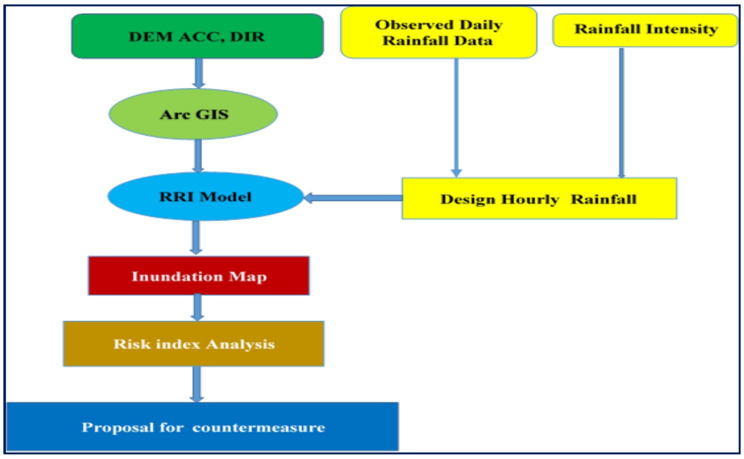

Figure 3: Flow chart of methodology

Rainfall intensity curve

Figure 4 shows a rainfall intensity curve in Bogor district in Indonesia. Vertical axis of the curve is rainfall intensity (mm/h) and horizontal axis is duration of rainfall (min). In this figure, the equation below gives rainfall intensity during certain rainfall period with different return periods such as 10, 25, 50 100, 200 return periods by using coefficient of A, B and C as shown in table.1.This rainfall intensity curve is used on the assumption that Indonesian climate is almost similar to Timor Leste because the rainfall intensity curves in Timor Leste are not available.

$$r = \frac{A}{t^B + C}$$

while r: Rainfall Intensity (mm/h),
t: time (min),
A, B, C: Coefficient

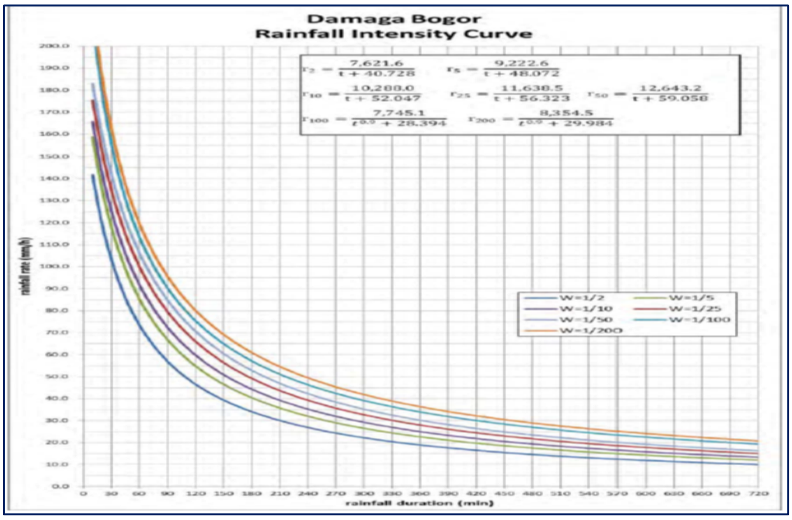

Figure 4 :Rainfall Intensity curve (JICA report)

Table 1: Coefficient for intensity curve

Return Period	10 years	25 years	50 years	100 years	200 years
A	10,288	11,638.5	12,643.2	7,745.1	8,354.5
B	1	1	1	0.9	0.9
C	52.047	56.323	59.058	28.394	29.984

Table 3:Annual peak daily rainfall (mm) in the basin in the past

years	Annual peak daily rainfall in the past period at Ossu
2010	130.5 mm
2011	80.4 mm
2012	93.2 mm
2013	276.1 mm
2014	135.2 mm
2015	73.4 mm

Centralized design rainfall based on rainfall intensity curve

Observed annuall peak rainfall in the Figure 5 shows centralized hourly design rainfall for the target river basin assumed based on rainfall intensity curve in Bogor district in Indonesia. Design rainfall is assumed for 720 minitues by 10 minutes interval considering diffferent return periods such as 10, 25, 50, 100-200 years return period.

