LAND SUITABILITY AND DYNAMIC SYSTEM MODEL FOR LANDUSE PLANNING OF PADDY FIELD IN INDRAMAYU REGENCY, WEST JAVA, INDONESIA

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Wiwin Ambarwulan, Widiatmaka, Titik Suparwati, Irman Firmansyah, Niendyawati

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INSTITUT PERTANIAN BOGOR

GEOSPATIAL INFORMATION AGENCY

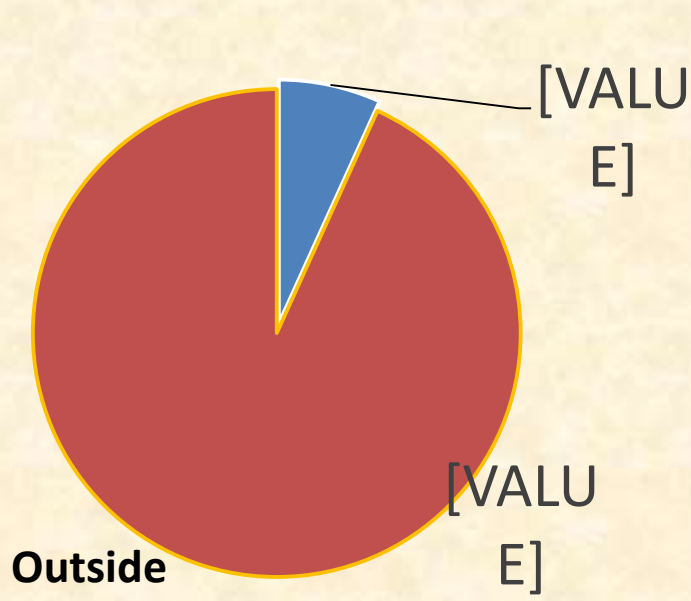
BOGOR AGRICULTURAL UNIVERSITY

I. INTRODUCTION

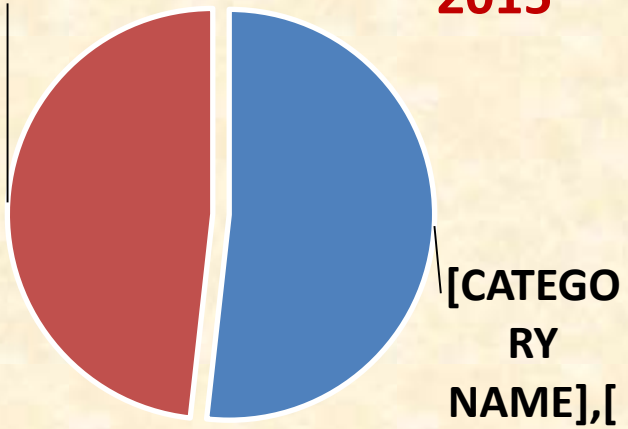
1.1. Background

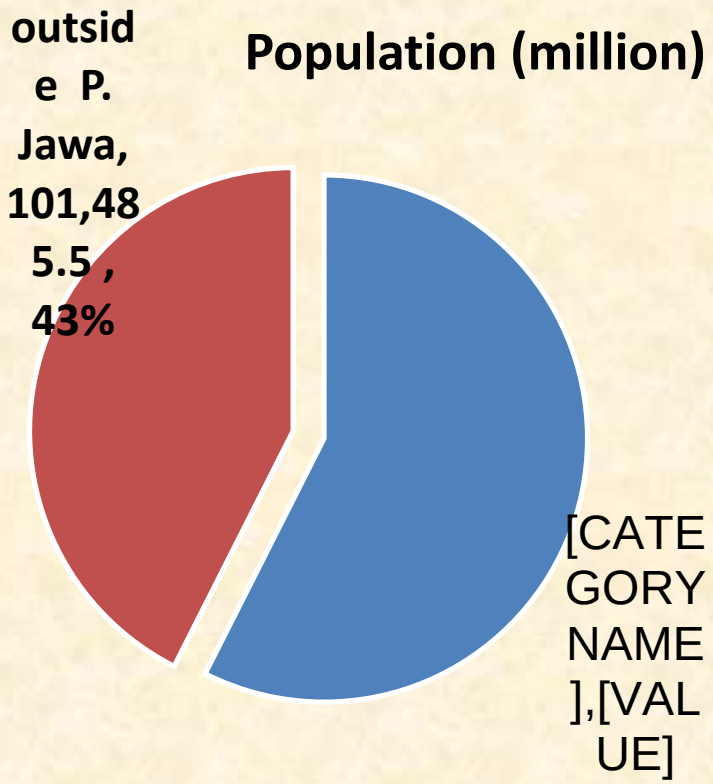
- **Serious problem of food supply in Indonesia:**
  - High amount of population : 250 million (No. 4 in the world)
  - High rice consumption: 113 $kg.capita^{-1}.year^{-1}$
  - Most of rice (50%) was produced by agricultural land in Java Island
  - Java island: only 7% of Indonesian territory
  - 50% of Indonesian population in Java Island
- **Pressure on Java island to produce food as well as conversion to residence, industry, etc.**

1. PRODUCTION CONCENTRATION IN JAVA ISLAND



Pady (ton) 2015





Source: Indonesian Statistics (2015)

Implication

- High dependence on food production in Java Island
- High pressure for agricultural land in Java island
- High rate of paddy field conversion into other land utilization

FOOD INSECURITY

How to solve the problem?

1. Spatially location with HIGH LAND SUITABILITY should be conserve
2. Each region should maintain its self sufficiency in order to maintaining country's food security

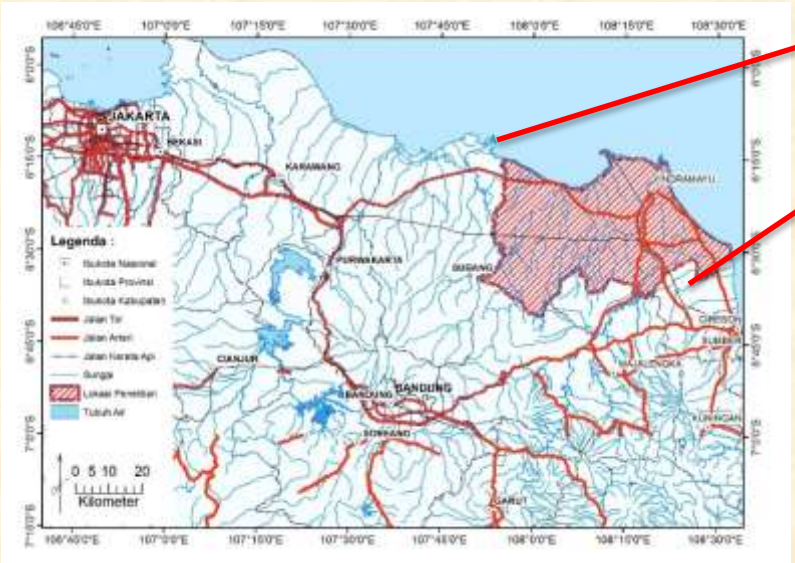
1.2. Objective

1. To asses land suitability for paddy field
2. To model the adequacy of food in the regency
3. To plan land utilization based on land suitability for paddy field and dynamic system model

II. METHODOLOGY

2.1. RESEARCH LOCATION

Indramayu Regency, West Java Province, Indonesia (one of rice production center in West Java Province)



- Size of Indramayu = 209,942 ha
- Paddy field = 144,429 ha (69%)

