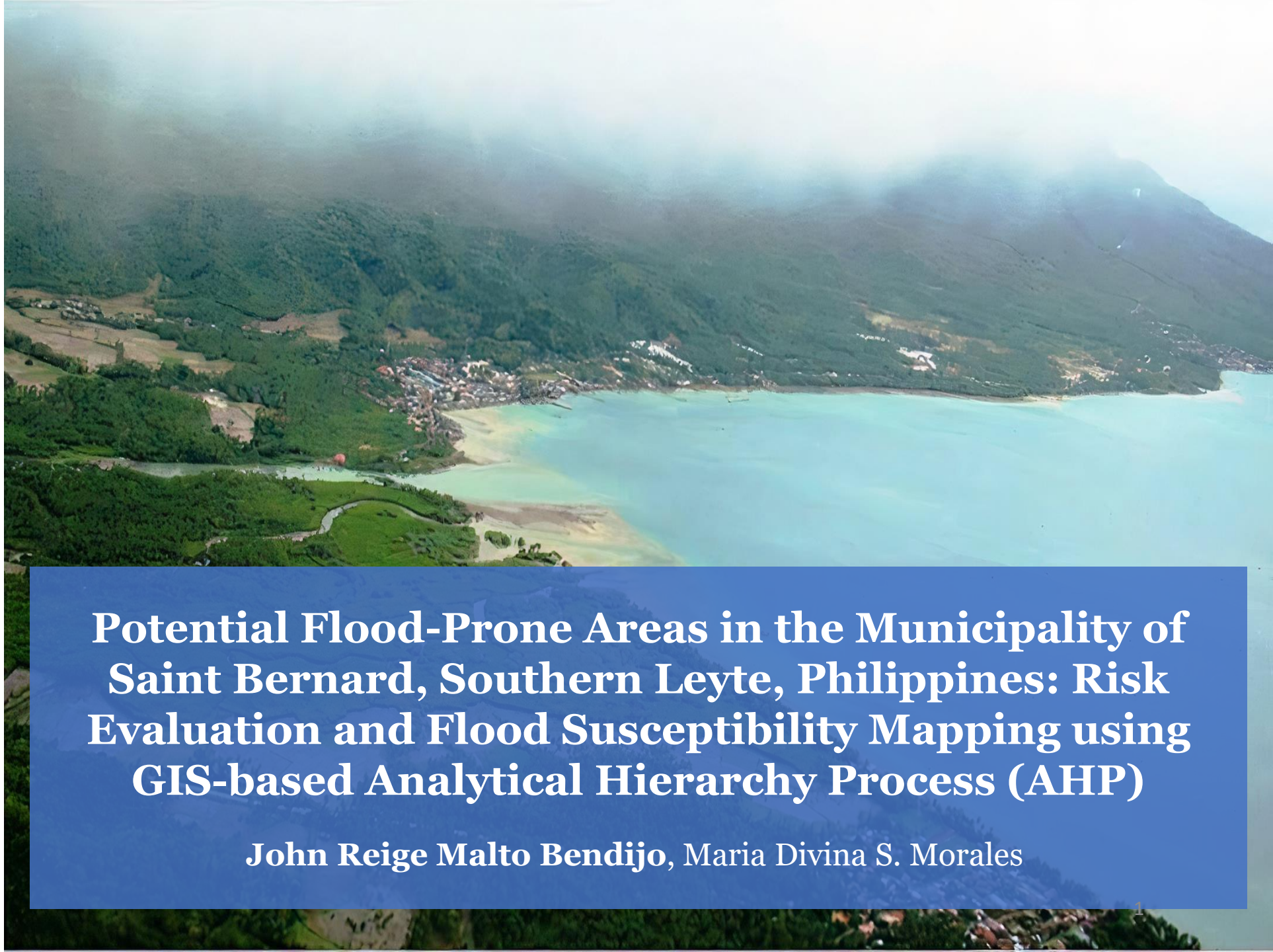


Potential Flood-Prone Areas in the Municipality of Saint Bernard, Southern Leyte, Philippines: Risk Evaluation and Flood Susceptibility Mapping using GIS-based Analytical Hierarchy Process (AHP)

John Reige Malto Bendijo, Maria Divina S. Morales

EGU Abstract

INTRODUCTION

STUDY AREA

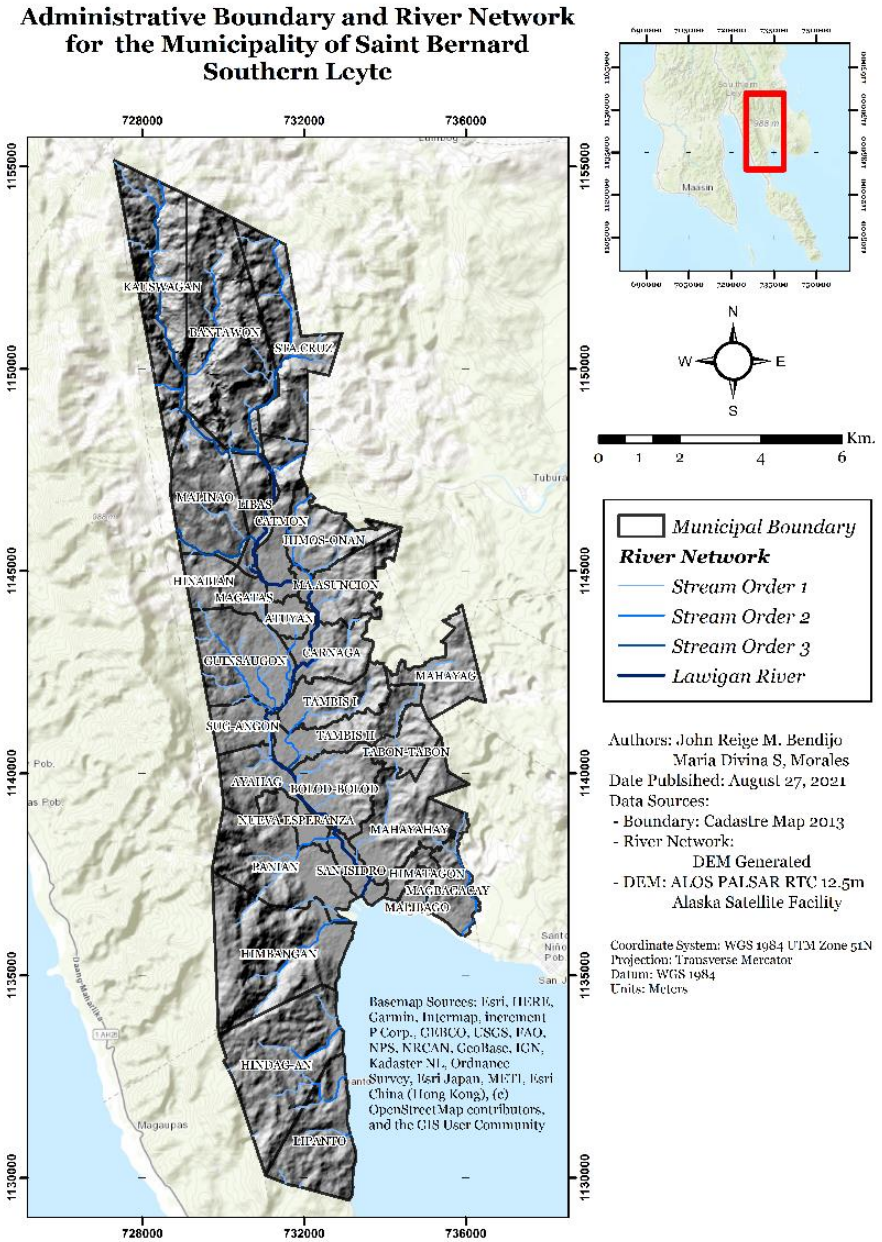
Municipality of Saint Bernard, Southern Leyte, Philippines. A fourth-class municipality and classified as 2nd climate type by PAGASA.

