

***Training-Workshop on Climate Change Adaptation in Watersheds for
Water, Food and Environmental Security in Southeast Asia***

SEARCA

College, Laguna, PHILIPPINES 4031

October 15-18, 2013

**PROMOTING SUSTAINABILITY OF
WATERSHEDS IN A CHANGING CLIMATE**

Part 3:

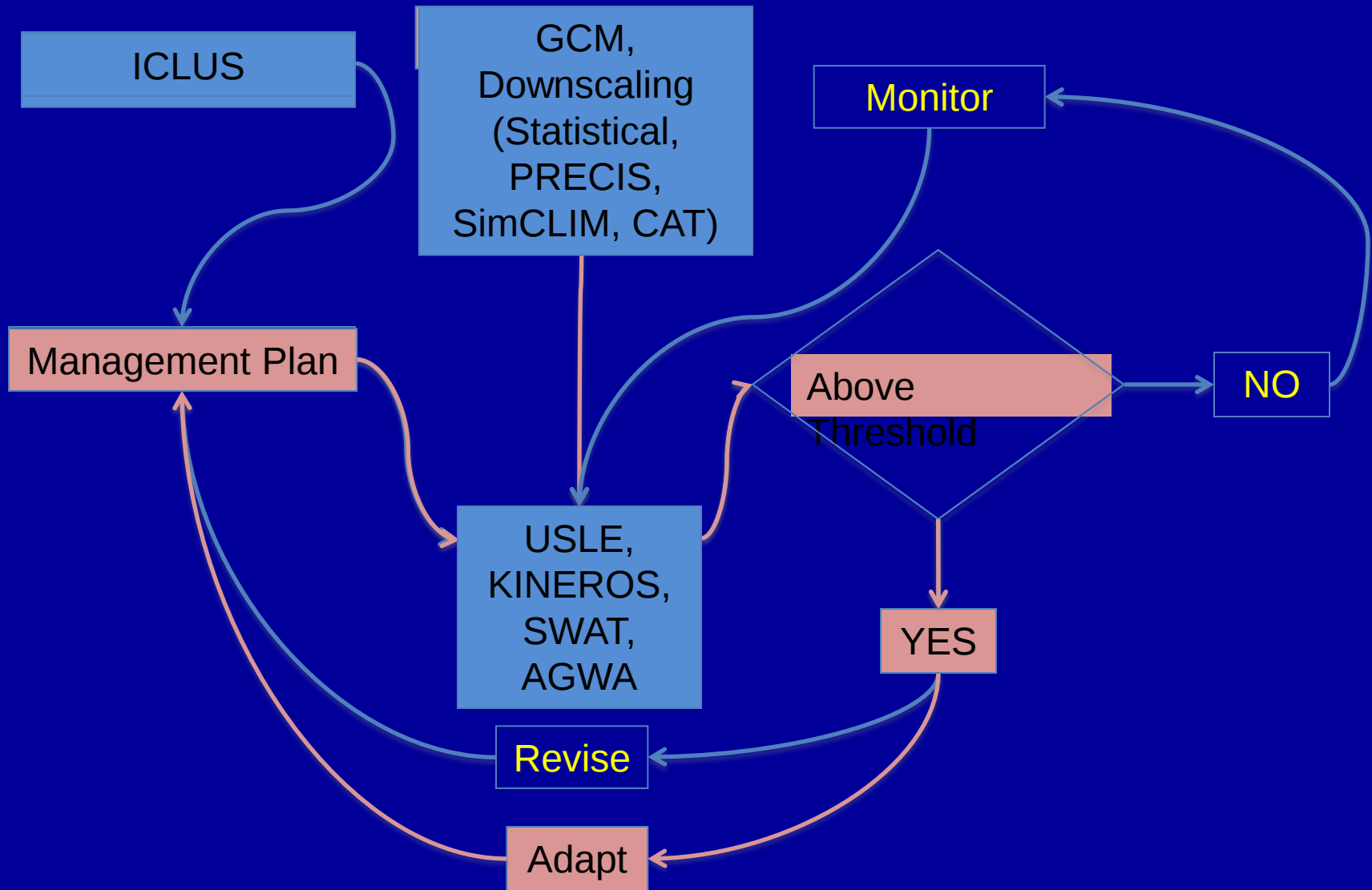
Watershed Management cum CC Adaptation Planning