From the observed records, annual rainfall maximum is 2800 mm/year and minimum rainfall is 900 mm/year. Daily rainfall is observed at Meteorological and Hydrological stations along this river, such as Ossu in upstream, Loihuno in middle stream, and viqueque in downstream. Table 3 shows the annual peak daily rainfall at Ossu.

Considering this records, total rainfall during the assumed design rainfall with 10 year return periods corresponds to the daily rainfall observed at Ossu in 2014. And total rainfall during the design rainfall with 200 year return periods is similar to the severe daily rainfall at Ossu in 2013.

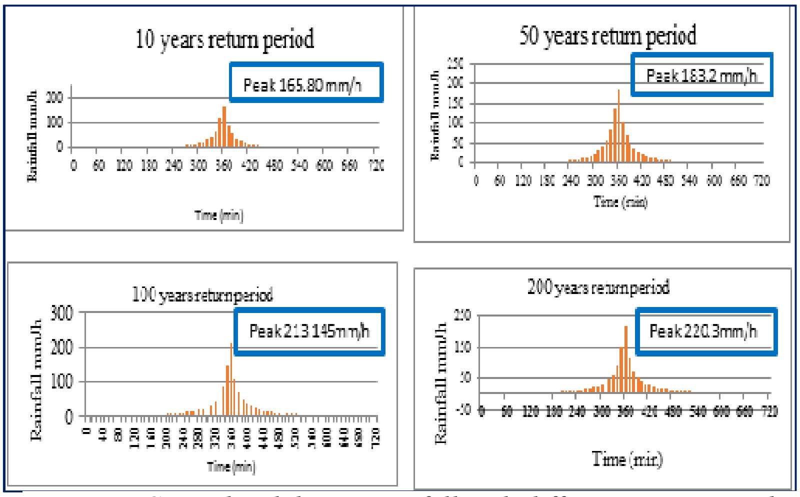

Figure 5 :Centralized design rainfall with different retun periods.

Flood Risk Index

Flood risk index is proposed from the viewpoint of human safety based on the measurements of a typical house in the area. Risk rank is proposed as follows: rank C: a house is submerged, rank B: people inside a house have a risk of death, rank C: middle water exceeds floor level, rank D: water is below floor level as shown in table and figure below.

Table 4:Concept Flood Risk index

Risk Index	Rank A (Very High)	Rank B (High)	Rank C (Middle)	Rank D (Low)
Maximum Inundation	>5.6m	1.5 - 5.6 m	0.3 m- 1.5 m	<0.3 m
Condition	A house is submerged	People inside a house have a risk of death.	Water exceeds floor level.	Water is below floor level.

Figure 6:Measurement of a house

DATA

In RRI model simulation, ACC, DEM, DIR data were downloaded from HydroSHED and used. HydroSHED provides DEM data of both 15 and 30 seconds. In this study, DEM data of 15 arc second was used as shown Figure 7 because the target river basin is relatively small.

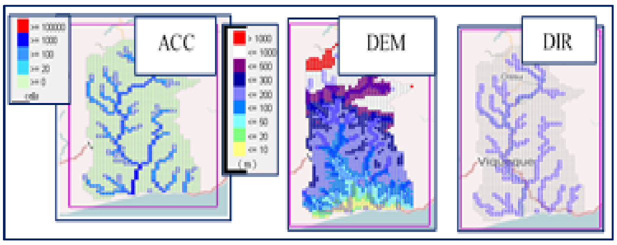

Figure 7 :Digital elevation map and river network.

RESULTS

Simulation by RRI model

Using centralized design rainfall data, RRI simulation was conducted and flood inundation area was identified. Discharge obtained by RRI simulation at river mouth of Cuha river basin incresed when the return periods of artificial rainfall changed from 10, 25, 50, 100-200 years, as shown Figure 8.