BACKGROUND OF THE STUDY

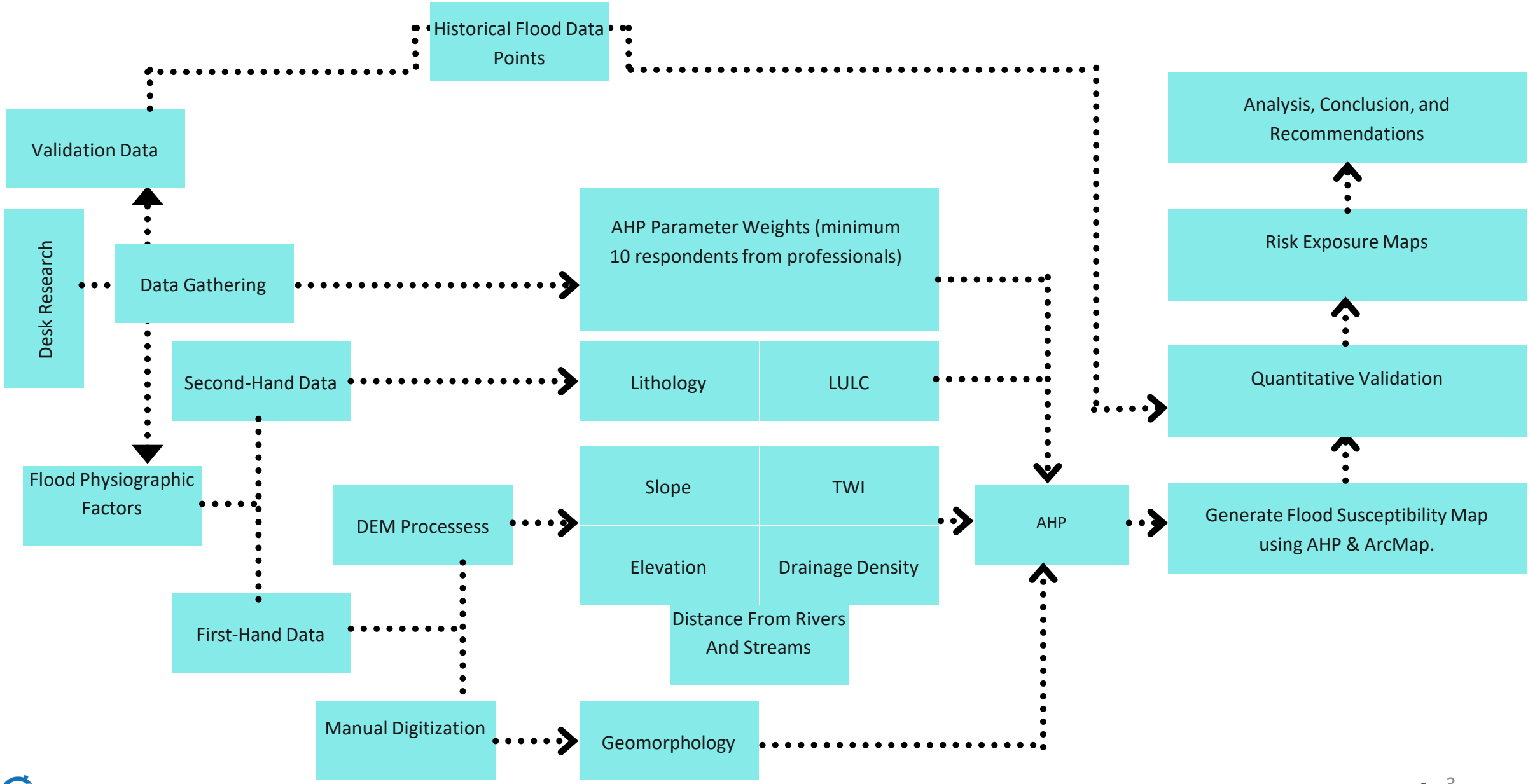
The lack of information, data, and studies on natural hazards, especially flood hazards in the area lead to a lack of mitigation and preventive measures in the event of flooding.

OBJECTIVES

- To present an alternative and effective methodology for identifying and assessing flood susceptible areas in a data-scarce area;
- Generate a risk exposure map.