Rex Victor O. Cruz, PhD

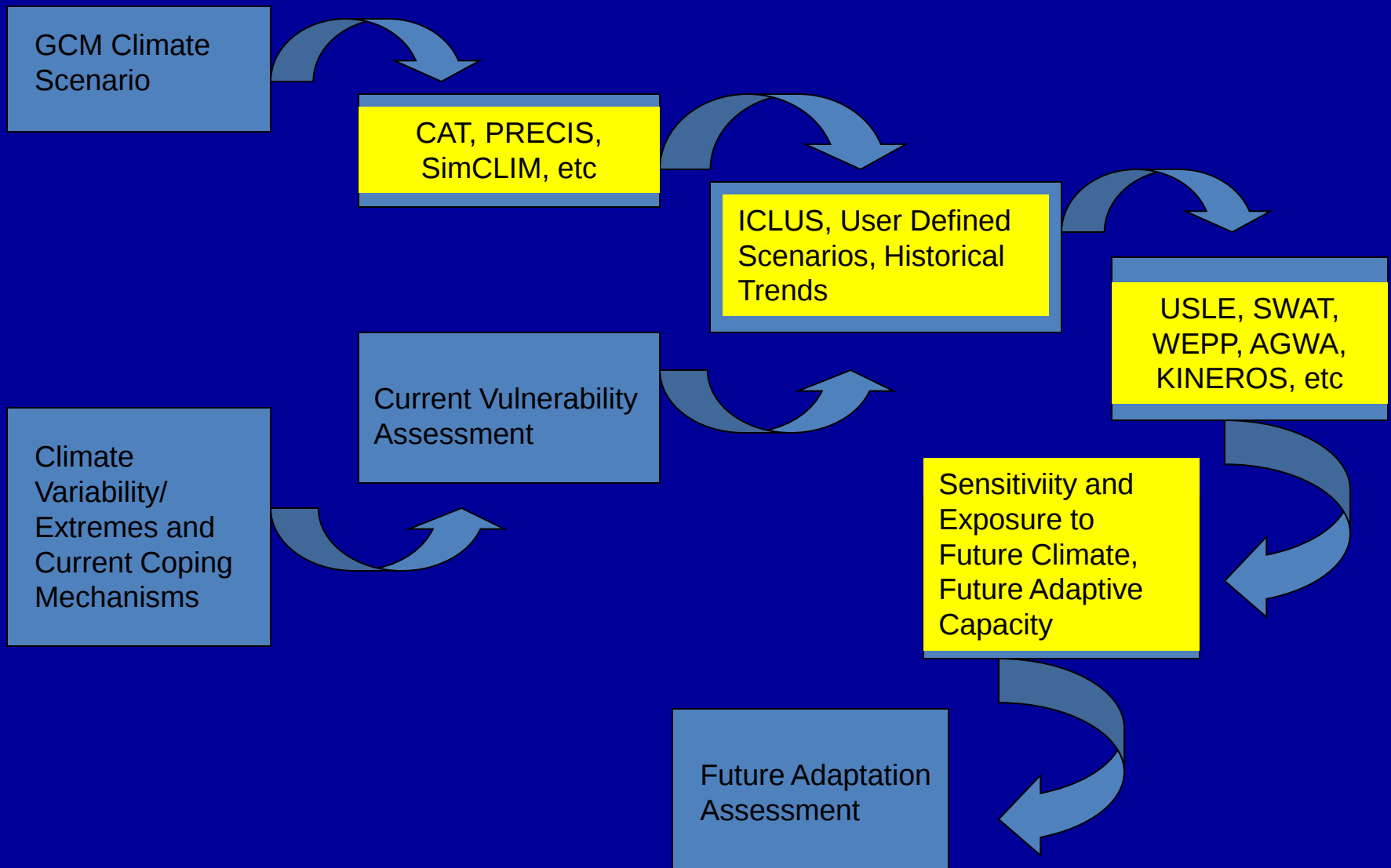
University of the Philippines Los Baños

College, Laguna

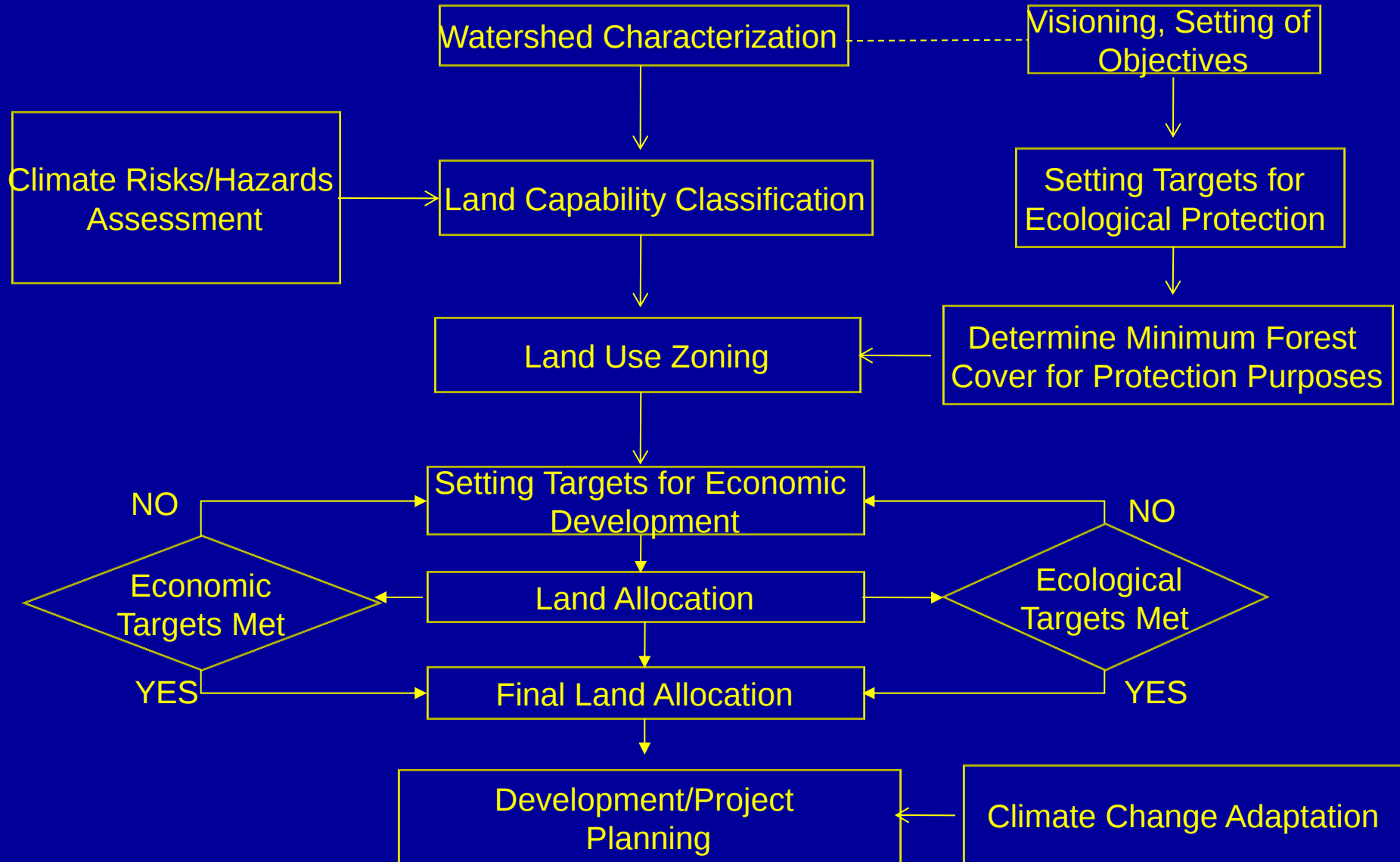
Assessing Impacts of Climate and Human Stressors on PA



General Methodology of the study AIACC - Philippines



Watershed Management cum Adaptation Plan

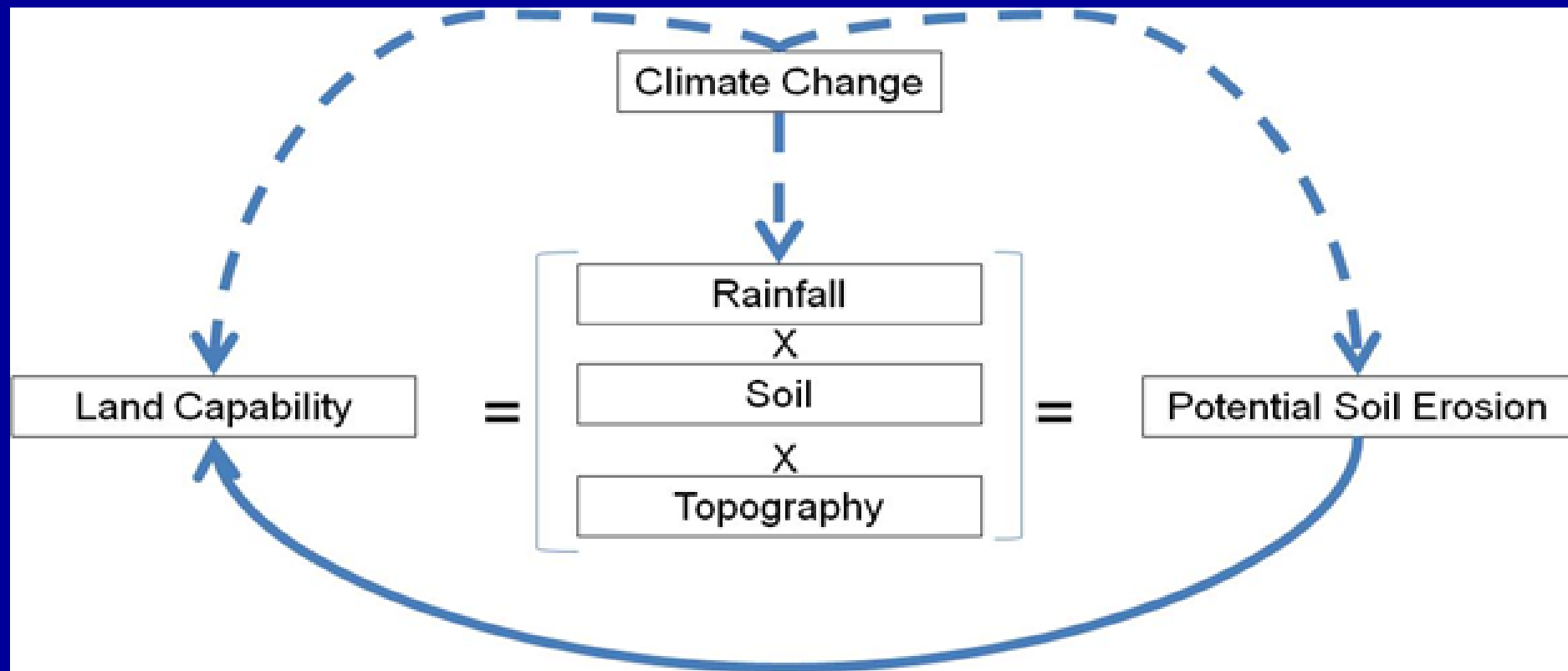


Basic Concepts

Land capability – inherent capacity of land to sustain plants and animals, and certain uses

