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Assessing Flood Risk in Prek Thnot River Basin Using AHP and GIS Analysis

Chanponleourothana Samrith[1], Ty Sok[1,2] , Sophal Try[3], Ilan Ich[1], Ratboren Chan[1,2], Chantha Oeurng[1]

[1] *Faculty of Hydrology and Water Resources Engineering, Institute of Technology of Cambodia, Phnom Penh, Cambodia.*

[2] *Research and Innovation Center, Institute of Technology of Cambodia, Phnom Penh, Cambodia.*

[3] *Disaster Prevention Research Institute, Kyoto University, Japan.*

Presenter: Chanponleourothana SAMRITH

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1.1 Background

- In Cambodia, the flood event in 2000 was reported as a severe flood that affected more than 3.4 million people, damaged 768 houses, and killed 347 people.
- In 2020, there was reported flooding killed 11 people and affected about 67955 household.
- The number of damages were decreased compared to flood in 2000.
- **Prek Thnot River Basin** is one of the largest basins in lower Mekong Basin that is a frequent location of calamitous frequent flood and flash floods, where the people suffered critical damages from flood.

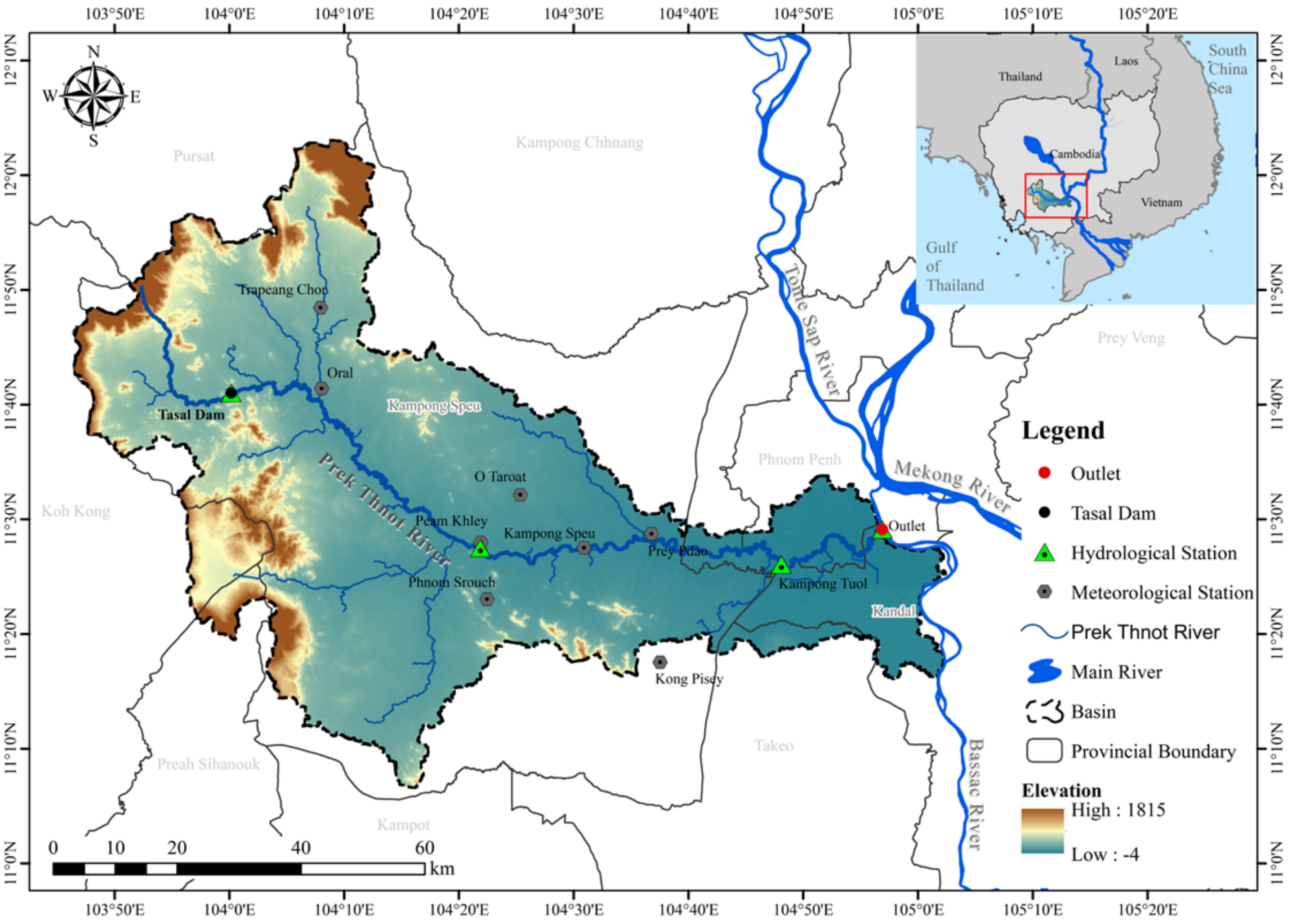
1.2 Objectives

- This study aims to determine flood risk levels across the Prek Thot River Basin using coupling AHP–GIS analysis.
  - To achieve the overall goal, specific objectives to be done:
    - (1) Classify the parameters of flood hazard
    - (2) Weight of AHP method
    - (3) Develop flood hazard map
    - (4) Sensitive analysis and Confirmation of flood risk map.

2.1 Study Area

The Prek Thnot River Basin

- Partly covers : Koh Kong, Kampong Speu, Kampot, Takeo, Kandal, and Phnom Penh
- Total area : 6660 km^2
- Elevation : -4 m – 1815 m MASL



2.2 Data Collection

Table 2.1. Requirement data input in assessing flood risk in Prek Thnot River Basin

Data input	Data description	Period	Data source
Rainfall	Ground observed rainfall measures daily time series; eight ground observed station: Kampong Speu, Kong Pisey, Oral, O Taroat, Peam Khley, Phnom Srouch, Prey Pdao, and Trapeang Chor	1997 - 2011	DHRW of MOWRAM
Digital Elevation Model (DEM)	Resolution 30m × 30m, Geographic coordinated latitude and longitude with 16 bits in units of vertical meters	-	ASTER-GDEM 2
Soil type	Resolution 250m×250m, soil type separated into 17 classes	2002	MRC
Land used	Resolution 250m×250m, land-use in Prek Thnot River Basin is separated into 18 classes	2002	MRC