2.2. Analysis Methods

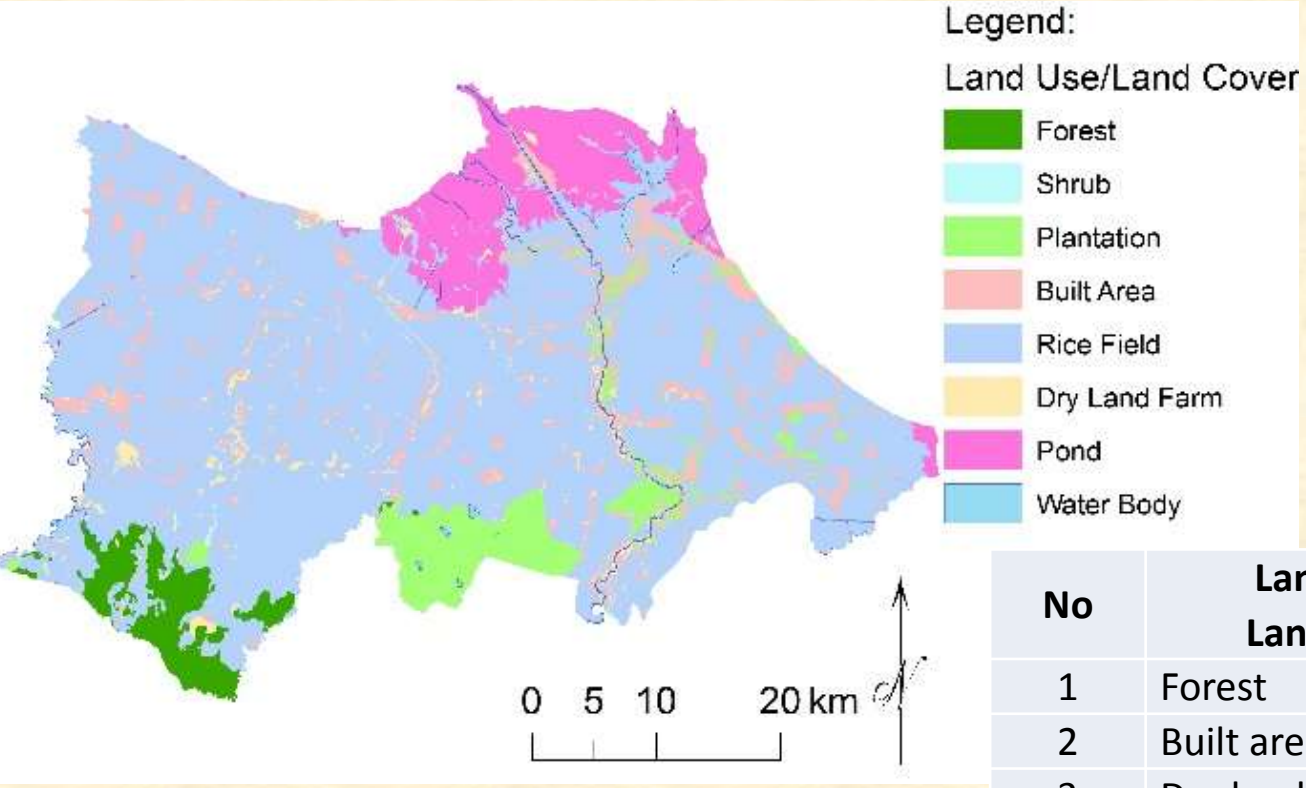
1. ***Land use and land cover***.
   - ❑The analysis is focused on paddy fields.
   - ❑Existing paddy field delineation was conducted using SPOT-6 imagery (2014).
2. ***Land Suitability Analysis.***
   - ❑Use the Automated Land Evaluation System (ALES) (Rossiter, 2001).
   - ❑Land Mapping Unit (LMU): 35 LMU
3. ***System Dynamic Modelling.***
   - ❑ Powersim Studio 8

Land Suitability Criteria for Paddy

Land Quality/ Land Characteristics	Sim-bol	Land Suitability				
		S1	S2	S3	N1	N2
Temperature	(t)					
• Yearly average (°C)		23-25	>25-28 20-<23	>28-32 18-<20	-	>32 <18
Water availability	(w)					
• Dry month (<75 mm)		3-7.5	>7.5-8.5	>8.5-9.5	-	>9.5
• Annual rainfall (mm)		1000-1500	>1500-2500 700-<1000	>2500-3500 500-<700	-	>3500 <500
Rooting media	(r)					
• Soil drainage		Well, moderate	Slightly rapid	Poor, Slightly poor	-	Very poor
• Texture		L, SCL, SiL, Si, CL, SiCL,	SL, SC, C	LS, SiC,	-	gravel, sand
• Soil effective depth (cm)		>50	30-50	20-<30	15-<20	<15
Land preparation	(p)					
• Surface rock (%)		<3	3-15	>15-40	Td	>40
• Rock outcrops (%)		<2	2-10	>10-25	>25-40	>40
• Consistency				Very hard, very taft firm, very sticky		Pebbled, stony
Erosion hazard	(e)					
• Lereng (%)		<3	3-8	>8-15	>15-25	>25
Flood hazard	(b)	F0-F1	F2	F3	F4	F4
Toxicity	(x)					
• Sulfidic depth (cm)		≥100	75-<100	50-<75	40-<50	<40
Nutrients retention	(f)					
• Soil CEC		≥ Medium	Low	Very low	-	-
• Base saturation (%)		>35	20-35	<20	-	-
• Soil pH		6,0-7,0	>7,0-7,5 5,5-<6,0	>7,5-8,0 5,0-<5,5	>8,0-8,5 4,0-<5,0	>8,5 <4,0
• Organic-C (%)		≥0,8	<0,8	-	-	-
Available nutrients	(n)					
• Total N		≥ Medium	Low	Very low	-	-
• P2O5		High	Medium	Low, Very low	-	-
• K2O		≥ Medium	Low	Very low	-	-