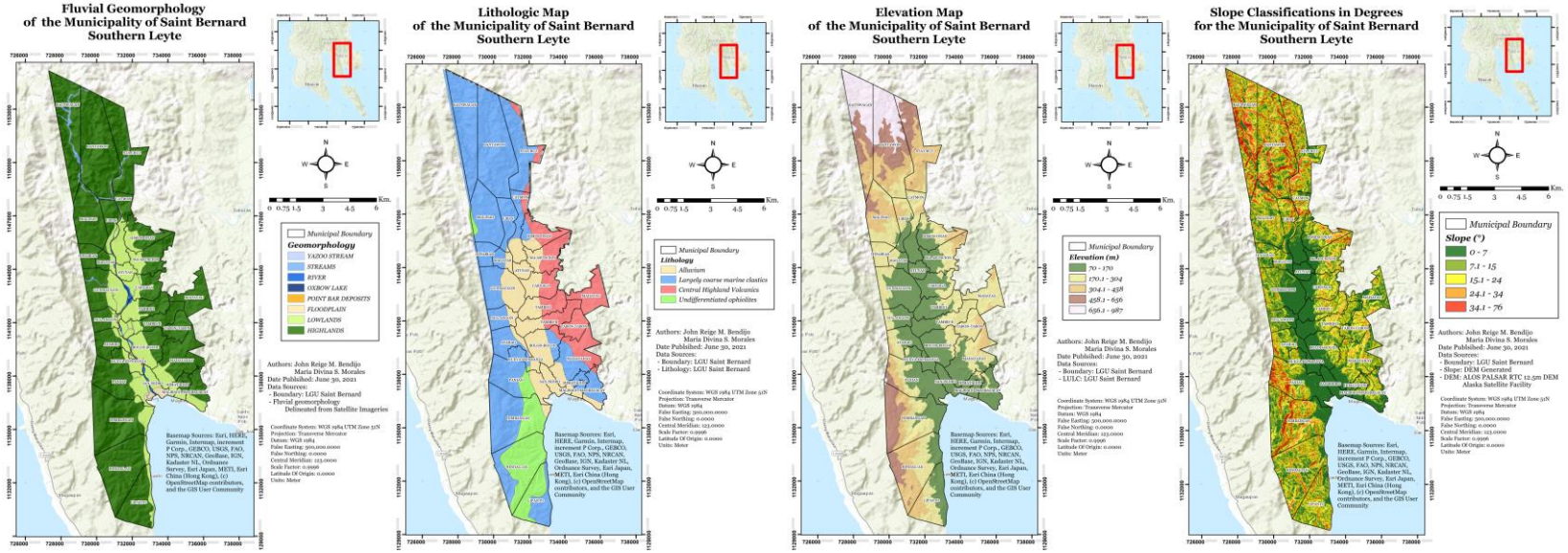
Methodological Framework

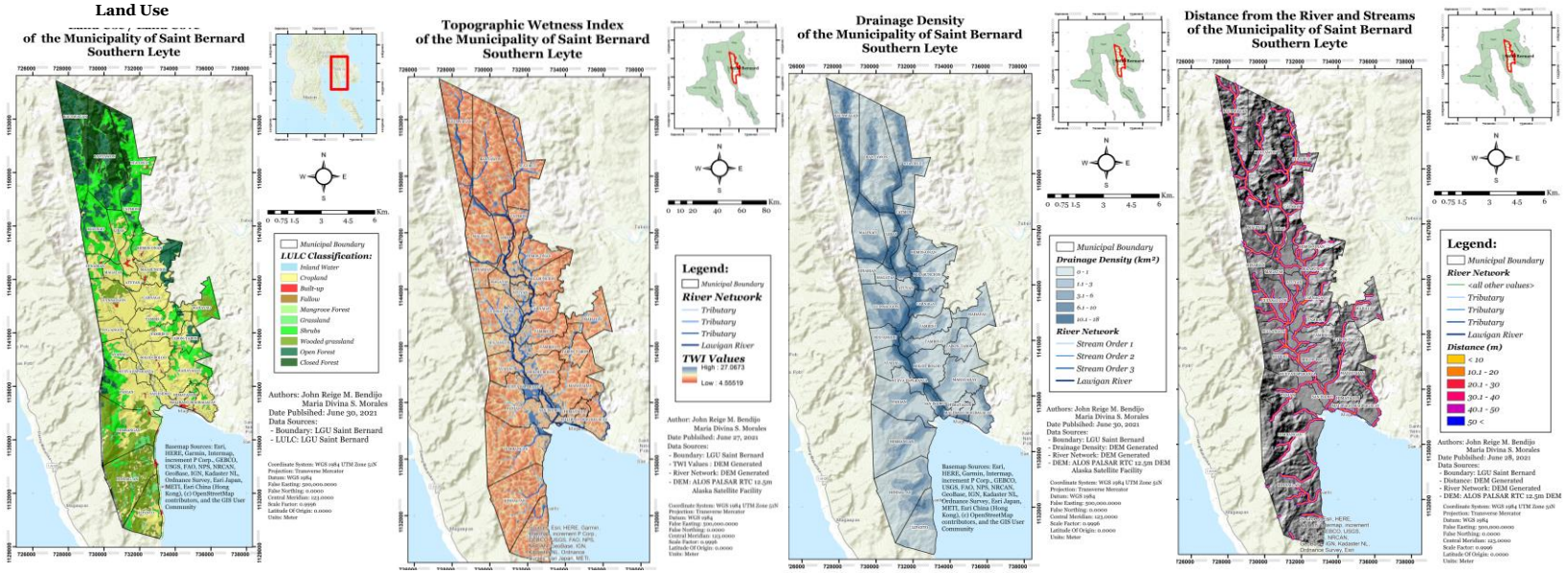


Flood Psychographic Factors

01 FLUVIAL GEOMORPHOLOGY	8 Classficiations	02 LITHOLOGY	4 Classifications
03 ELEVATION	5 Classifications	04 SLOPE	5 Classifications
05 LAND USE	9 Classifications	06 TOPOGRAPHIC WETNESS INDEX	5 Classifications
07 DRAINAGE DENSITY	5 Classifications.	08 DISTANCE FROM RIVERS AND STREAMS	5 Classifications

Software utilized: ArcMap 10.7.1





Flood Psychographic Factors Maps

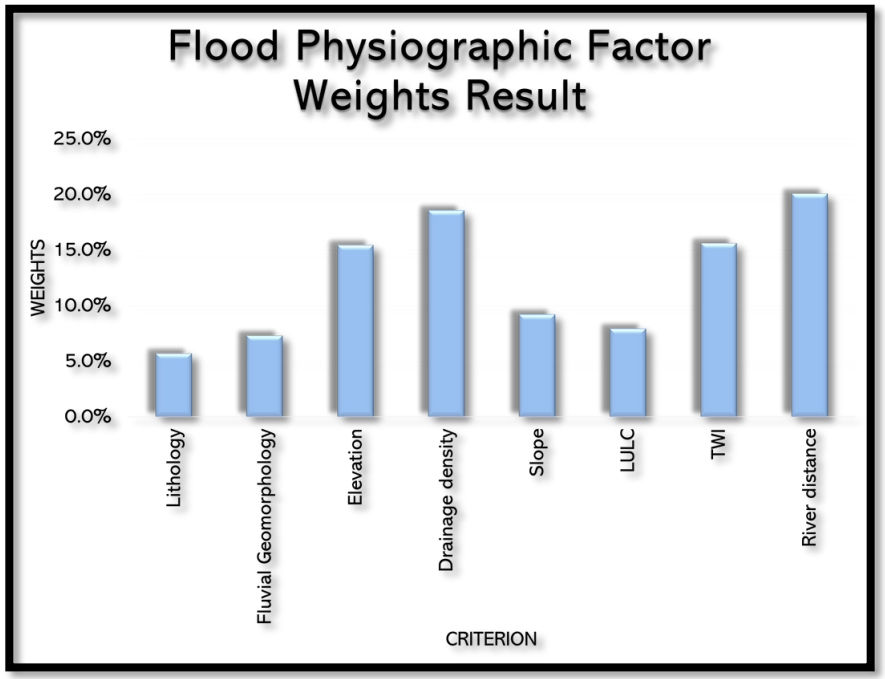
ANALYTICAL HIERARCHY PROCESS

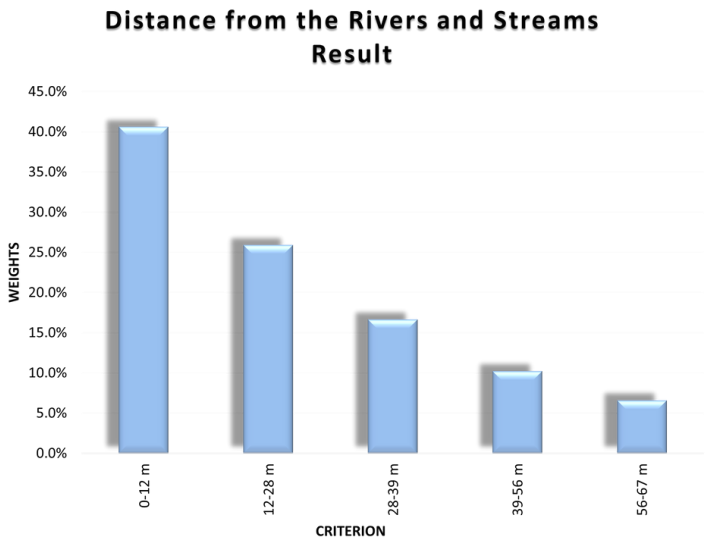
THE INTENSITY OF IMPORTANCE ON AN ABSOLUTE SCALE	DEFINITION	EXPLANATION
1	Equal importance	Two activities contribute equally to the objectives
2	Moderate importance of one over another	Experience and judgment strongly favor one activity over another.
5	Essential or strong importance	Experience and judgment strongly favor one activity over another.
7	Very strong importance	Activity is strongly favored, and its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between two adjacent judgments	When compromise is needed
RECIPROCALS	If activity i has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	
RATIONALS	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix.

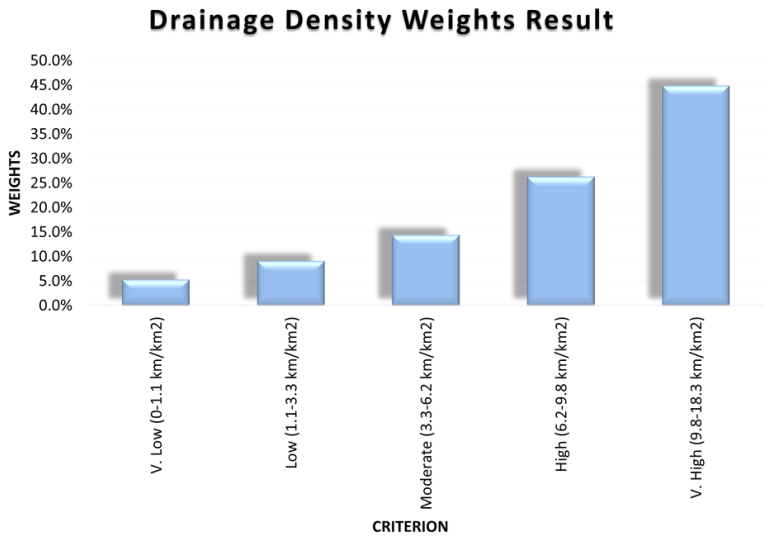
The Fundamental Scale of AHP where values assigned to each parameter are based on the degree of importance.