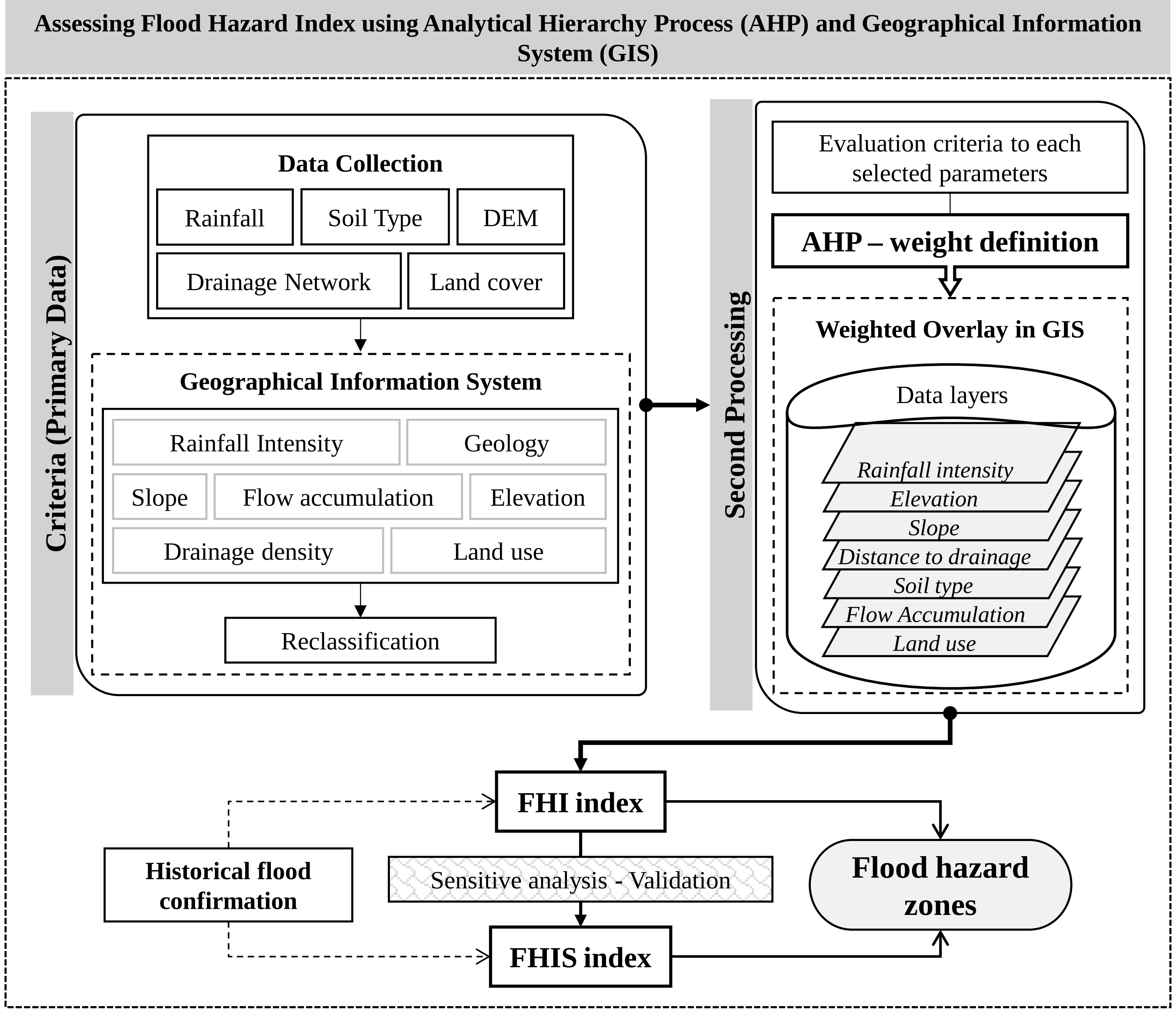
2.3 Study framework

- The **Analytical Hierarchy Process (AHP)** is one of the Multi Criteria decision-making technique that can help us make better analyzing complex problems.
- Pairwise comparison from AHP is accepted when Consistency Ratio (CR) is less than 10%.

$$CR = \frac{CI}{RI}, \quad (CR < 10\%)$$

CI: the consistency index

RI: the random index



2.3 Study framework (cont.)

Table 2.2. The definition of comparative importance

The intensity of Importance on an Absolute Scale	Definition
1	Equal Importance