III. RESULTS AND DISCUSSION

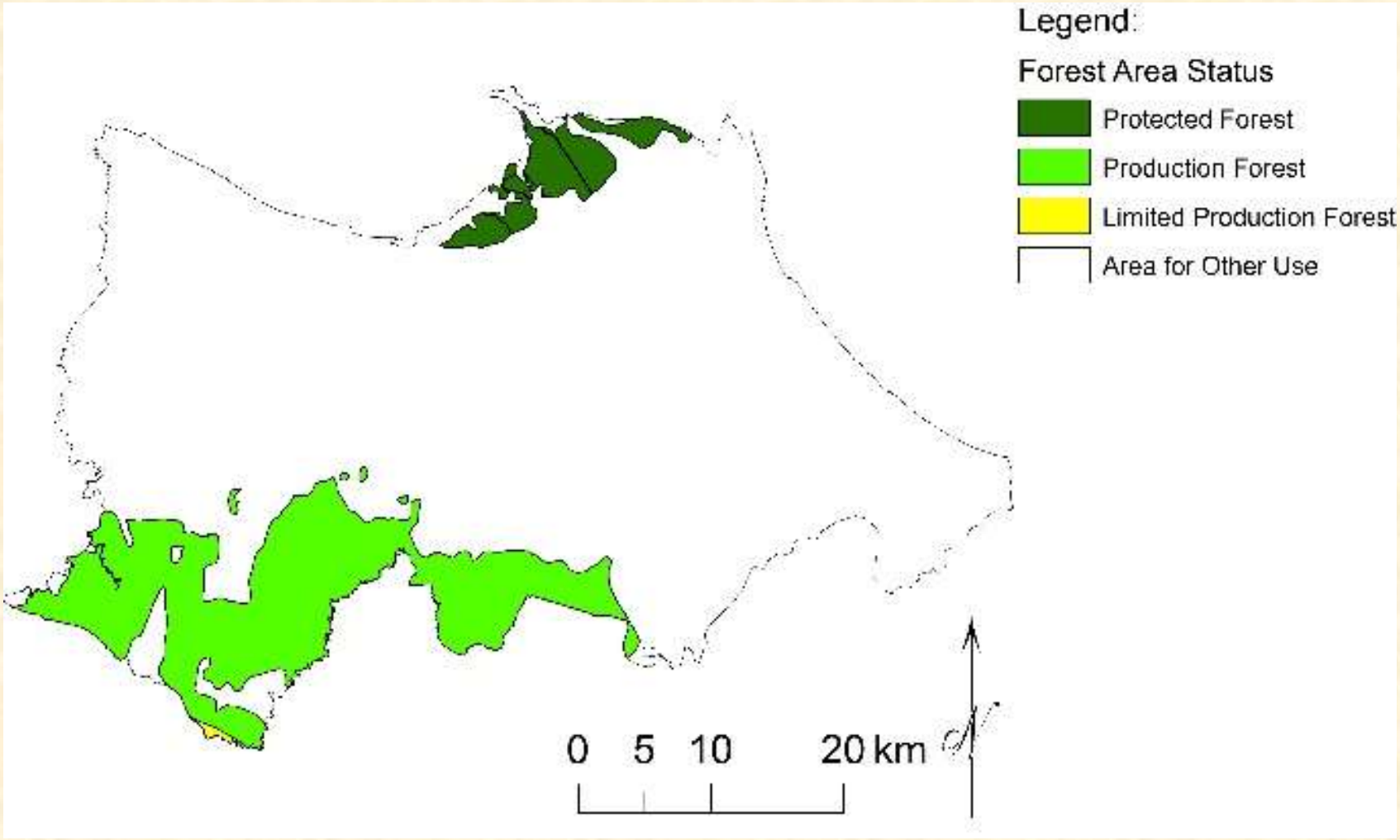
3.1. Landuse/Land Cover



No	Land use/ Land cover	Area	
		ha	%
1	Forest	7,920	3.8
2	Built area	18,214	8.8
3	Dry land	4,099	2.0
4	Water body	1,453	0.7
5	Estate/plantation	12,485	6.0
6	Paddy field	144,429	69.4
7	Shrubs	75	0.0
8	Fishpond	19,334	9.3
	Total	208,009	100.0