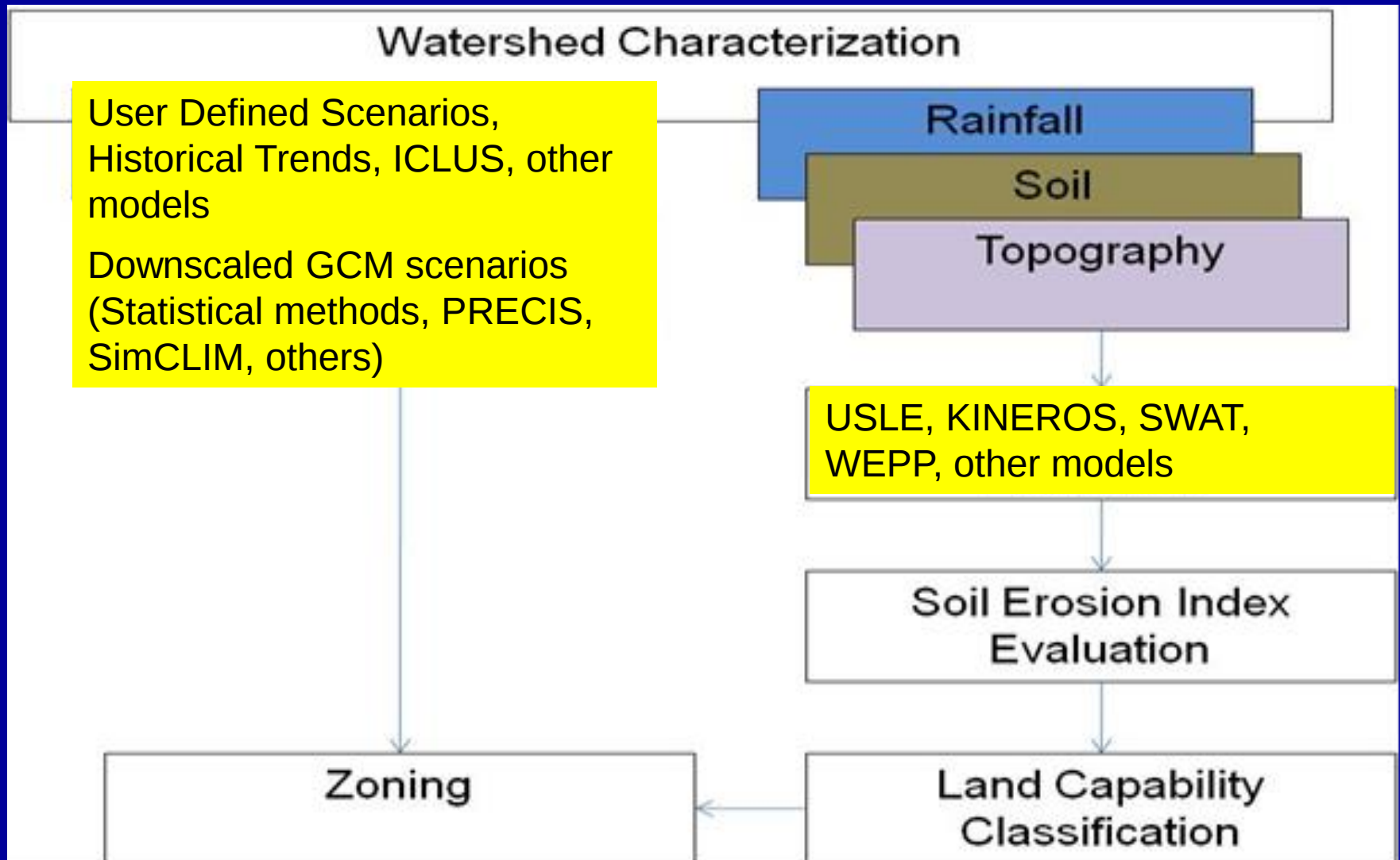
Land capability classification – subdivision of large areas i.e., watersheds into homogenous land management units