2	Weak or slight
3	Moderate importance of one over another
4	Moderate plus
5	Essential or strong importance
6	Strong plus
7	Very strong importance
8	Very, very strong
9	Extreme importance

- A composite **FHI** contributes the rating score and the priority weight from the AHP of each parameter. The composite **FHI** is defined and calculated following:

$$\mathbf{FHI} = \sum_{i=1}^{n} \mathbf{r_i \times w_i}$$

$$FHI = F \cdot w_F + I \cdot w_I + G \cdot w_G + U \cdot w_U + S \cdot w_S + E \cdot w_E + D \cdot w_D$$

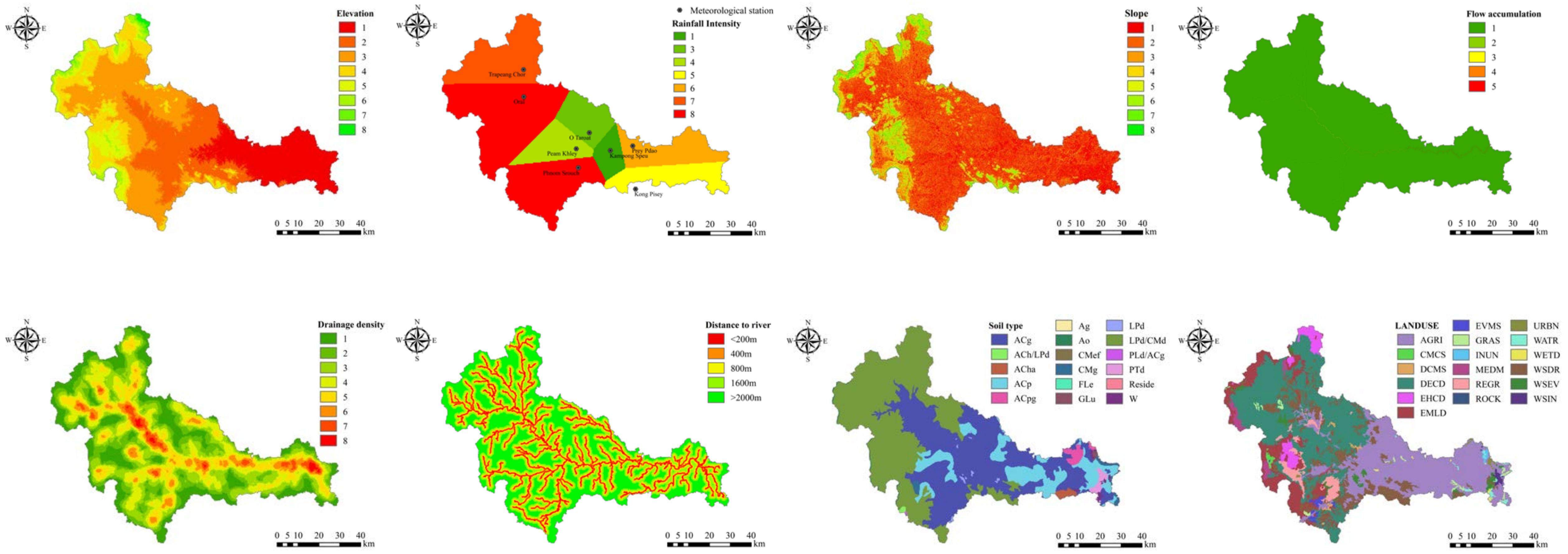
Where:

r_i the score rating of the flood causative factor in each point

w_i the effective weight of each flood causative factor

n the number of flood causative factors

2.4 Thematic maps



3.1 Result AHP

CR=0.9% <10%, Acceptable

Table 3.2. Normalize pairwise for flood hazard, Analytical Hierarchy Process

Parameters	R	E	Sl	DD	D	F	So	LU
Rainfall	**1**	1	1	5	6	3	8	9
Elevation	1	**1**	1	5	6	3	8	9
Slope	1	1	**1**	5	6	3	8	9
Drainage Density	0.20	0.20	0.20	**1**	1	0.50	2	3
Distance to river	0.17	0.17	0.17	1	**1**	0.33	2	3
Flow accumulation	0.33	0.33	0.33	2	3	**1**	3	4
Soil type	0.13	0.13	0.13	0.50	0.50	0.33	**1**	1
Land-use	0.11	0.11	0.11	0.33	0.33	0.25	1	**1**
AHP-Weight	0.251	0.251	0.251	0.053	0.048	0.096	0.028	0.024
AHP-Weight (%)	25	25	25	5	5	10	3	2

3.2 Sensitive analysis

Table 3.2. The score of each classes of the eight parameters

Parameter	Class	Class no.	Score
Elevation (m)	< 61	1	5
	61.01 - 134	2	3
	134.01 - 241	3	3
	241.01 - 383	4	2
	383.01 - 558	5	1
	558.01 - 797	6	1
	797.01 - 1,157	7	1
	1,157.1 - 1,815	8	1
Rainfall (Thiessen Polygon) (mm)	56.905 - 85.259	1	5
	85.260 - 89.310	3	5
	89.311 - 102.48	4	5
	102.49 - 129.82	5	7
	129.83 - 182.48	6	6
	182.49 - 193.62	7	2
	193.63 - 315.14	8	4
Slope (Degree)	0 - 2.138	1	7
	2.139 - 5.226	2	5
	5.227 - 9.026	3	3
	9.027 - 14.01	4	2
	14.02 - 19.48	5	1
	19.49 - 25.65	6	1
	25.66 - 33.26	7	1
	33.27 - 60.57	8	1