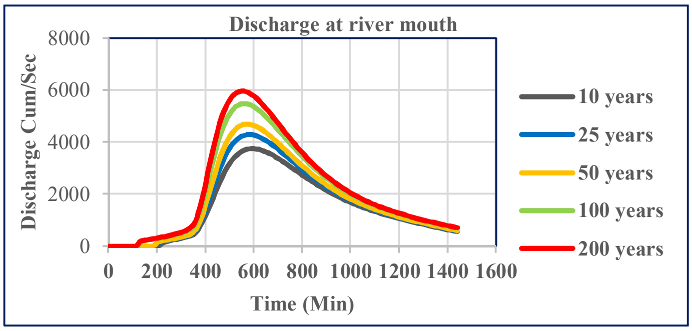

Figure 8 :Discharge simulated by the RRI model.

Flood Inundation Mapping Considering Different Return Periods

One of the major purpose of this study is to develop the flood hazard map for the flood management by RRI model simulation. Flood inundation maps of 10, 25, 50,100 and 200 years return period were created by application of GIS tools as shown Figure 9 below. In these maps, area of each risk index (A, B, C and D) identified by the thresholds shown in Table 4 is plotted. As the return period increases, the area of rank A expands especially at the river mouth.
Figure 10 shows the risk index plotted on Google Earth. Right map in the figure describes the risk index in the area of Viqueque. It identifies the high risk rank (A) area at the cross-section of several tributaries