Scientific Basis

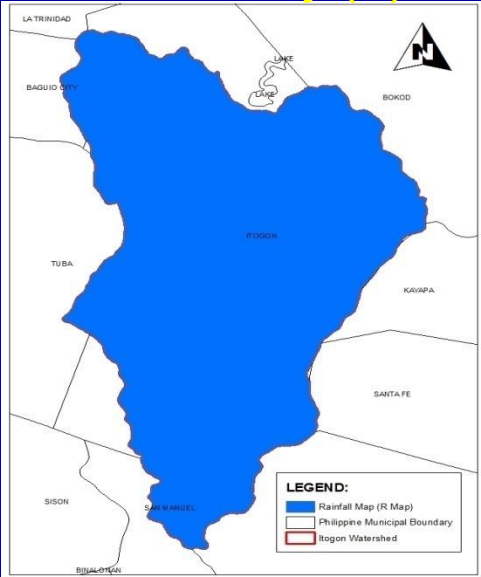


LAND CAPABILITY EVALUATION

Land Capability Classification Process

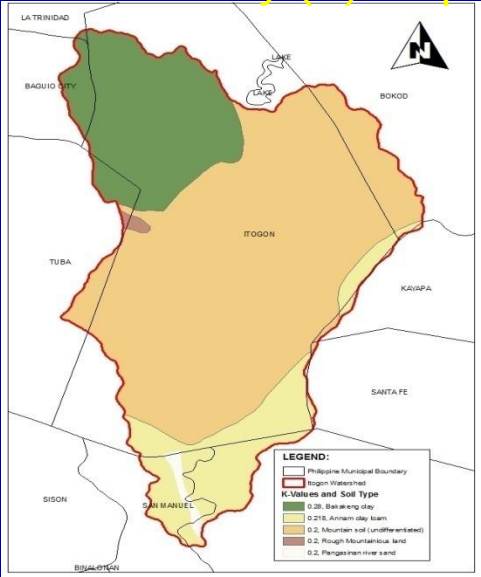


Rainfall Erosivity (R) Map



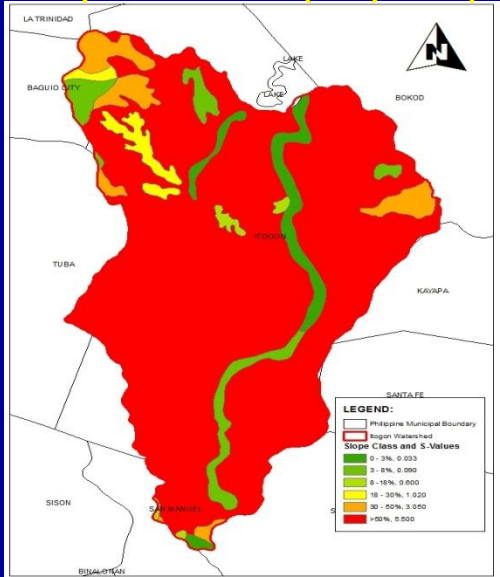
X

Soil Erodibility (K) Map



X

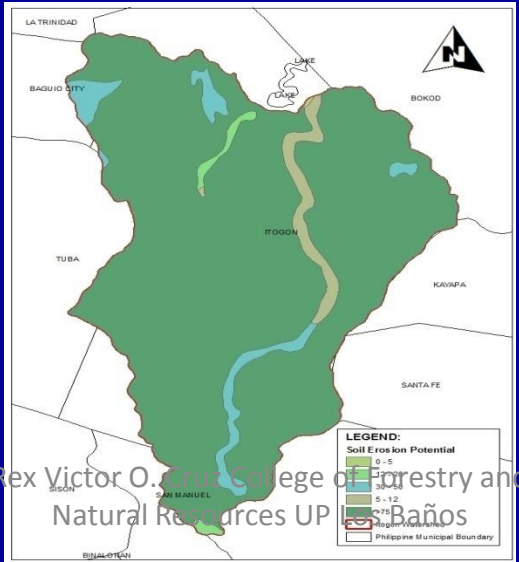
Slope Factor (LS) Map



R

K

S

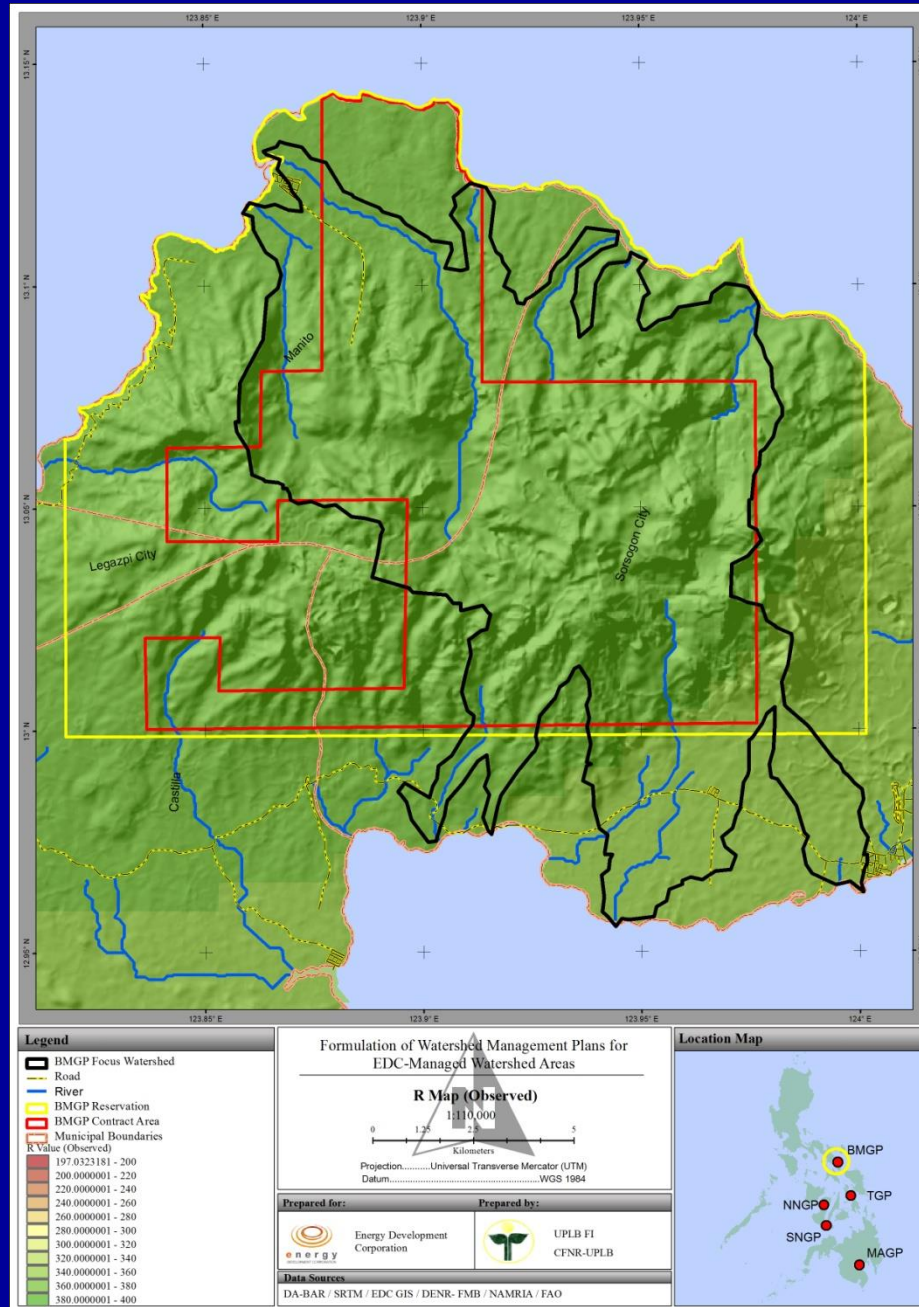


Potential Soil Erosion

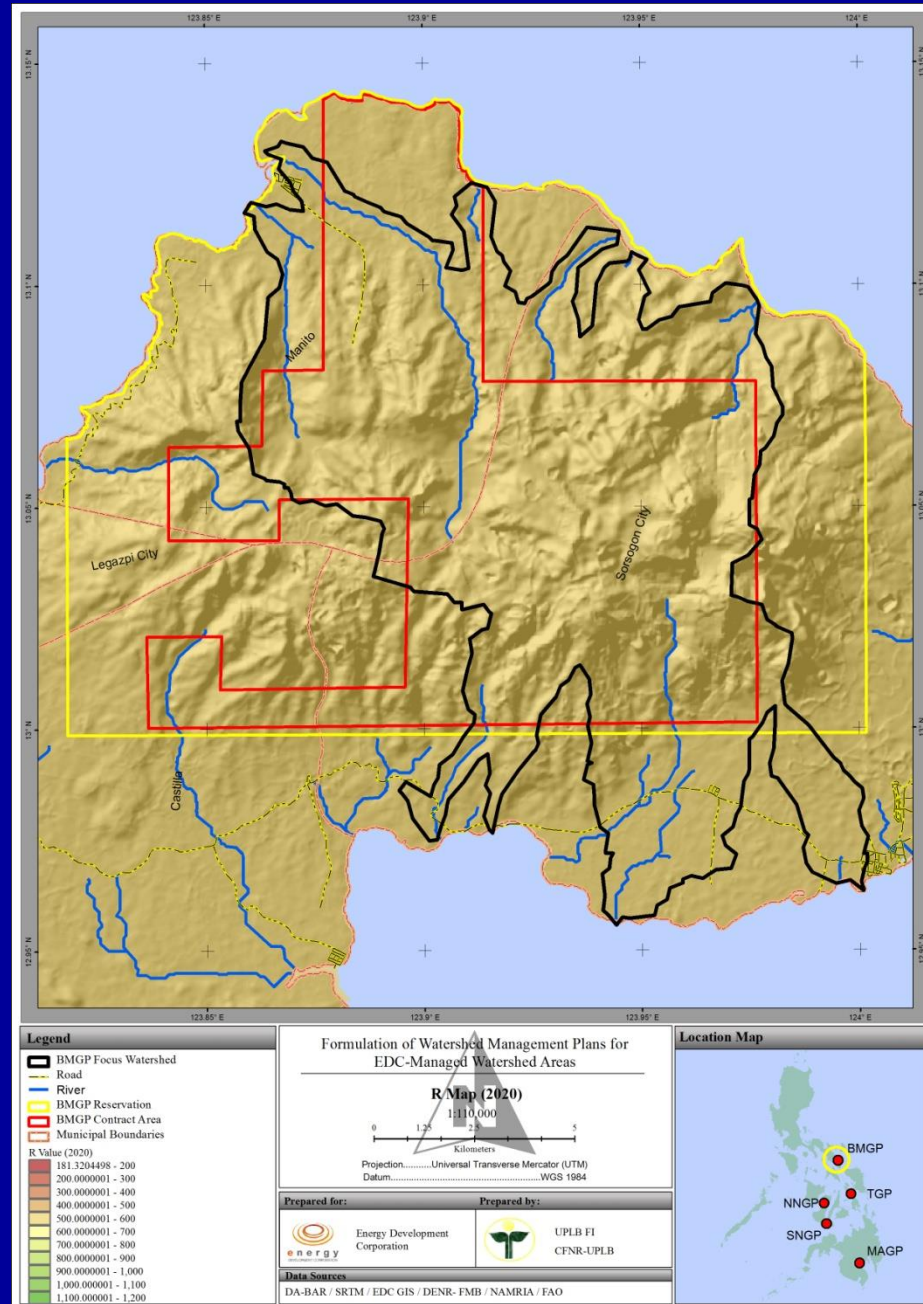
Summary of R-value of various PAGASA Stations for 3 time periods, PAGASA.