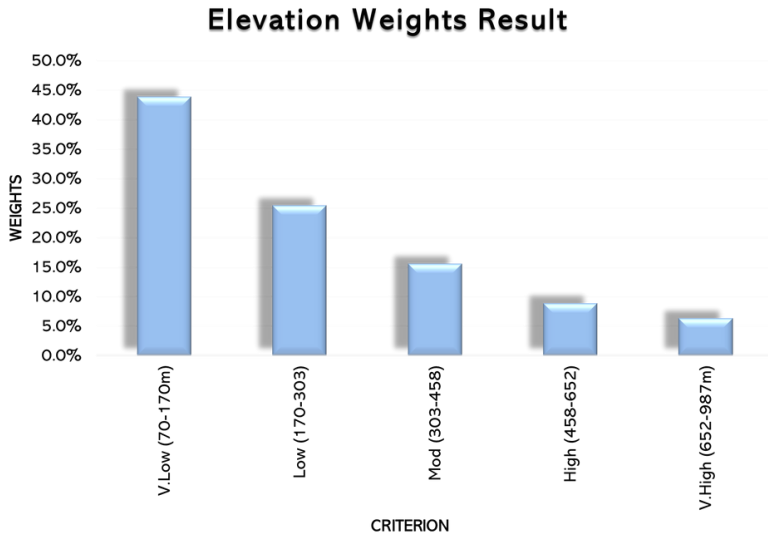
Software utilized: Microsoft Excel AHP Template (Goepel, 2013)

Flood Psychographic Factors Weights Results from AHP

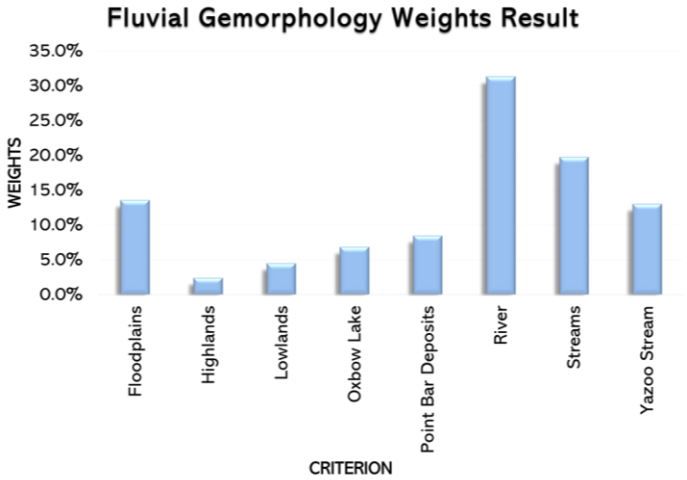


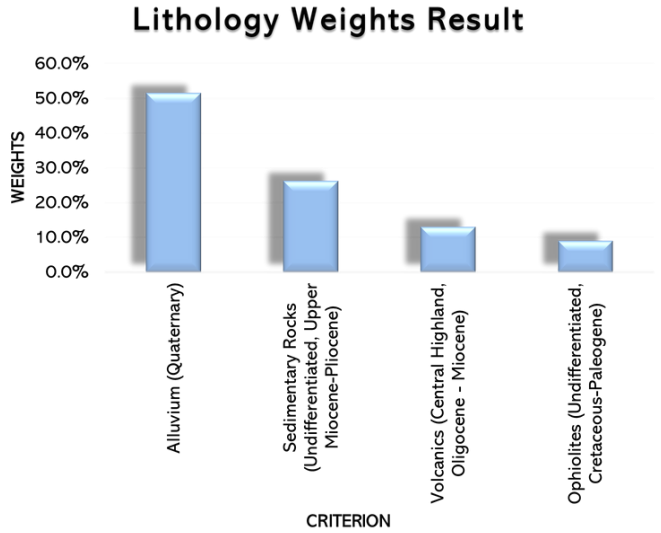


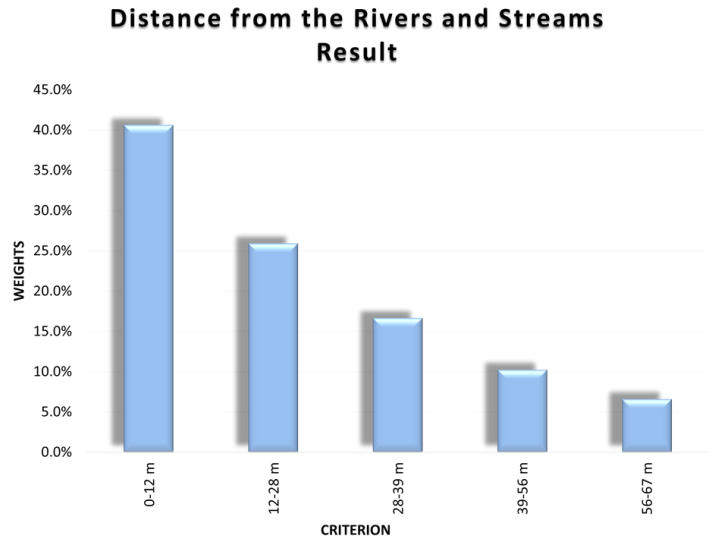


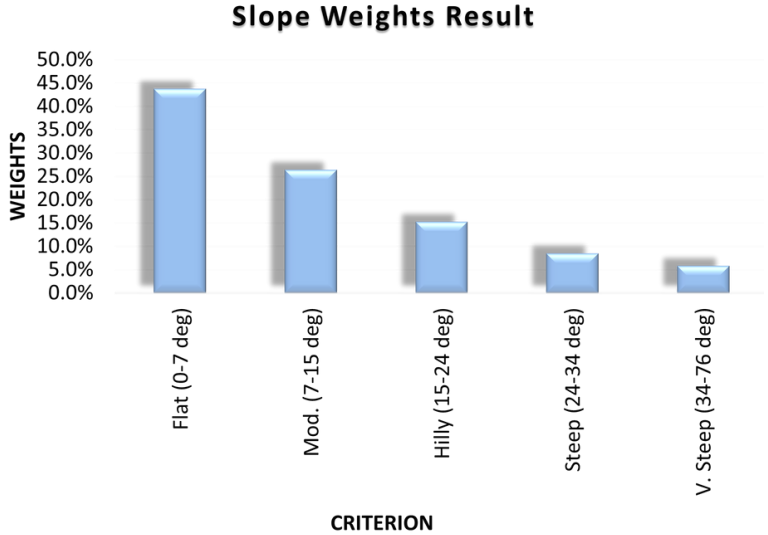


Flood Psychographic Factors Weights Results from AHP









FLOOD SUSCEPTIBILITY CALCULATION

$$FS = \frac{\sum wi}{T}$$

Where;