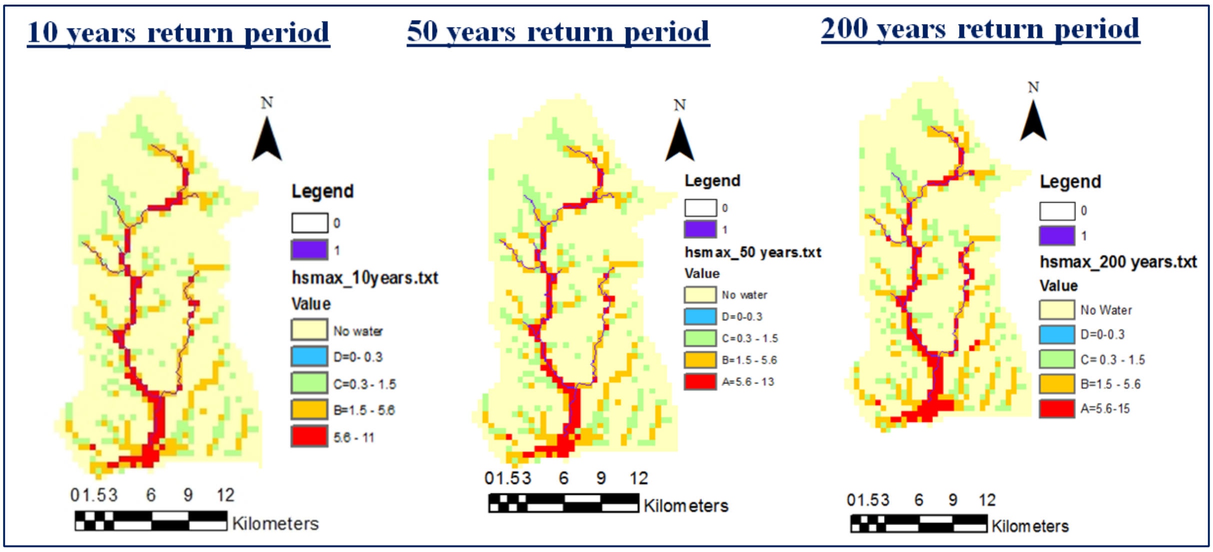

Figure 9 :RRI simulation for diffrent return periods

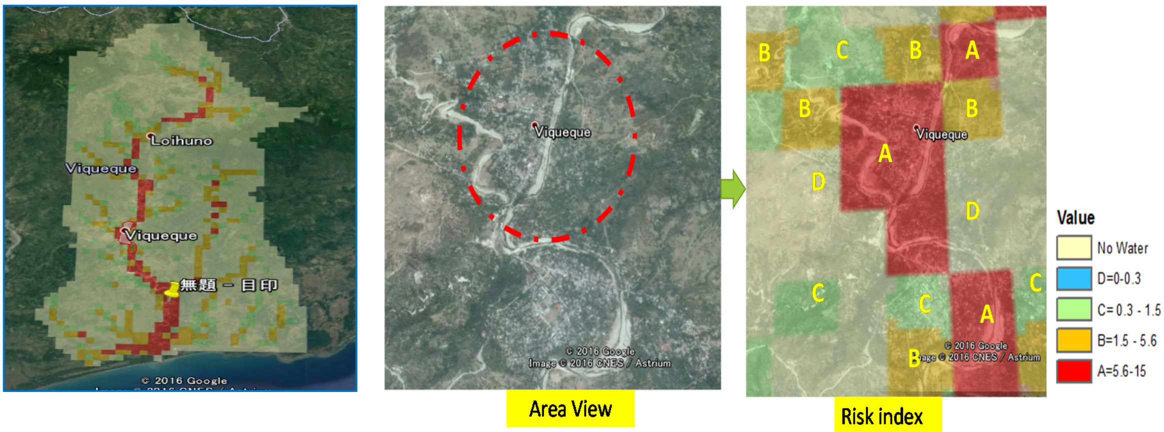

Figure 10: Area of risk rank for 50 years return period
(Left: all river basin, Center: Arial view at Vuqueque, Right: Risk index at Viqueque)

CONCLUSIONS

In this study, flood risk in the Cuha river basin in Timor Leste was evaluated by flood simulation by RRI model and risk index analysis.

First, centralized design rainfall for the target river basin was assumed on rainfall intensity curves of different return periods such as 10, 25, 50, 100, 200 return periods. Rainfall intensity curves in Bogor district in Indonesia were used because the curves in Timor-Leste were not available. Discharge and inundation was calculated under a given scenario with 10-200 years return period floods. Inundation depth in the river basin was shown in the map using ArcGIS.

In order to show flood risk in the area in more comprehensive way, flood risk index was proposed from the viewpoint of human safety based on the measurements of a typical house in the area. Four risk ranks (A, B, C and D) were proposed using the thresholds value of the inundation height which are determined by the measured height such as first flood level and roof-top level of a one-story house. Flood risk rank for human safety in each area was obtained from estimated flood inundation depth and shown on the Google earth map.

In the high risk rank area in Viqueque district in Cuha river basin, countermeasures such as public education of flood risk, flood early warning for safer evacuation, evacuation space, land use planning, and implementation of flood insurance are strongly recommended for reducing flood damage due to future floods.

RECOMMENDATIONS

In Cuha river, observed data of hourly rainfall is not available. Strengthening and improving rainfall observation system is recommended. In this study, observed discharge was not available. Strengthening river monitoring system is also recommended. By conducting calubration of the RRI model with observed discharge, the accuracy of the calcuation will be imcreased. Further validation of RRI model based on water level record and discharge records are recommended. More simulation by changing parameters such as infiltration ratio duration of rainfall is necessary to analyze risk rank in each area in the river basin.

In this study, risk index from the viewpoint of human safety was analyzed. However, more risk index frorm the different viewpoints can be discussed as follows.

Evacuattion index, inundation duration index, house damage risk index, evacuation space index,vulnerable people index,total risk index.

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REFERENCES

1. GIS Map Application (Geographic information system)
2. GUIBOOK RRI Model (Rainfall Run of Inundation Model).
3. *(UNISDR)*The United Nations Office for Disaster Risk Reduction Data Period 1992 to 2016
4. http//www. *IWRM* (Integreted water related management inTimor Leste. Report 2016)
5. Ministry Social Solidarity of Department Natural Disaster of Timor Leste Handbook 2007.
6. Timor-Leste: Disaster Management Reference Handbook 2016.
7. Assessment of water availability and water demand in Timor Leste at river basin level 2004.
8. Timor Leste National Disaster Risk Management Policy Source: Timor Leste Government.
9. Sayama, Ozawa, Kawakami, Nabesaka, Fukami. "Rainfall-Runoff-Inundation analysis of the Pakistan flood in the Kabul River basin." Hydrological Science Journal, 57(2), 2012: 298-312.
10. The project for capacity development of Jakarta comprehensive flood management JICA report in district Bogor Indonesia, 2013.