STATIONS	Observed	2020	2050
Tuguegarao	179	336	277
Dagupan	327	414	466
Baguio	691	1187	1482
Daet	365	462	507
Legaspi	388	572	592
Virac Synop	52	129	122
Masbate	197	181	237
Catarman	376	1112	1164
Catbalogan	238	226	331
Tacloban	202	257	235
Iloilo	198	160	229
Dumaguete	58	30	47
Tagbilaran	68	119	129
Cebu	91	66	109
Maasin	146	573	585
Dipolog	208	203	208
Cotabato	115	168	155
Davao	123	42	52
General Santos	35	15	29

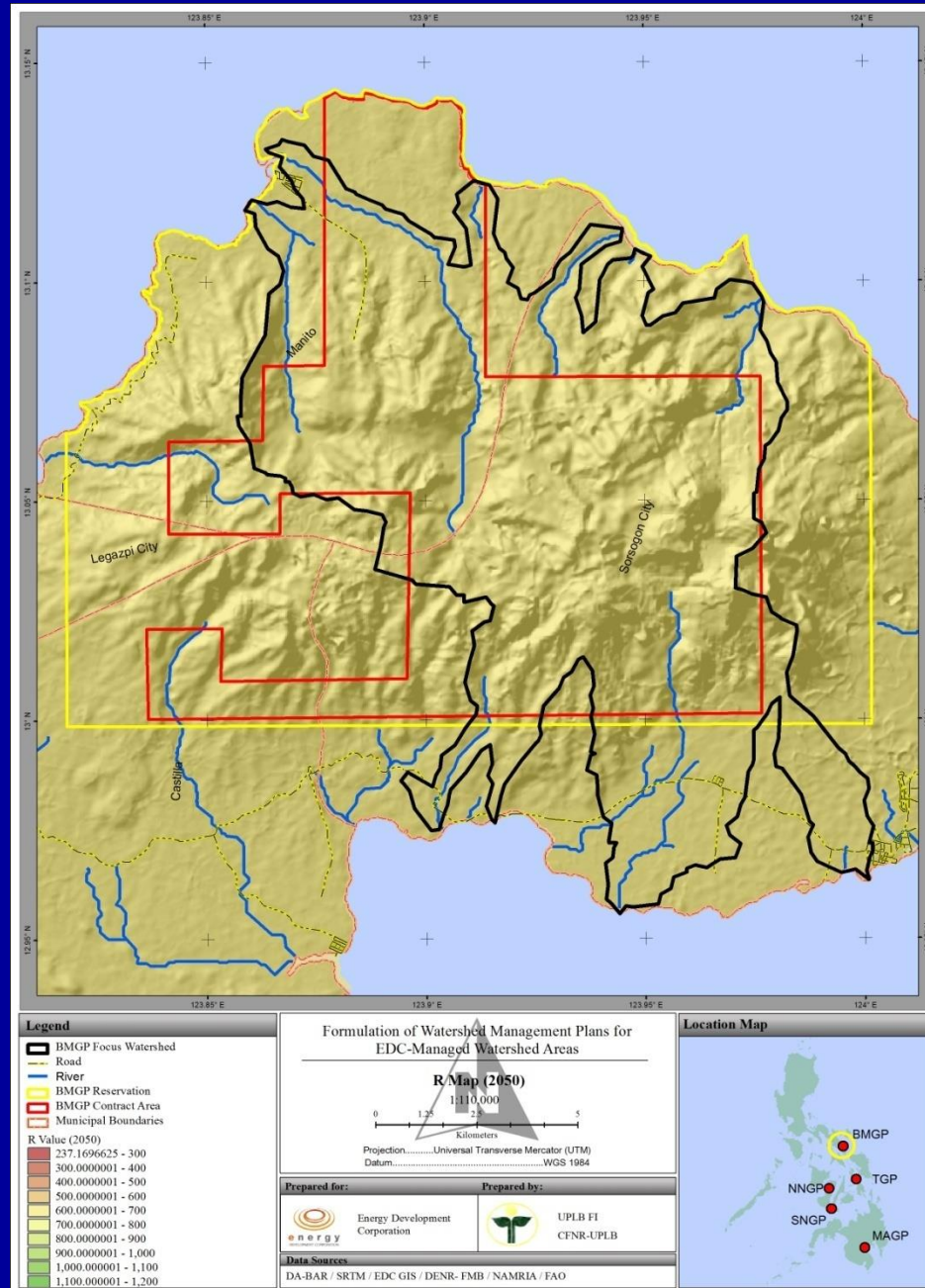
R values for BMGP (Observed)



R values for BMGP (2020)