FS – Flood Susceptibility,

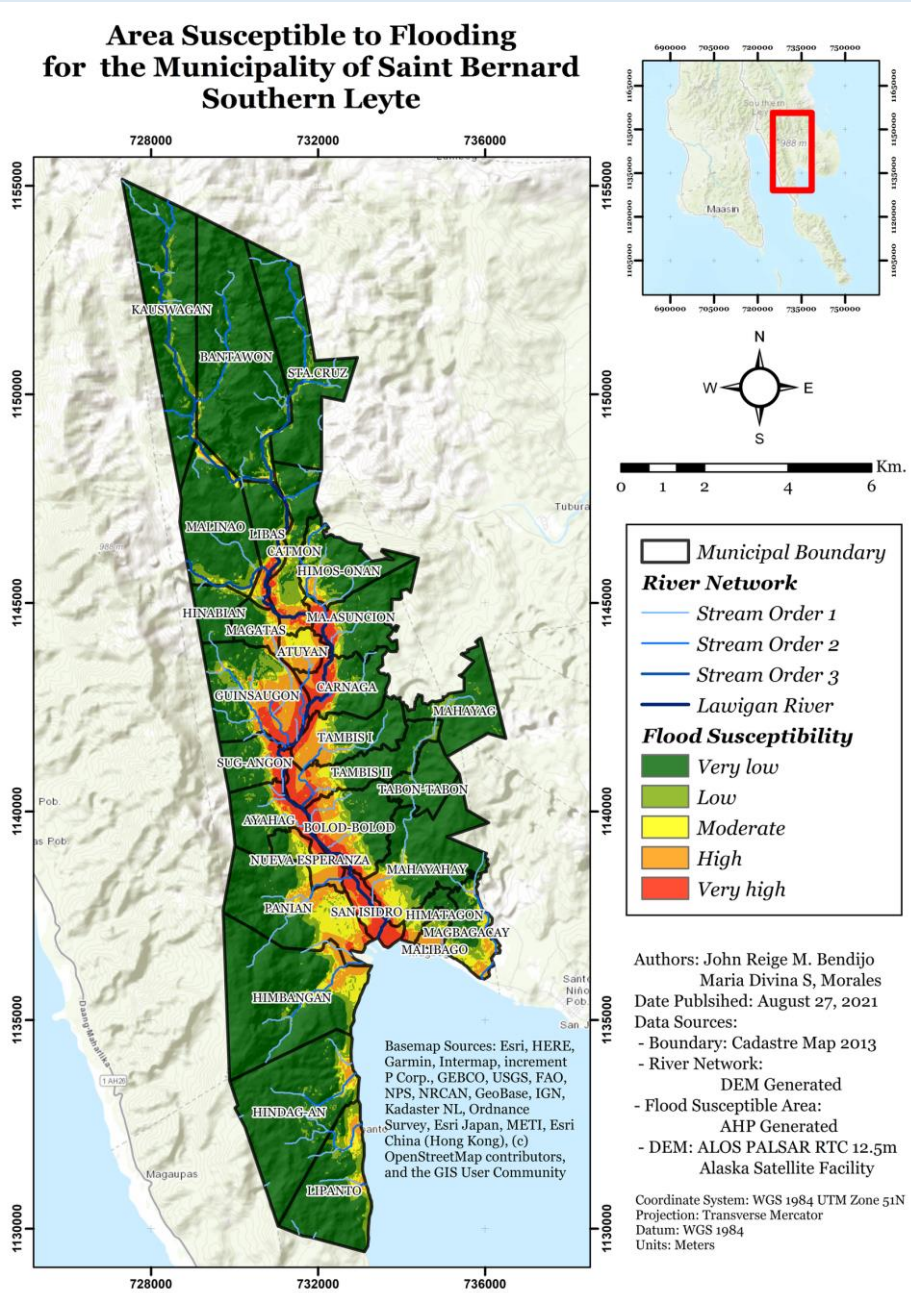
wi – Weight of factors i, and

T – Total number of the flood psychographic factor

Software utilized: ArcMap 10.7.1:

- Field Calculator
- Polygon to Raster
- Reclassify using Natural breaks (Jenks) to maximize the differences between classes.

FLOOD SUSCEPTIBILITY



Flood Susceptibility	1	2	3	4	5	6	7	8	Normalized Principal Eigenvector/ Weights (%)
1. Lithology	1	4/7	2/5	1/3	1/2	3/4	2/5	1/3	5.71%
2. Fluvial Geomorphology	1 7/9	1	3/7	2/7	5/7	1	3/8	3/7	7.31%
3. Elevation	2 1/2	2 1/3	1	3/4	1 8/9	2	1 1/6	2/3	15.47%
4. Drainage density	2 5/6	3 1/3	1 1/3	1	1 7/8	1 4/5	1 2/5	5/6	18.59%
5. Slope	1 7/8	1 2/5	1/2	1/2	1	1 3/8	1/2	2/5	9.23%
6. LULC	1 1/3	1	1/2	5/9	3/4	1	4/9	1/2	7.96%
7. TWI	2 4/7	2 2/3	6/7	5/7	2	2 2/9	1	2/3	15.64%
8. River distance	3	2 3/8	1 1/2	1 1/5	2 3/5	2	1 3/7	1	20.10%
Consistency Ratio: 0.9%									

QUANTITATIVE VALIDATION

Applies the correlation between the AHP-generated flood susceptibility map and the 55 historical flood data points.

Software utilized: ArcMap 10.7.1:

- Extract Values to Points

FLOOD RISK EVALUATION

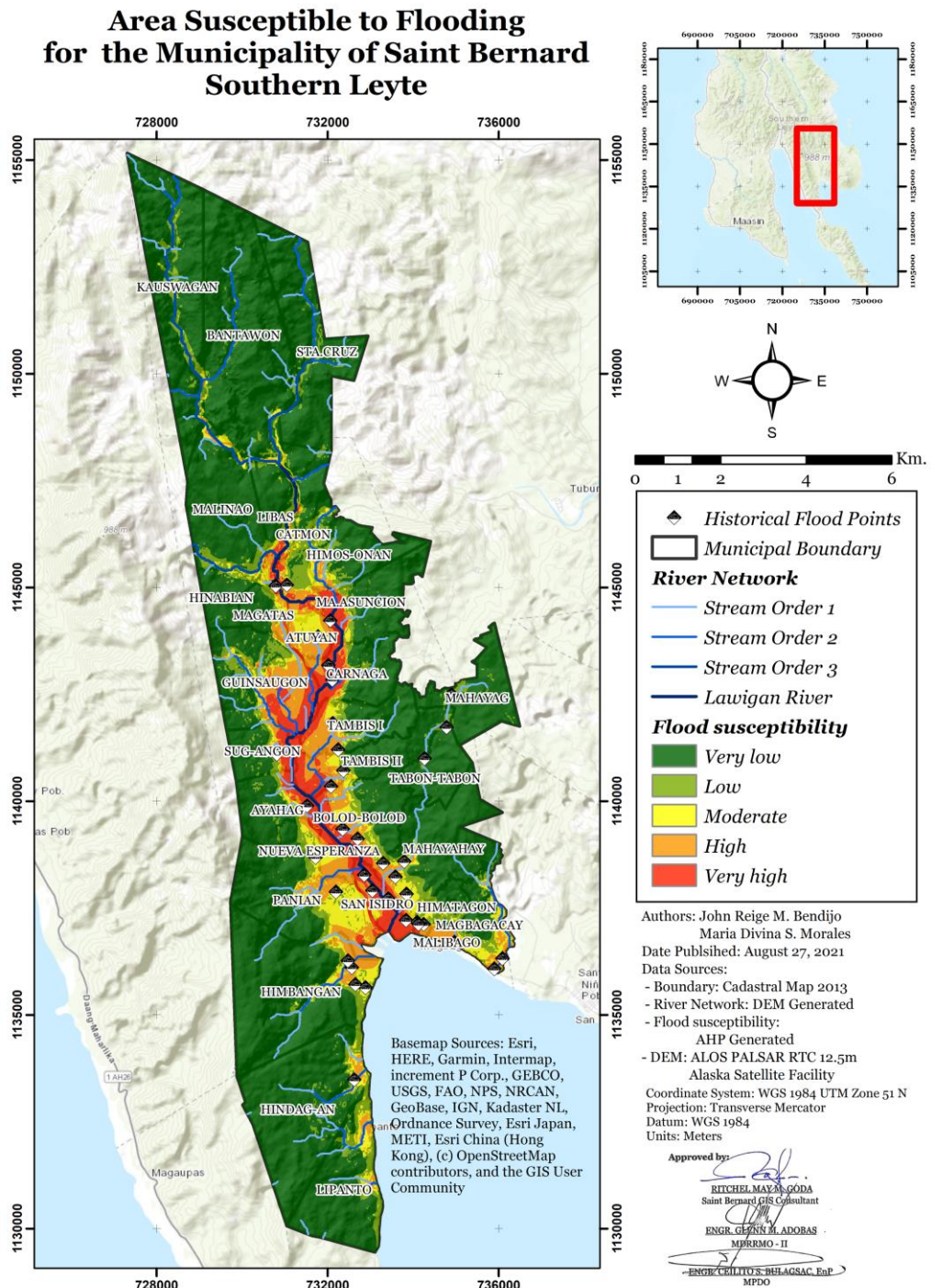
Imperative to calculate the percentage of how susceptible the barangay is in terms of roads*, population, and built-ups* to flooding and eventually generate the risk exposure maps.