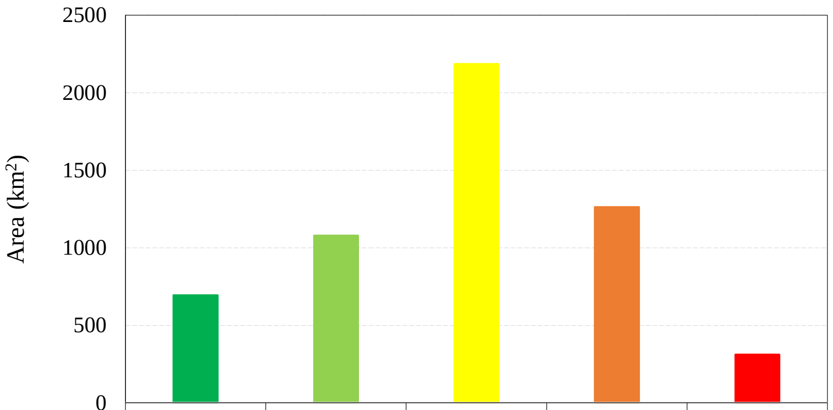
Parameter	Class	Class no.	Score
Flow accumulation (m^3/s) ($\times 10^6$)	0 – 0.18	1	3
	0.18 - 1.08	2	3
	1.08 - 2.44	3	5
	2.44 - 4.43	4	8
	4.43 - 5.98	5	9
DD (m/km^2)	0 - 0.109	1	1
	0.11 - 0.219	2	1
	0.22 - 0.328	3	3
	0.329 - 0.438	4	3
	0.439 - 0.547	5	5
	0.548 - 0.657	6	7
	0.658 - 0.766	7	8
	0.767 - 0.876	8	9
Distance to river (m)	<200	1	9
	400	2	7
	800	3	5
	1600	4	3
	>2000	5	1

Parameter	Name	Type	Score
Soil types	Ag	C	5
	Ao	B	3
	LPd	D	9
	LPd/CMd	D	7
	FLe	B	1
	GLu	D	9
	PTd	C	5
	PLd/ACg	D	9
	ACp	C	5
	ACpg	C	5
	ACg	C	5
	ACh/LPd	B	5
	ACha	B	3
	CMg	C	5
	CMef	B	3
	Reside	D	9
	W	D	9

Parameter	Name	Score
Land-use	AGRI	3
	CMCS	5
	DCMS	3
	DECD	1
	EHCD	1
	EMLD	3
	EVMS	3
	GRAS	7
	INUN	9
	MEDM	1
	REGR	7
	ROCK	9
	URBN	9
	WATR	9
	WETD	9
	WSDR	1
	WSEV	1
	WSIN	7

3.3 Flood risk map

- The risk of flooding is linked to combined action of many different 8 factors such as elevation, slope, rainfall, drainage density, distance to river, soil type, and land use.
- **FHI** defines five levels of risk, ranging from very low, low, moderate, high to very high.



	Very low	Low	Moderate	High	Very High
Area (km2)	694.55	1079.09	2186.82	1263.33	310.75