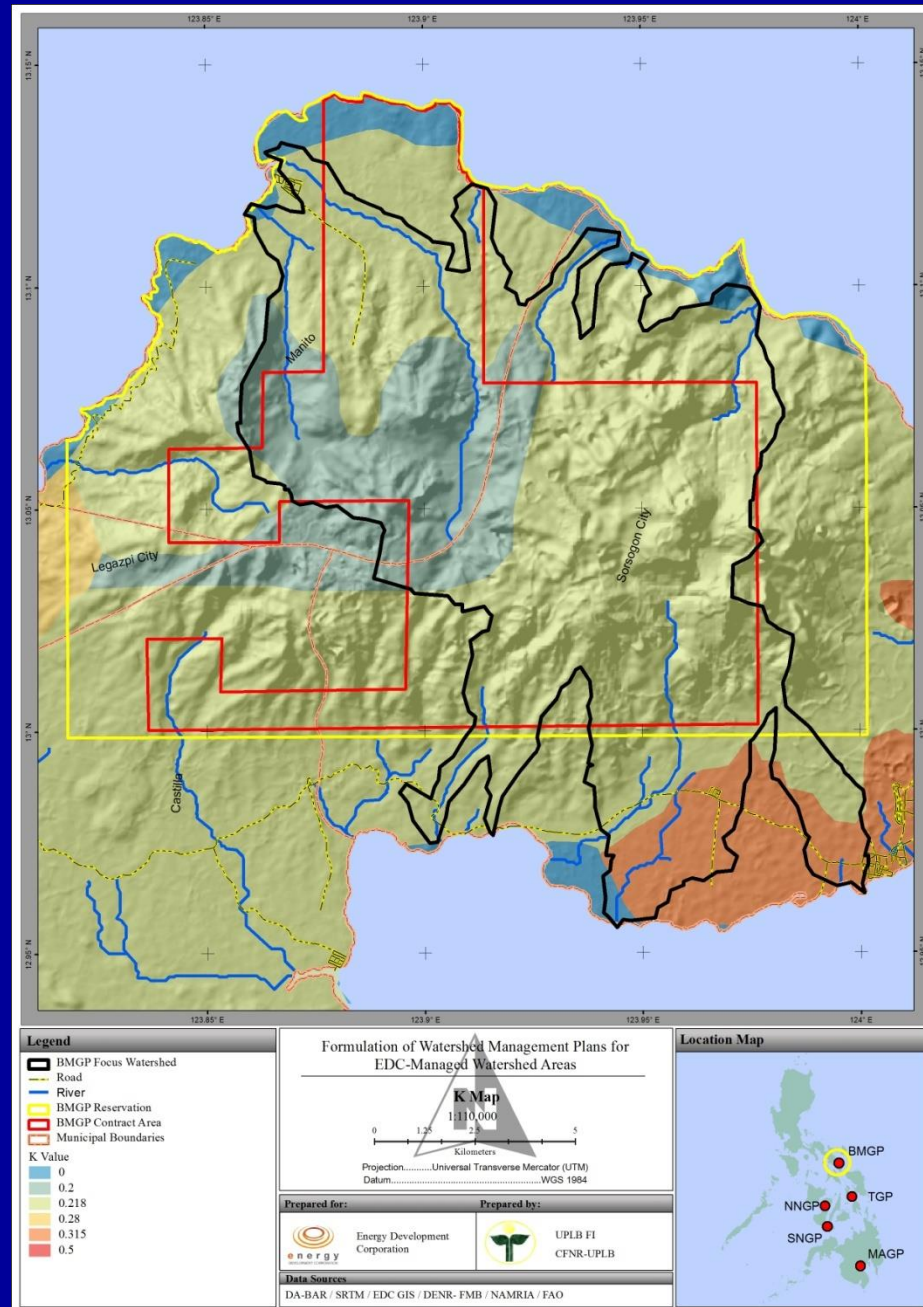
R values for BMGP (2050)



The K values for BMGP

K Value	Hectares
0	2151
0.1	
0.2	4364
0.207	
0.218	44647
0.26	
0.28	9612
0.3	
0.31	
0.315	4571
0.38	
0.43	
0.5	211
<i>TOTAL</i>	<i>65556</i>

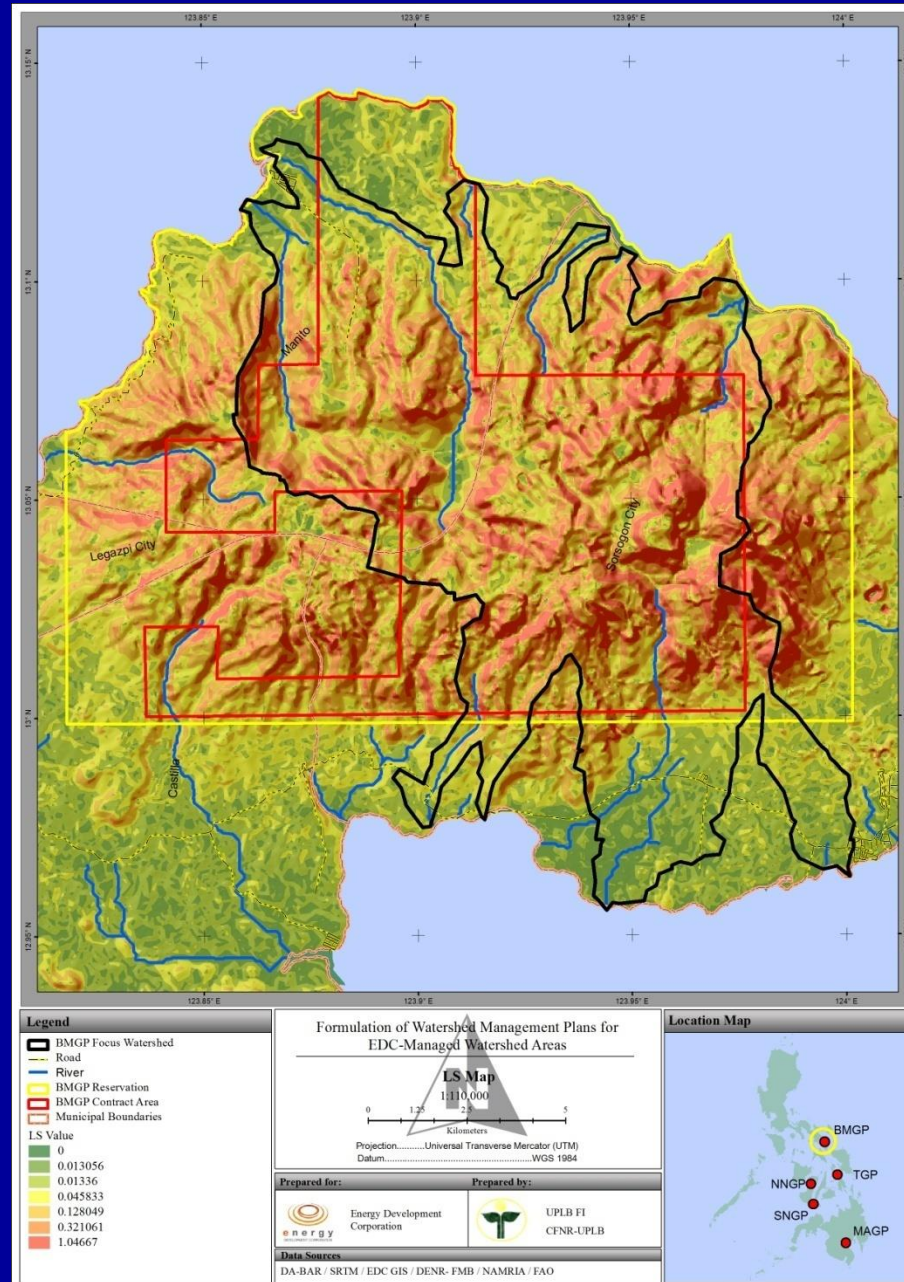
BMGP K Map



LS factor for soils in BMGP

LS Value	Hectares
0	913
0.013056	8901
0.013360	20842
0.045833	15722
0.128049	8726
0.321061	7325
1.046668	3127
<i>TOTAL</i>	<i>65556</i>