Source: Image interpretation, SPOT 6 imagery

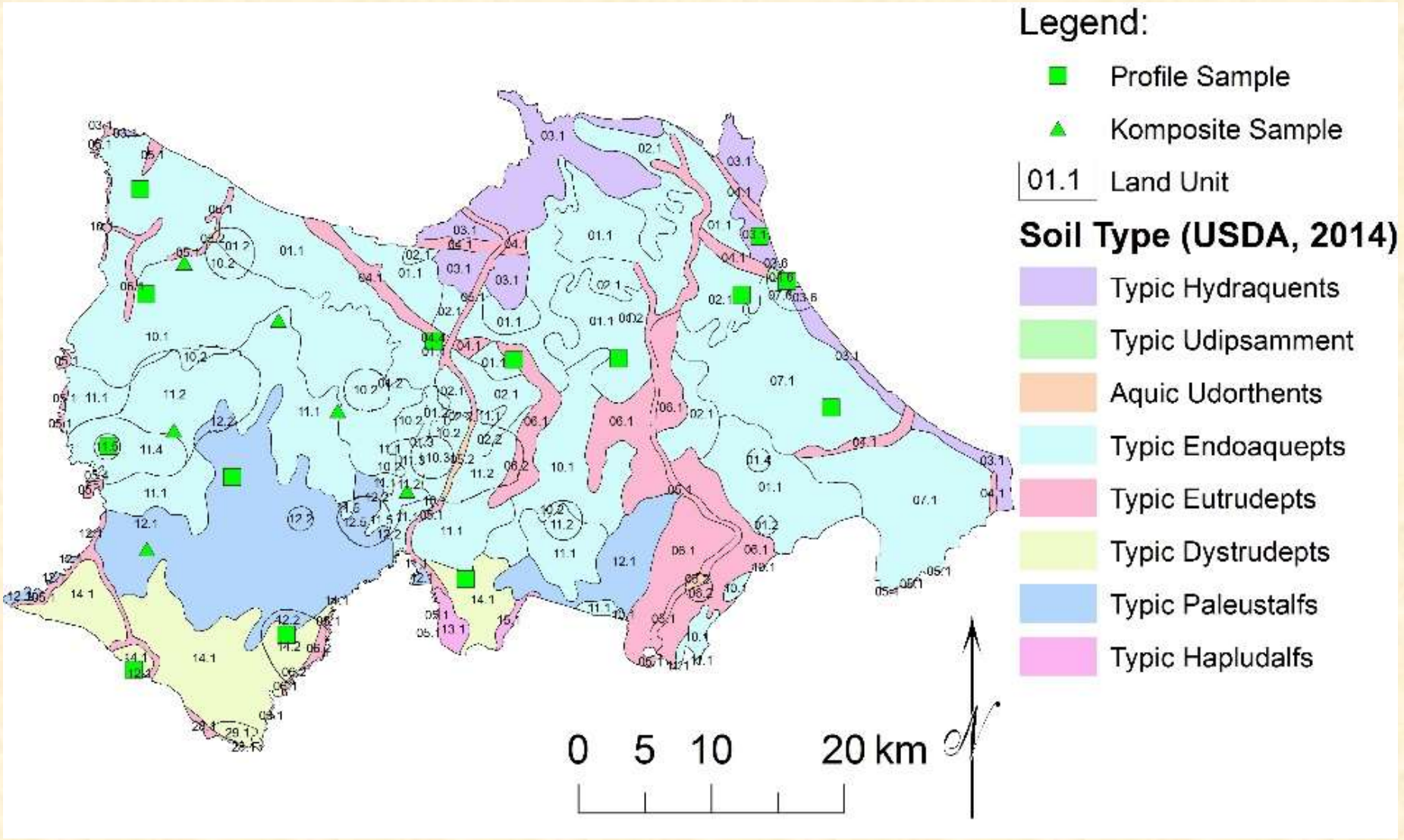
3.2. Forest Area Status



Map of Forest Area Status of Indramayu Regency

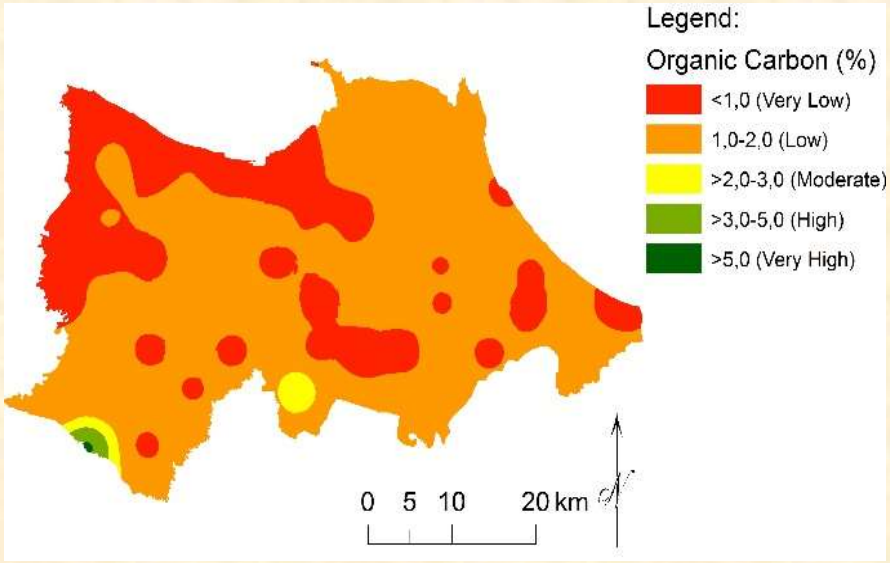
Should be maintained as forest

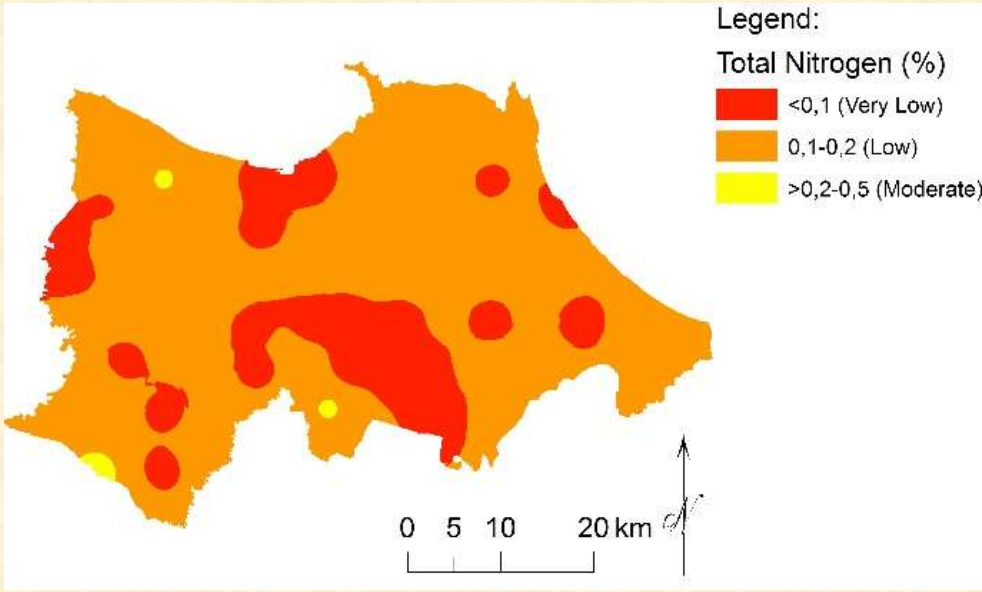
3.3. Soil Map

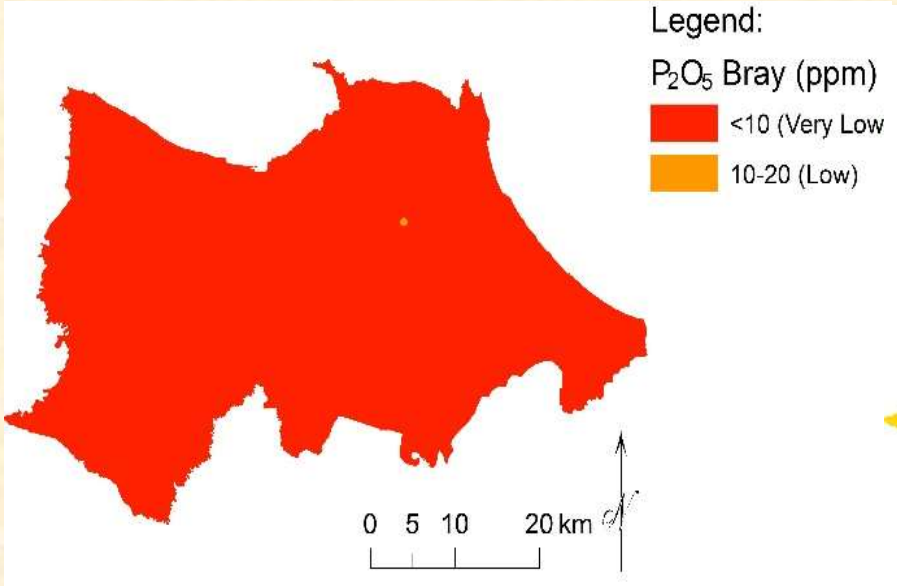


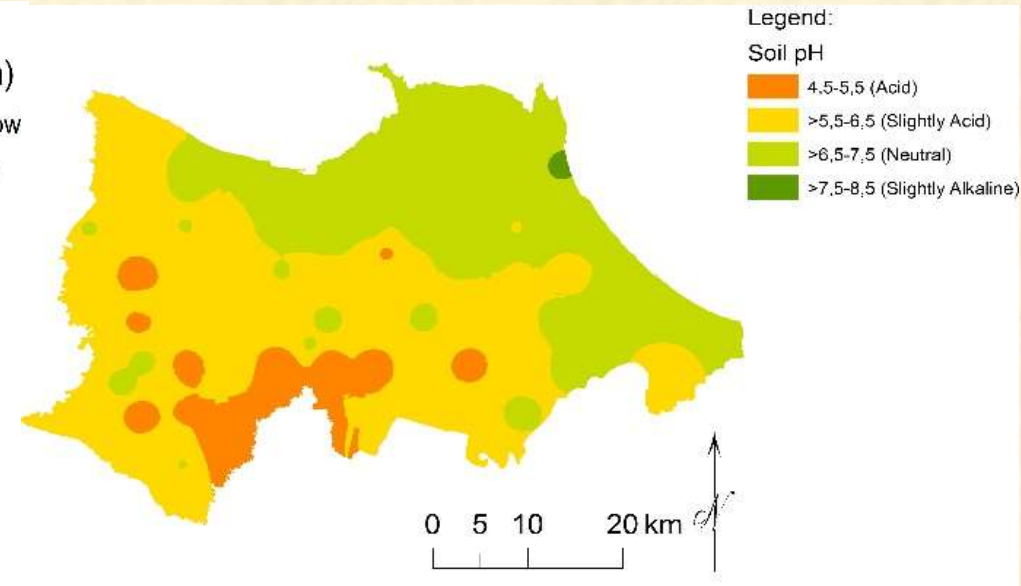
Soil map and map and sampling site for analysis laboratory

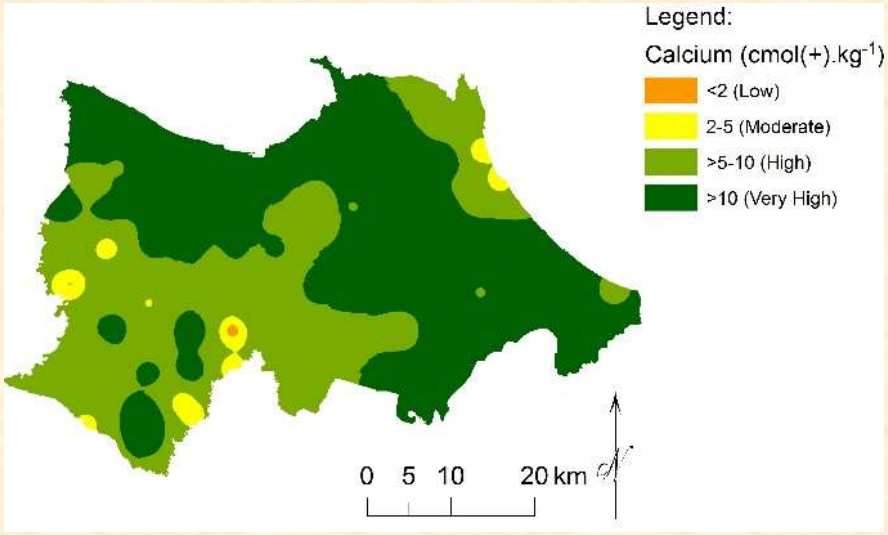
3.4. Soil Characteristics (Result of Laboratory Analysis)