Fig. 3.2. Area cover by flood risk level

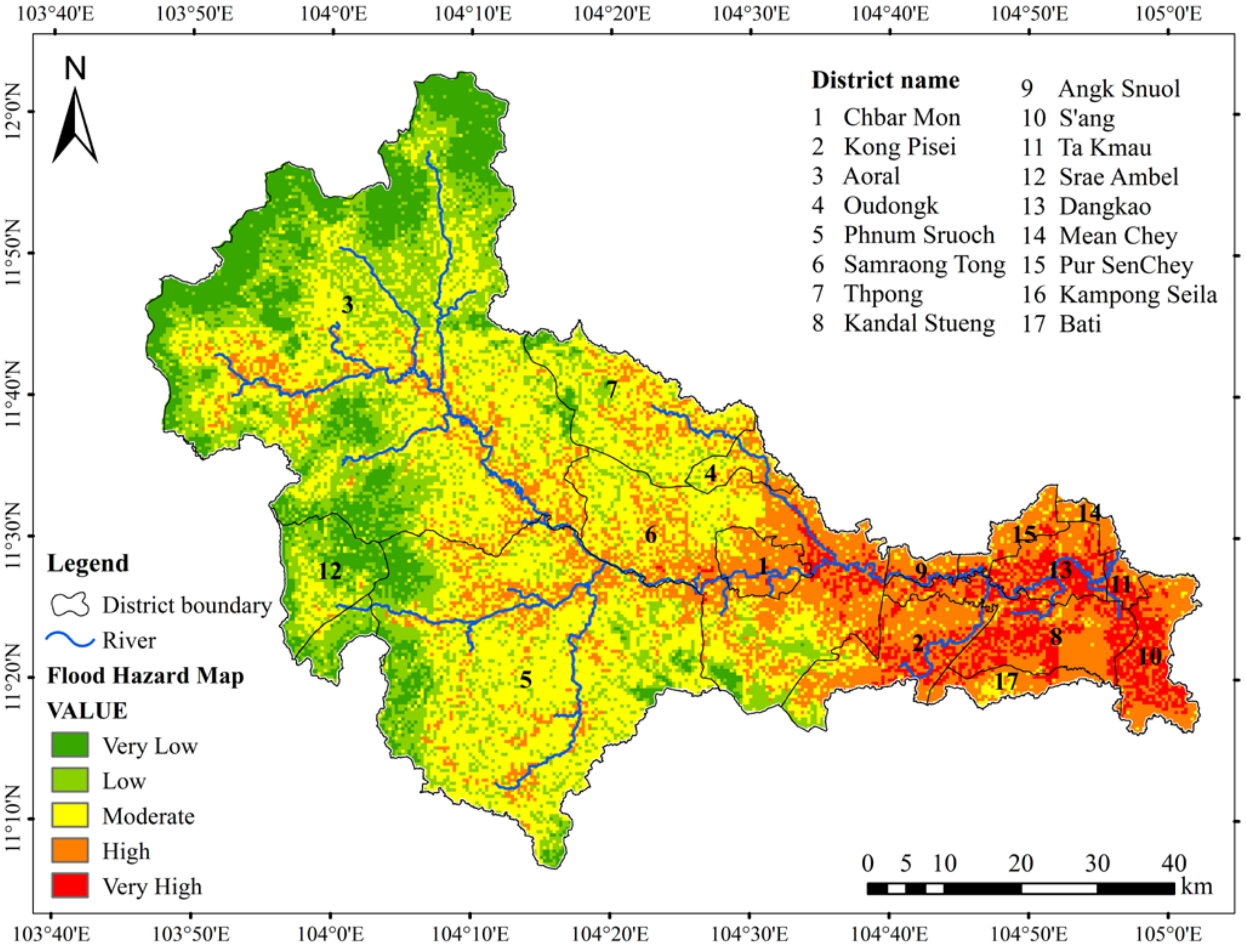
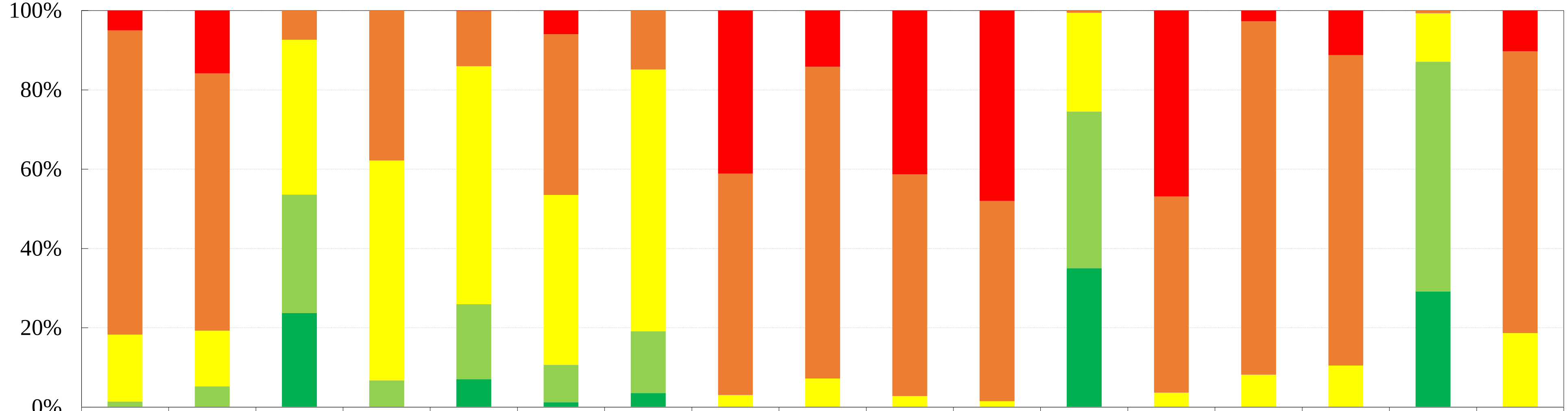