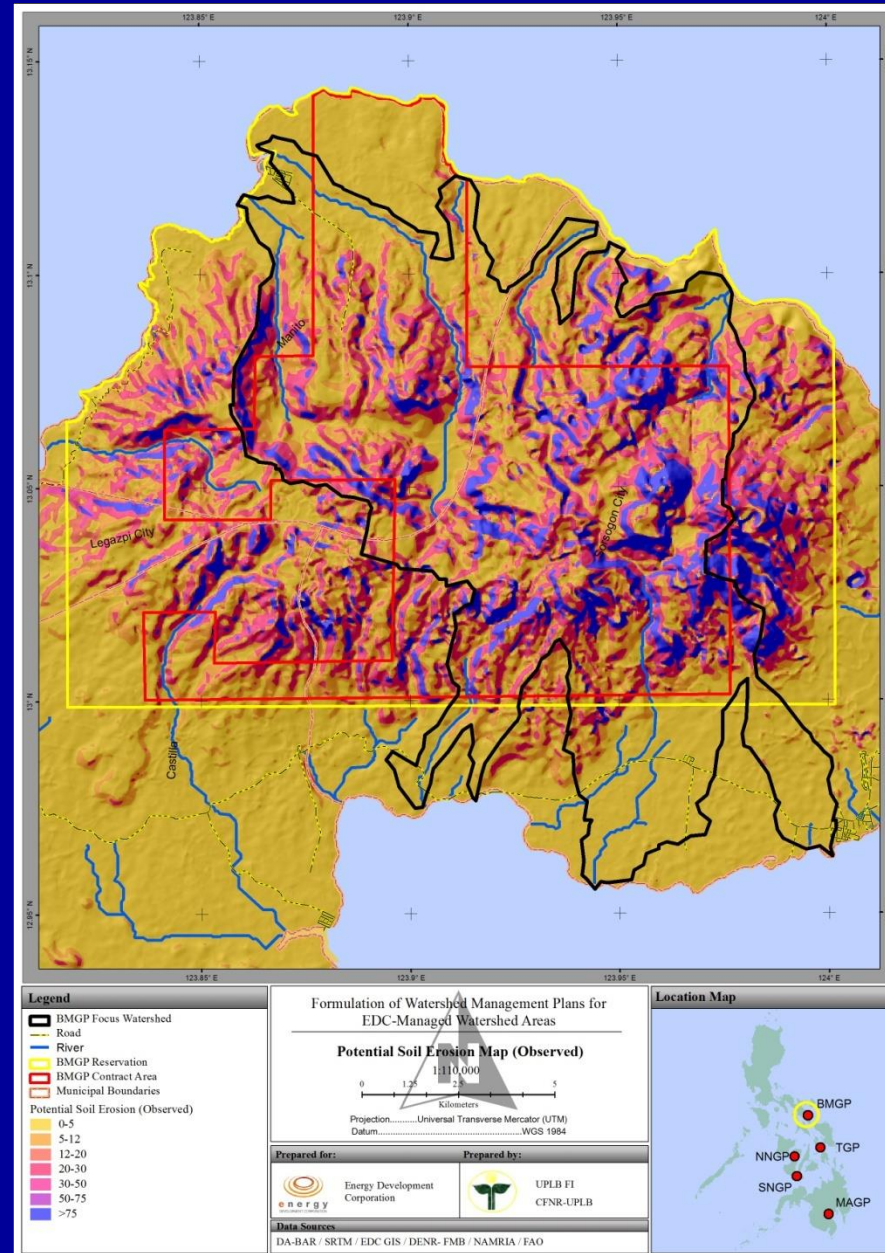
BMGP LS Map



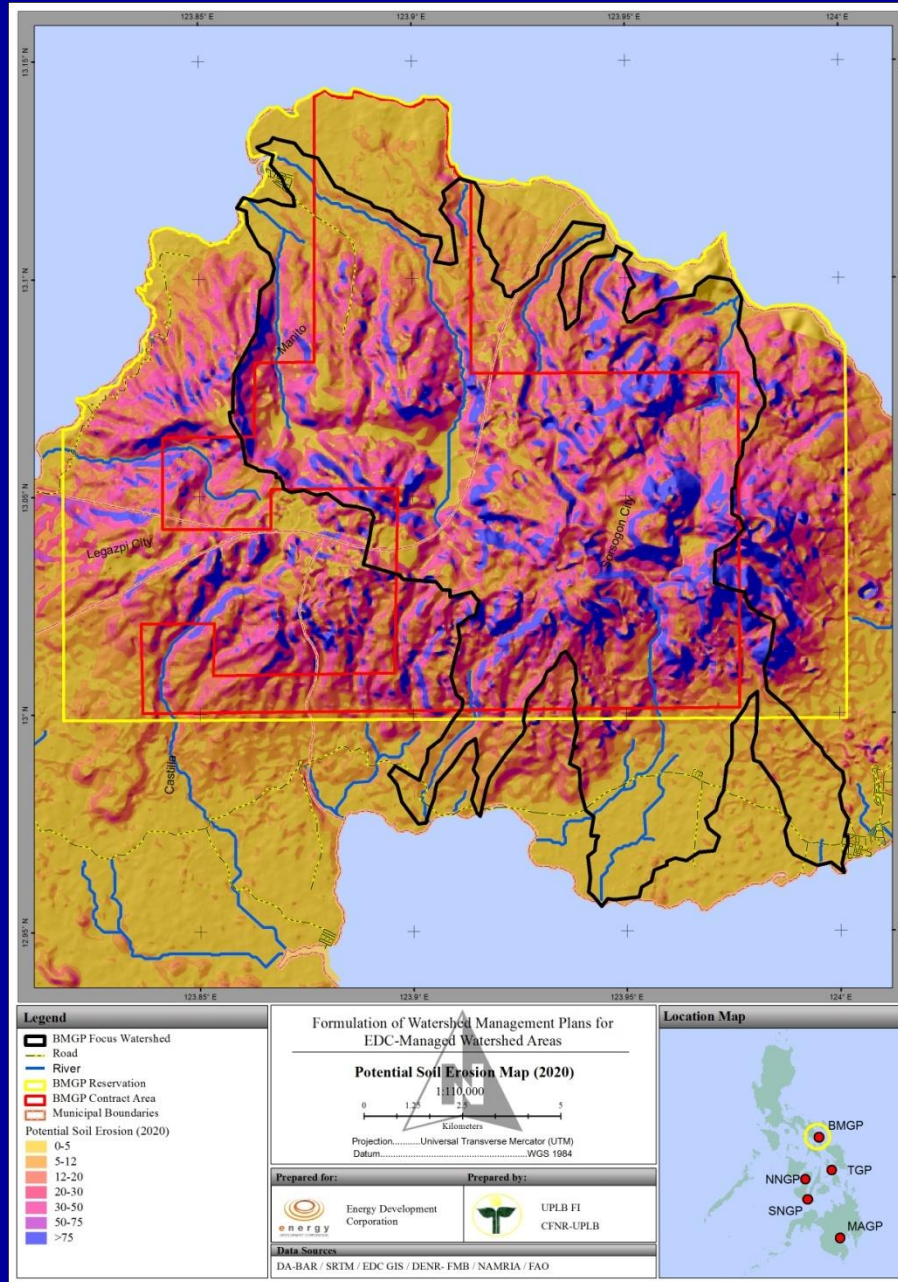
Potential soil erosion of areas (ha) in BMGP

Classes	SOIL EROSION POTENTIAL		
	Observed	2020	2050
0-5	46581	32096	31267
5-12	8108	14484	15314
12-20	530	8107	8107
20-30	7109	531	531
30-50	124	7109	7109
50-75		124	124
>75	3105	3105	3105
TOTAL	65556	65556	65556