Software utilized: ArcMap 10.7.1:

- Zonal Statistics*

$$PRE = \frac{(\%\ Built-up\ Flood\ Risk) + (\%\ Road\ Flood\ Risk)}{2} \times 100$$

QUANTITATIVE VALIDATION



Susceptibility classes (5)	Area (km^2)	Area %	Historical Flood Events (55) *	Share of Flood Events (%)
Very high	6	5.8	16	29.1
High	8	7.8	25	45.5
Moderate	6	5.8	11	20.0
Low	9	8.7	3	5.5
Very low	74	71.8	0	0.0

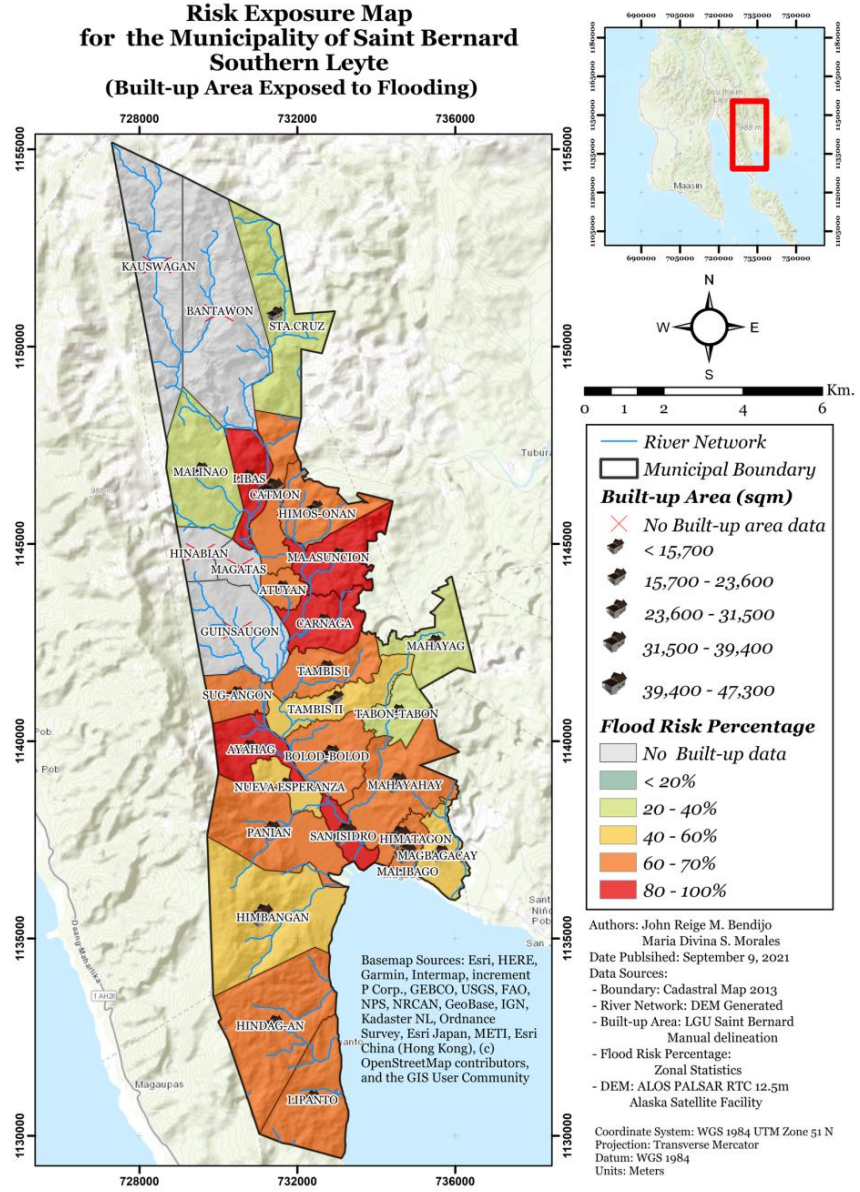
*Historical Flood Events – MDRRMO Saint Bernard (2021).

74.6% of the flood events were correlated with high or very high susceptibility levels