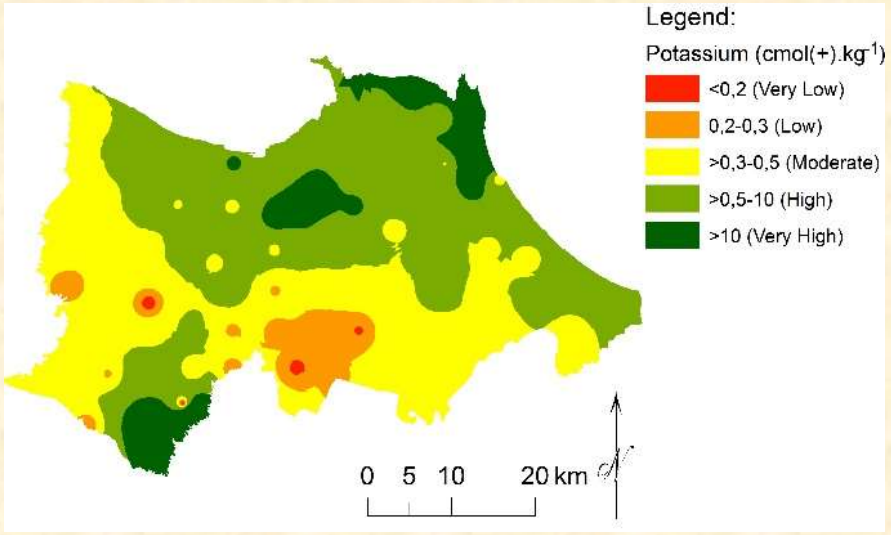


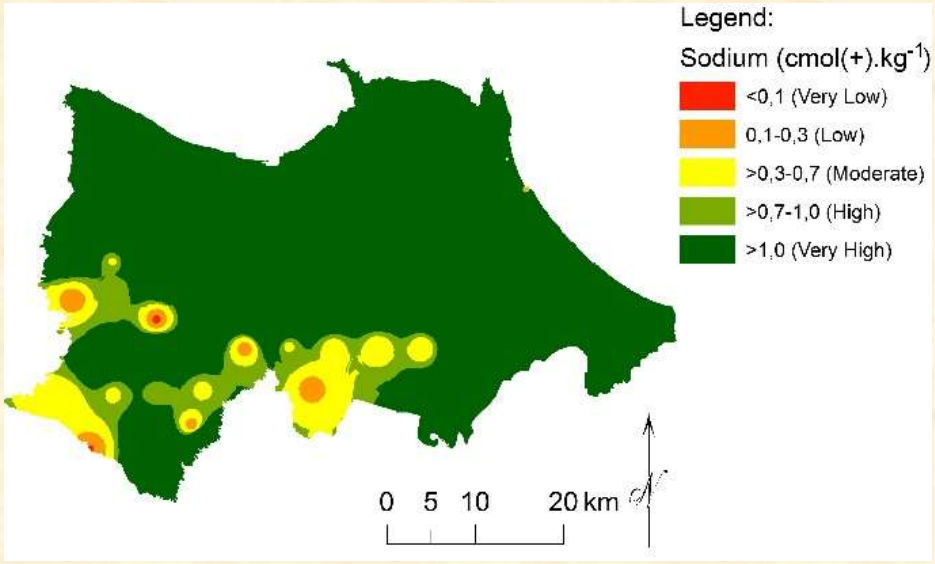


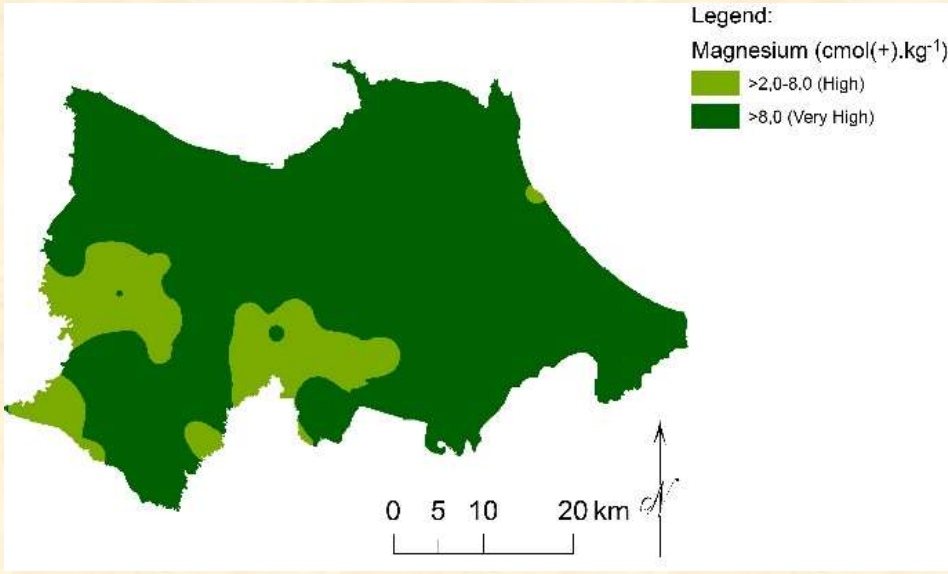


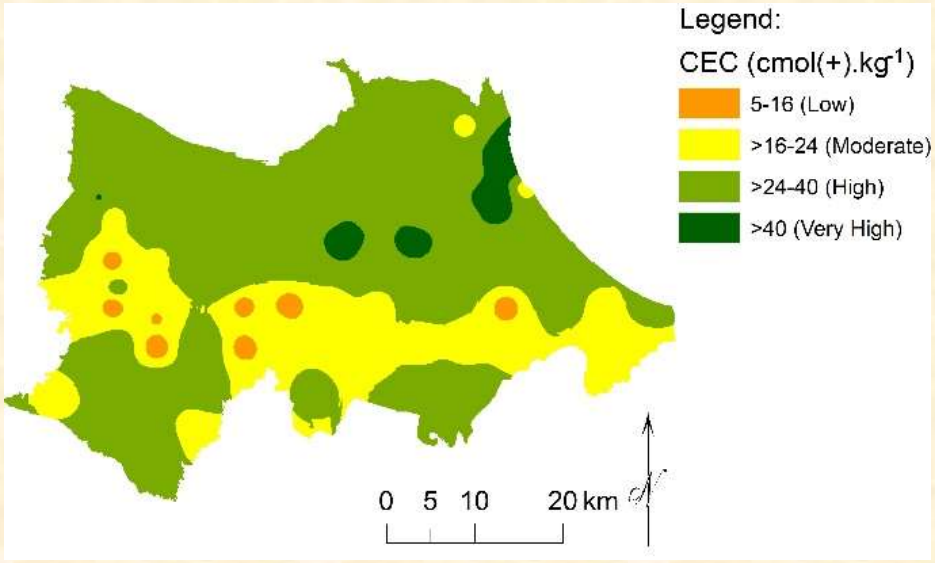


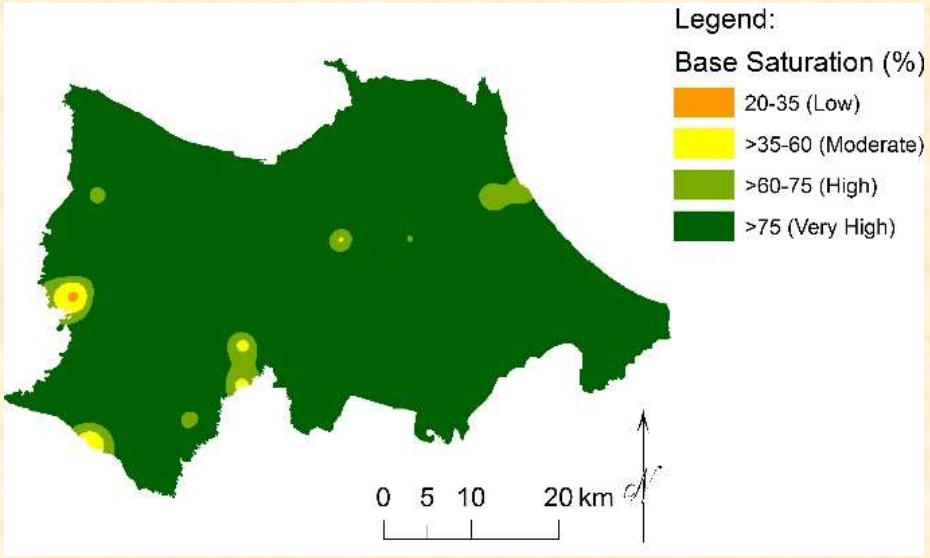

Legend:
Calcium (cmol(+).kg-1)
<2 (Low)
2-5 (Moderate)
>5-10 (High)
>10 (Very High)
0 5 10 20 km


Legend:
Potassium (cmol(+).kg-1)
<0,2 (Very Low)
0,2-0,3 (Low)
>0,3-0,5 (Moderate)
>0,5-10 (High)
>10 (Very High)
0 5 10 20 km