Fig. 3.1. Flood risk map of Prek Thnot river basin

3.3 Flood risk map (cont.)



	Chbar Mon	Kong Pisey	Aoral	Oudong k	Phnom Sruoch	Samraon g Tong	Thpong	Kandal Stueng	Ang Snuong	S'ang	Ta Khmau	Srae Ambel	Dangkao	Mean Chey	Pur Senchey	Kampon g Seila	Bati
Very High	5%	16%	0%	0%	0%	6%	0%	41%	14%	41%	48%	0%	47%	3%	11%	0%	10%
High	77%	65%	7%	38%	14%	41%	15%	56%	79%	56%	50%	1%	49%	89%	78%	1%	71%
Moderate	17%	14%	39%	55%	60%	43%	66%	3%	7%	3%	2%	25%	4%	8%	11%	12%	19%
Low	1%	5%	30%	7%	19%	9%	16%	0%	0%	0%	0%	40%	0%	0%	0%	58%	0%
Very low	0%	0%	24%	0%	7%	1%	4%	0%	0%	0%	0%	35%	0%	0%	0%	29%	0%

Fig. 3.3. District area of flood hazard level cover

3.4 Confirmation with satellite flood map

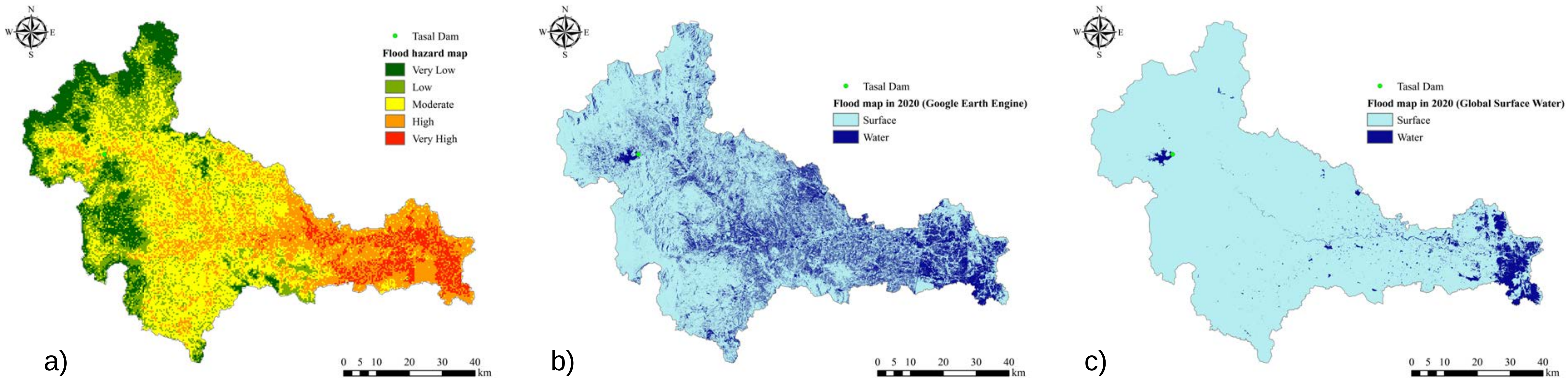


Fig. 3.4. a) flood risk AHP-GIS, b) Flood map from Google Earth Engine, c) Flood map from Global Surface Water

- In this study, the eight flood influence factors were selected as the parameters for deriving the flood risk map of Prek Thnot River Basin using the AHP-GIS method.
- The developed flood map of Prek Thnot River Basin was confirmed to be acceptable with the other two satellite flood maps.
- In conclusion, this study's results indicated the flood risk level tendency extent at the low-lying area and area along the Prek Thnot River and its reach. The very low, low, moderate, high, and very high level covered 694.55km^2, 1079.09km^2, 2186.82km^2, 1263.33km^2, and 310.75km^2 of the basin of the Prek Thnot River, respectively.
- In view of the results obtained, the Prek Thnot River Basin is heavily exposed to the risk of flooding at the downstream and area along the Prek Thnot River. Thus, this resultant map can serve as a guideline to decision makers for potential anticipatory measures, better land use planning and flood risk management under climate change.

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THANK FOR YOUR ATTENTION!

CONTACT

OEURNG Chantha, PhD

Deputy Director
Institute of Technology of Cambodia,
Russian Federation Blvd, PO. Box 86, Phnom Penh
Mobile: (+855) 12 895 840
Email : chanthaposat@yahoo.com / chantha@itc.edu.kh / oeurng.chantha@gmail.com

SOK Ty, PhD

Lecturer-Faculty of Hydrology and Water Resources
Researcher-Research and Innovative Center
Institute of Technology of Cambodia,
Mobile : (+855) 11 980 698
Email : sokty@itc.edu.kh