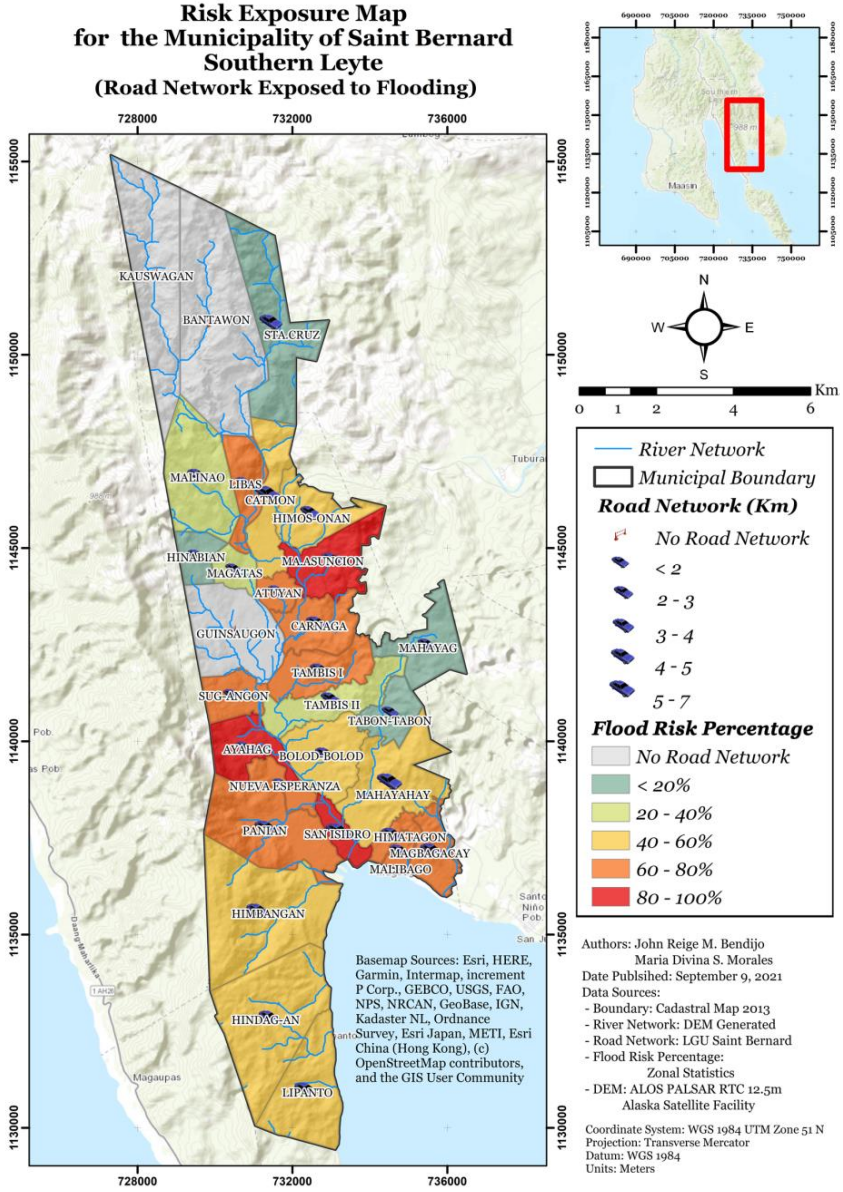
January 3, 2022

RISK EXPOSURE MAPS

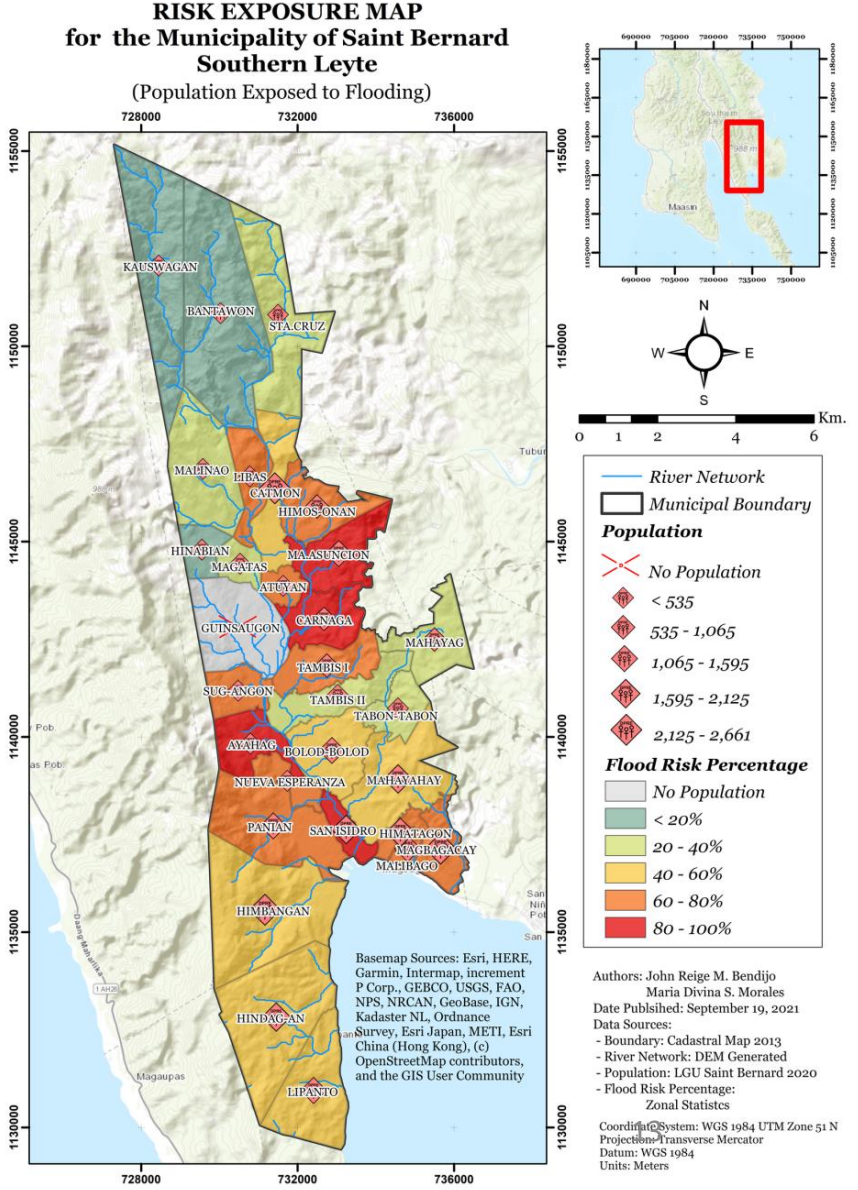
Built-up



Road Network



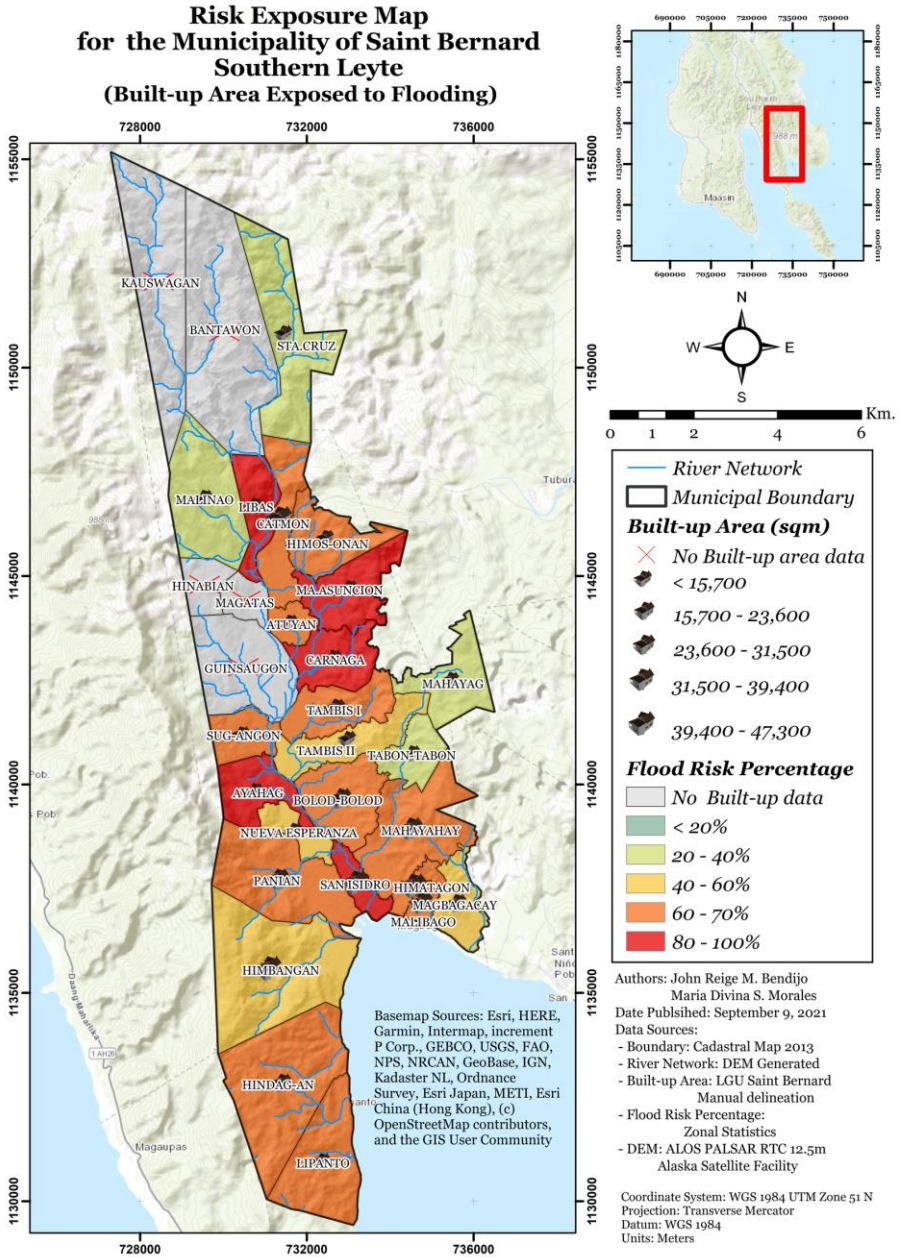
Population



Results of Built-ups, Roads, and Population at risk in percentage at Saint Bernard, Southern Leyte, Philippines.