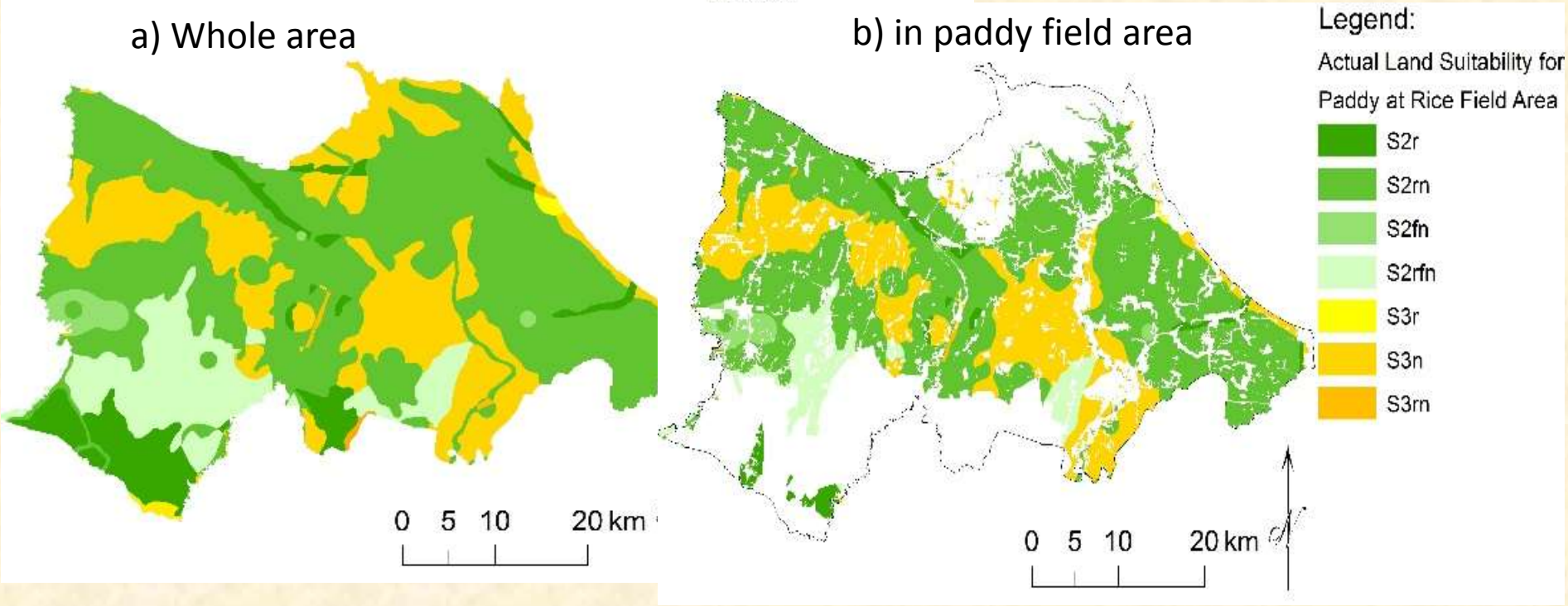

Legend:
Sodium (cmol(+).kg-1)
<0,1 (Very Low)
0,1-0,3 (Low)
>0,3-0,7 (Moderate)
>0,7-1,0 (High)
>1,0 (Very High)
0 5 10 20 km


Legend:
Magnesium (cmol(+).kg-1)
>2,0-8,0 (High)
>8,0 (Very High)
0 5 10 20 km


Legend:
CEC (cmol(+).kg-1)
5-16 (Low)
>16-24 (Moderate)
>24-40 (High)
>40 (Very High)
0 5 10 20 km
N


Legend:
Base Saturation (%)
20-35 (Low)
>35-60 (Moderate)
>60-75 (High)
>75 (Very High)
0 5 10 20 km
N

3.5. Land suitability for Paddy Field



No	Land Suitability	Size	
		ha	%
1	S2r	4,016.6	3.1
2	S2rn	79,652.3	62.4
3	S2fn	2,234.4	1.8
4	S2rfn	8,376.8	6.6
5	S3r	115.5	0.1
6	S3n	32,887.6	25.8
7	S3rn	315.3	0.2
	Total	127,598.4	100.0

Actual Land Suit. for Paddy Field

Limiting factor:

f = nutrient retention

n = nutrient availability

r = rooting media

3.6. Dynamic System Model for Paddy Field

MENU

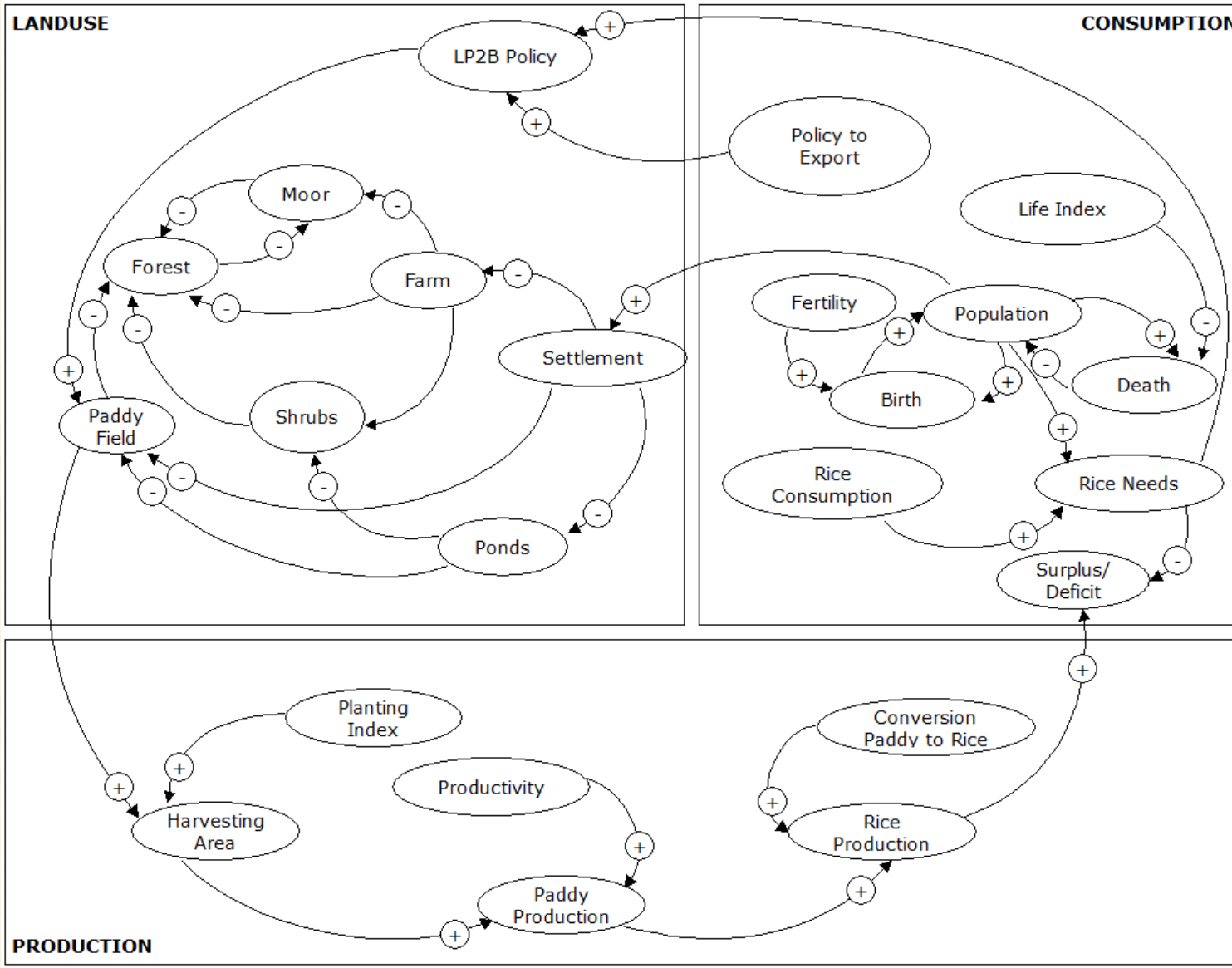
MENU

CAUSAL LOOP

SFD

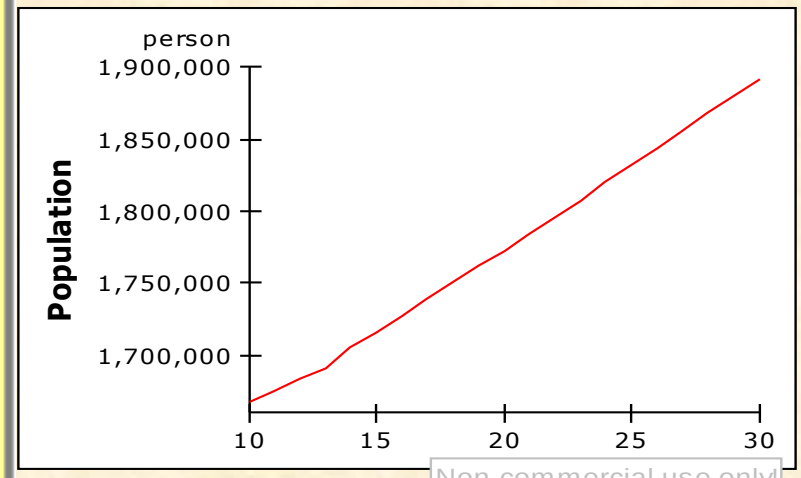
SIMULASI

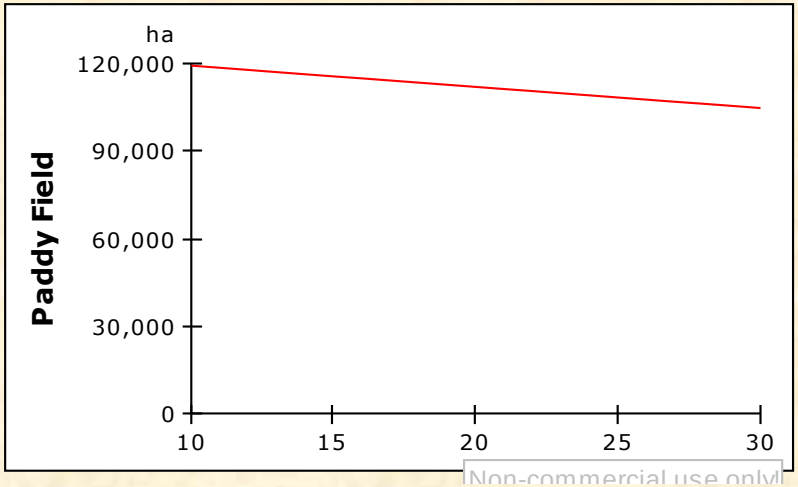
MAP

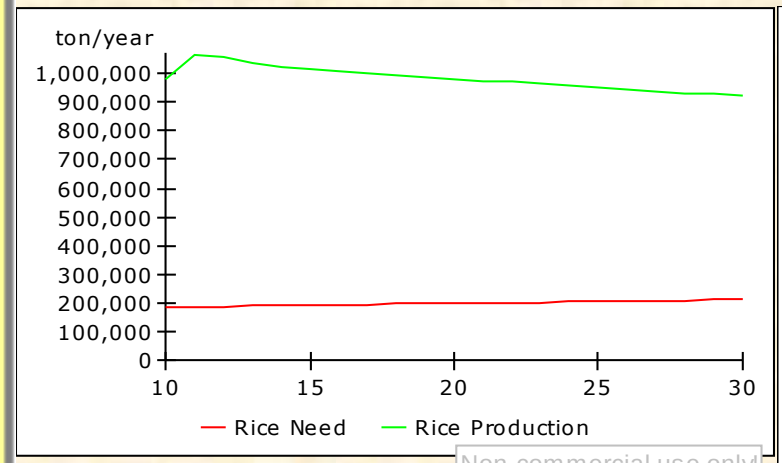


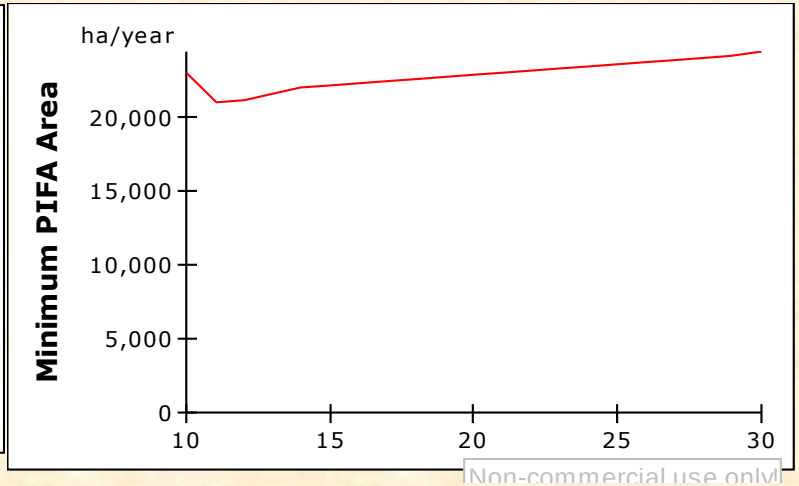
Performance surplus of rice in actual condition (business as usual)

Year	Rice Need	Actual	
		Rice production	Surplus/ Defisit
2010	188,501.29	975,492.97	786,991.68
11	189,364.25	1,062,583.68	873,219.43
12	190,231.16	1,054,369.85	864,138.69
13	191,101.85	1,033,791.18	842,689.33
14	192,694.68	1,017,781.49	825,086.81
15	193,950.09	1,011,652.54	817,702.46
16	195,213.67	1,005,523.59	810,309.92
17	196,485.49	999,394.65	802,909.16
18	197,765.59	993,265.70	795,500.11
19	199,054.03	987,136.76	788,082.72
20	200,350.87	981,007.81	780,656.94
21	201,656.16	974,878.87	773,222.71
22	202,969.95	968,749.92	765,779.97
23	204,292.29	962,620.97	758,328.68
24	205,623.26	956,462.03	750,868.77
25	206,962.89	950,363.08	743,400.19
26	208,311.26	944,234.14	735,922.88
27	209,668.41	938,105.19	728,436.79
28	211,034.40	931,976.25	720,941.85
29	212,409.28	925,847.30	713,438.02
2030	213,793.13	919,718.35	705,925.22









Result of model simulations in Indramayu Regency for: a. populations, b. paddy field area; c. rice consumption and rice Production, and d. Minimal area of paddy field for internal regional food availability (Minimum PIFA)

MODEL VALIDATION

- Validity Measurement:

➢ Model output and deviations from actual data, using Absolute Mean Error (AME) and Absolute Variation Error (AVE)

➢ Limit validity: <10%

- Total population: AME = 0.1140%, AVE = 0.0385%.
- Paddy field area: AME = 0.3425%, AVE = 0.0486%.
- Rice production: AME = 0.3316% , AVE = 2.4935%.