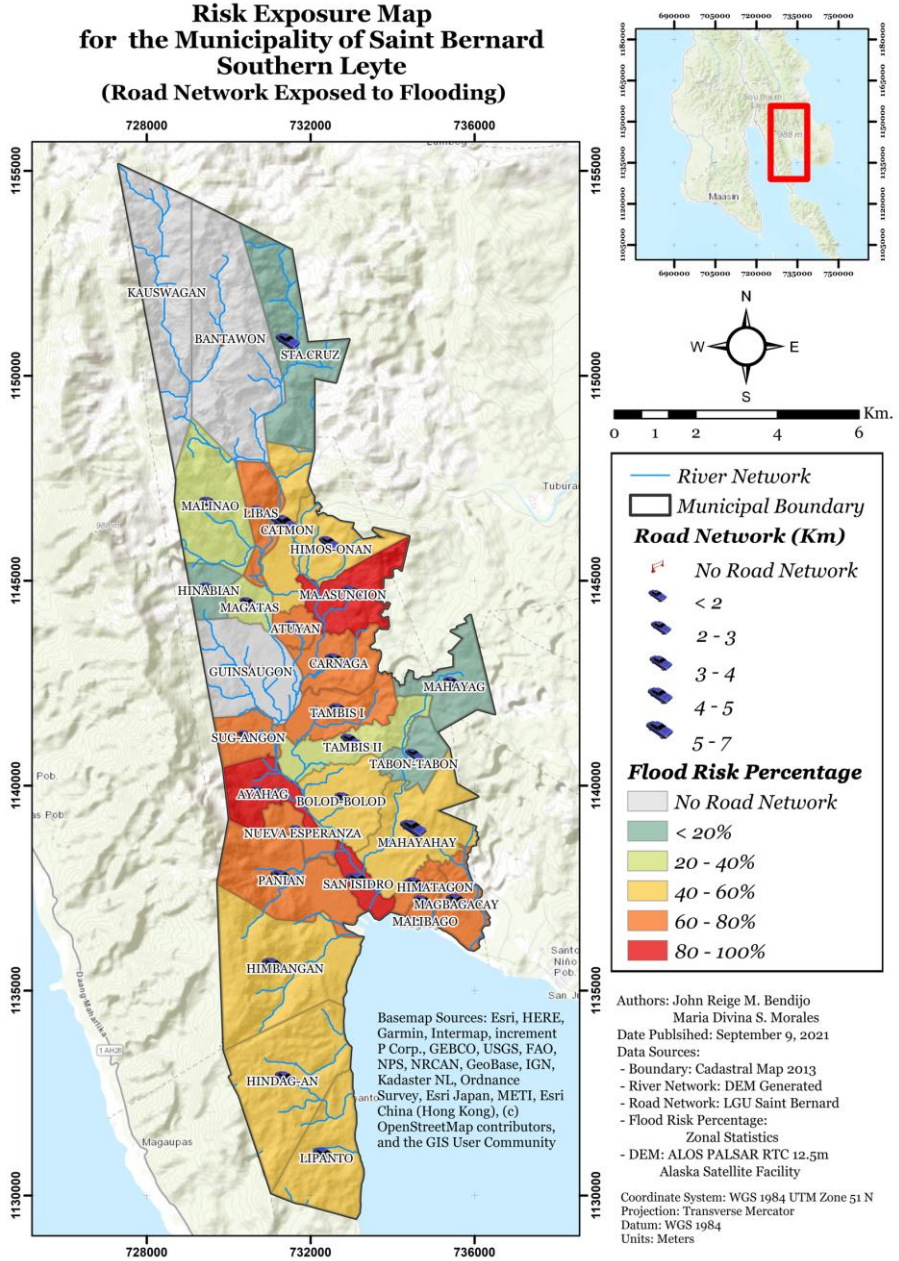
Barangays	Area (km^2)	Total Area of Flood Risks in barangay (%)	Built-up Area (sq.km)	Flood Risk for Built-up Area (%)	Road Length (Km)	Flood Risk for Road Length (%)	Population	Flood Risk for Population (%)
ATUYAN	0.9	74	9,332	76	2	72	476	74
AYAHAG	2.4	44	9,398	88	2	84	417	86
BANTAWON	10.2	20	0	0	0	0	228	20
BOLOD-BOLOD	3.3	51	27,176	60	3	57	1275	59
CARNAGA	2.6	50	12,138	96	4	73	923	85
CATMON	2.7	43	45,777	63	7	49	2548	56
GUINSAUGON	4.9	53	0	0	0	0	0	0
HIMATAGON	0.7	40	47,333	77	4	78	1748	78
HIMBANGAN	8.4	27	39,793	56	5	55	2661	56
HIMOS-ONAN	2.8	31	-	72	3	54	702	63
HINABIAN	1.3	23	0	0	1	19	99	19
HINDAG-AN	7.5	23	18,431	71	4	50	1605	60
KAUSWAGAN	7.2	20	0	0	0	0	28	20
LIBAS	2.1	41	12,603	82	2	68	411	75
LIPANTO	4.5	28	12,602	72	5	45	1276	59
MA. ASUNCION	3.1	36	6,851	98	3	89	1264	94
MAGATAS	1.1	39	-	0	2	32	88	32
MAGBAGACAY	1.9	43	21,474	57	5	65	2441	61
MAHAYAG	2.7	21	1,642	26	2	19	662	23
MAHAYAHAY	5.2	31	32,712	62	6	50	1701	56
MALIBAGO	0.5	53	38,263	77	3	74	1557	76
MALINAO	4.9	25	2,485	30	3	27	42	28
NUEVA ESPERANZA	1.2	59	8,017	59	2	64	107	62
PANIAN	5.6	39	29,657	62	5	63	1335	63
SAN ISIDRO	1.1	95	45,435	96	6	97	1953	97
STA.CRUZ	5.6	21	5,132	29	5	19	313	24
SUG-ANGON	1.7	45	4,322	66	2	70	382	68
TABON-TABON	1.7	21	900	27	2	19	312	23
TAMBIS I	2.8	43	18,698	77	3	78	882	78
TAMBIS II	2.9	44	15,092	44	3	36	99	40

BUILT-UP EXPOSURE



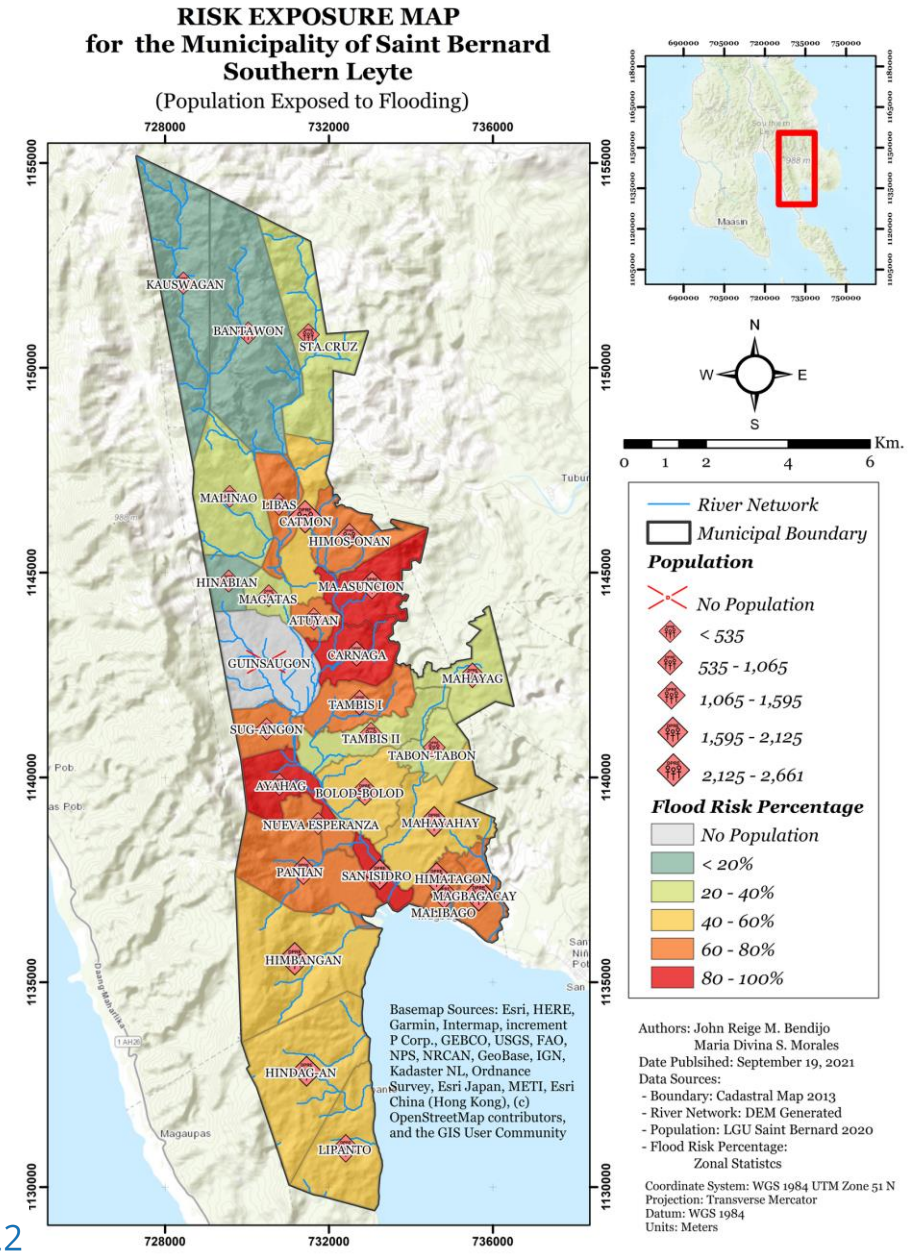
17 out of 25 Barangay's total built-up areas are at 60% to 98% high risk.

ROAD NETWORK EXPOSURE



14 out of 27 with road network data are at 60% to 97% high risk

POPULATION



15 out of 29 populated barangays are at 60% to 97% high risk

CONCLUSION AND RECOMMENDATION

1

The research shows that the GIS-based AHP is an **effective way for identifying and assessing flood susceptible areas in a data-scarce area** which was confirmed by the very good agreement between the susceptibility zones and historical flood events of which **74.6**% were coincident with high or very high susceptibility levels.

2

The Local Government Unit approved the flood susceptibility map, and the Risk Exposure Maps will be utilized during formulating mitigation and preventive measures in the event of flooding.

3

- A further step of this study is to conduct a flood simulation in order to determine the depth, duration, and velocity of floods, as well as to quantify the interaction between groundwater and surface water during flood events.
- Higher resolution of DEM can be utilized to obtain more accurate data.

REFERENCES

Goepel, K. D. (2013). *Implementing the Analytic Hierarchy Process as a Standard Method for Multi-Criteria Decision Making In Corporate Enterprises – A New AHP Excel Template with Multiple Inputs*, Proceedings of the International Symposium on the Analytic Hierarchy Process, Kuala Lumpur 2013.
DOI: https://doi.org/10.13033/isahp.y2013.047

THANK YOU!

Question?

EGU Abstract

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