➢ The model is able to simulate the paddy field production and consumption

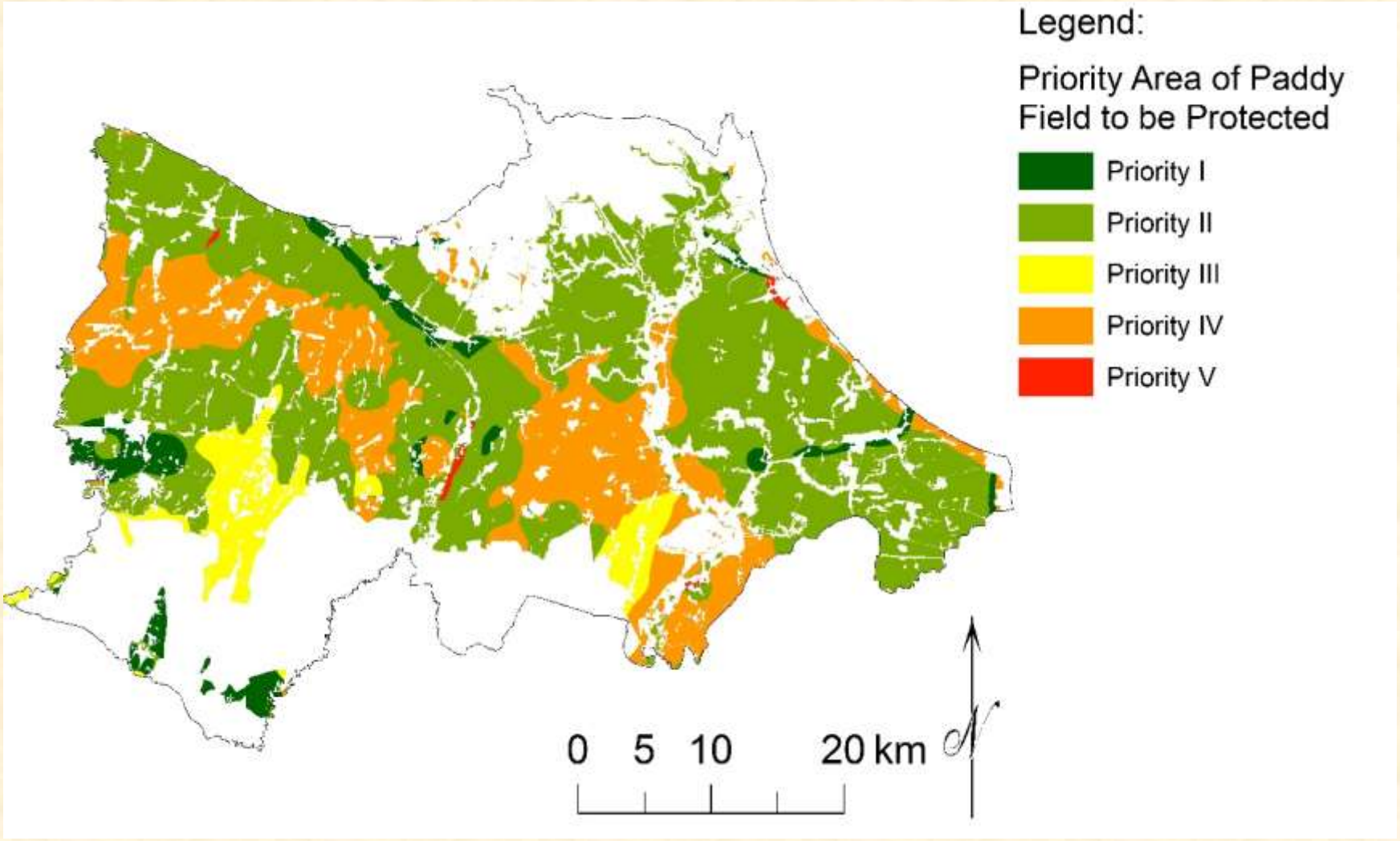
Scenario built in this research

	Business as Usual	SCENARIO 1 (Moderate)	SCENARIO II (OPTIMISTIC)
Planting Index	2.1	2.3	2.5
Productivity	5.1 (in land suitability of S2)	Increase 0.6%.year^{-1}	Increase 1%.year^{-1}
Consumption	113 kg.year-1	Decrease 2%.year^{-1}	Decrease 4%. Year^{-1}

Performance surplus of rice according to the scenario compared to actual condition (modeled)

Year	Rice Need	Actual		Scenario 1		Scenario 2	
		Rice production	Surplus/ Defisit	Rice Production	Surplus/ Defisit	Rice Production	Surplus/ Defisit
2010	188,501.29	975,492.97	786,991.68	975,492.97	786,991.68	975,492.97	786,991.68
11	189,364.25	1,062,583.68	873,219.43	1,062,583.68	873,219.43	1,062,583.68	873,219.43
12	190,231.16	1,054,369.85	864,138.69	1,054,369.85	864,138.69	1,054,369.85	864,138.69
13	191,101.85	1,033,791.18	842,689.33	1,033,791.18	842,689.33	1,033,791.18	842,689.33
14	192,694.68	1,017,781.49	825,086.81	1,017,781.49	825,086.81	1,017,781.49	825,086.81
15	193,950.09	1,011,652.54	817,702.46	1,011,652.54	817,702.46	1,011,652.54	817,702.46
16	195,213.67	1,005,523.59	810,309.92	1,005,523.59	810,309.92	1,005,523.59	810,309.92
17	196,485.49	999,394.65	802,909.16	999,394.65	802,909.16	999,394.65	802,909.16
18	197,765.59	993,265.70	795,500.11	1,136,572.70	938,807.11	1,235,405.10	1,037,639.51
19	199,054.03	987,136.76	788,082.72	1,129,559.47	930,505.44	1,227,782.04	1,028,728.00
20	200,350.87	981,007.81	780,656.94	1,122,546.25	922,195.38	1,220,158.97	1,019,808.10
21	201,656.16	974,878.87	773,222.71	1,115,533.03	913,876.88	1,212,535.90	1,010,879.75
22	202,969.95	968,749.92	765,779.97	1,108,519.81	905,549.86	1,204,912.84	1,001,942.89
23	204,292.29	962,620.97	758,328.68	1,101,506.59	897,214.29	1,197,289.77	992,997.47
24	205,623.26	956,462.03	750,868.77	1,094,493.37	888,870.11	1,189,666.70	984,043.44
25	206,962.89	950,363.08	743,400.19	1,087,480.14	880,517.25	1,182,043.64	975,080.74
26	208,311.26	944,234.14	735,922.88	1,080,466.92	872,155.67	1,174,420.57	966,109.31
27	209,668.41	938,105.19	728,436.79	1,073,453.70	863,785.30	1,166,797.50	957,129.10
28	211,034.40	931,976.25	720,941.85	1,066,440.48	855,406.09	1,159,174.44	948,140.04
29	212,409.28	925,847.30	713,438.02	1,059,427.26	847,017.97	1,151,551.37	939,142.08
2030	213,793.13	919,718.35	705,925.22	1,052,414.04	838,620.91	1,143,928.30	930,135.17

3.7. SPATIAL PRIORITY FOR PADDY FIELD, based on dynamic model and land suitability



The priority area of paddy field to be protected in 2030. The availability of rice in the longer term required higher area to be protected. Priority was based on land suitability (level of land suitability and the ease to manage according to limiting factor)

IV. CONCLUSIONS

- Based on existing land use and land cover, Indramayu Regency has main land use of paddy fields which covers >60% of the regency.
- land suitability for paddy fields in the area which is actually used as paddy field, the majority (> 70%)
  - land suitability level of S2 (suitable),
  - the other have land suitability level of S3 (marginally suitable).
- The limiting factors consist of nutrient retention, nutrient availability and rooting media

- **System dynamic modeling results show that in the current conditions,**
  - Indramayu regency still have sufficient food for its population, the regency can even contribute to national food sovereignty by exporting 81% of rice out of the territory.
  - Along with the increasing food needs due to population growth and decreasing paddy field area due to land conversion, the ability to export out of the regency was reduced with 14% from in 2030 compared to the export of 2014.
- **With the moderate scenario by improvement of cropping index:**
  - Indramayu regency in 2030 will still able to export rice 79% out of the territory.
- **In the optimistic scenario:**
  - the ability to export out of the territory is even higher, surpassing even export in the existing (2014) condition.

- Based on the analysis of land suitability and equilibrium of production and consumption according to the model, the priority of paddy field to be protected can be then arranged within five (5) priority levels, which can be presented spatially.

THANK YOU