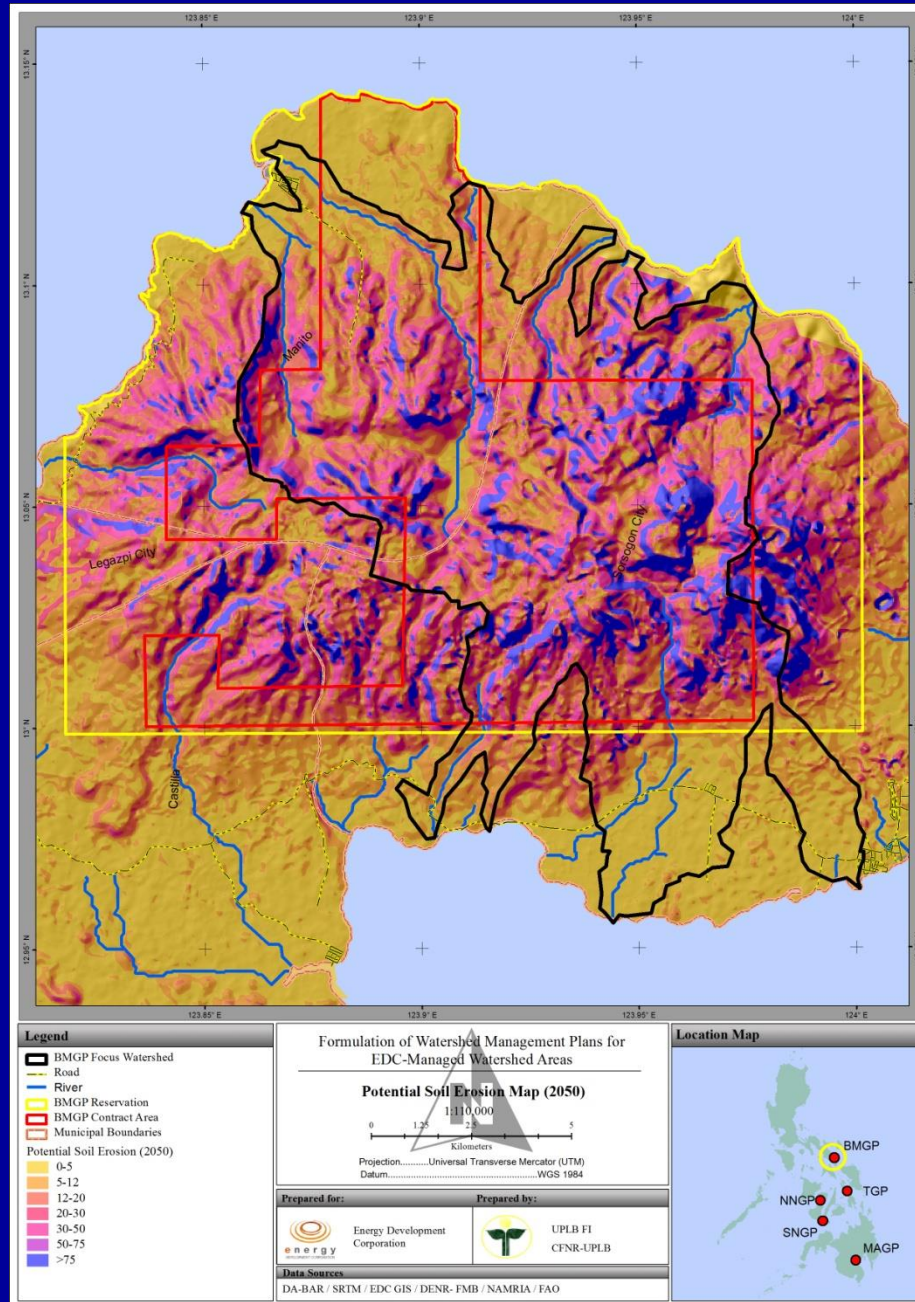
BMGP Potential Soil Erosion Map (Observed)



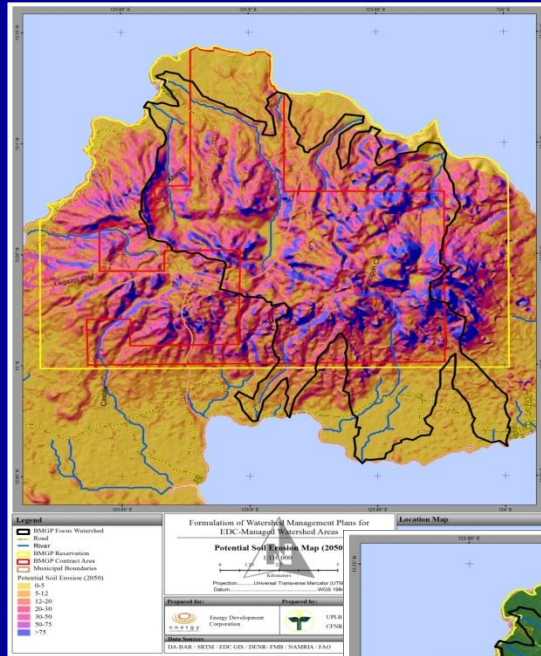
BMGP Potential Soil Erosion Map (2020)



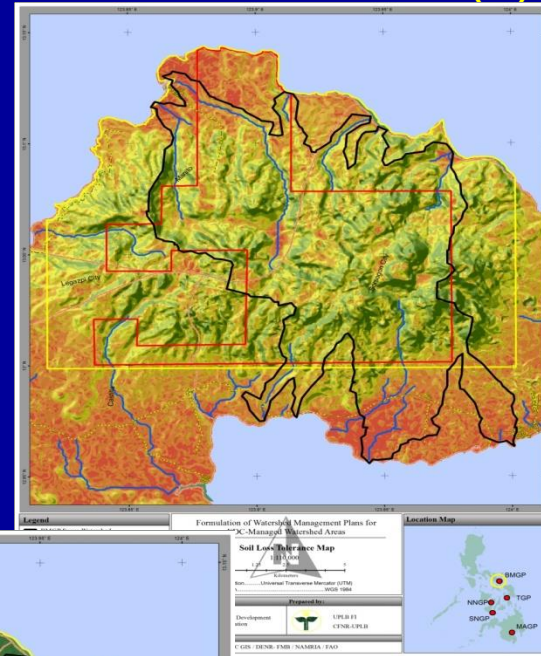
BMGP Potential Soil Erosion Map (2050)



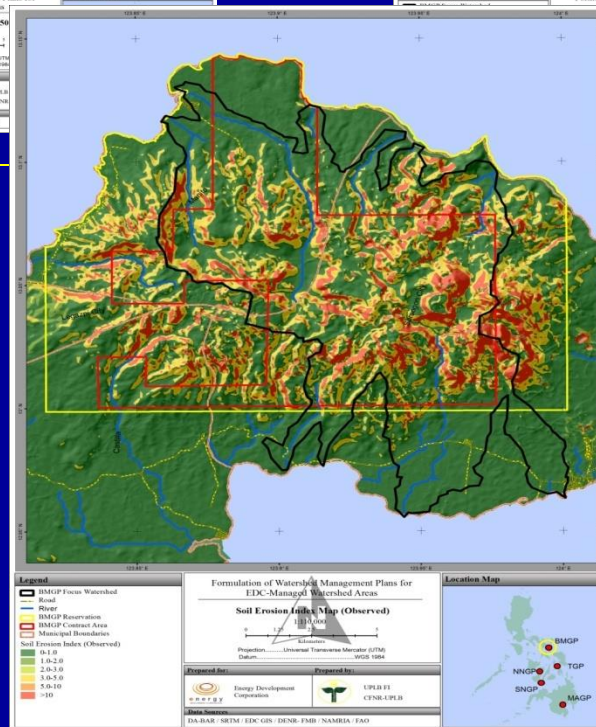
Potential Soil Erosion



Soil Loss Tolerance (T)



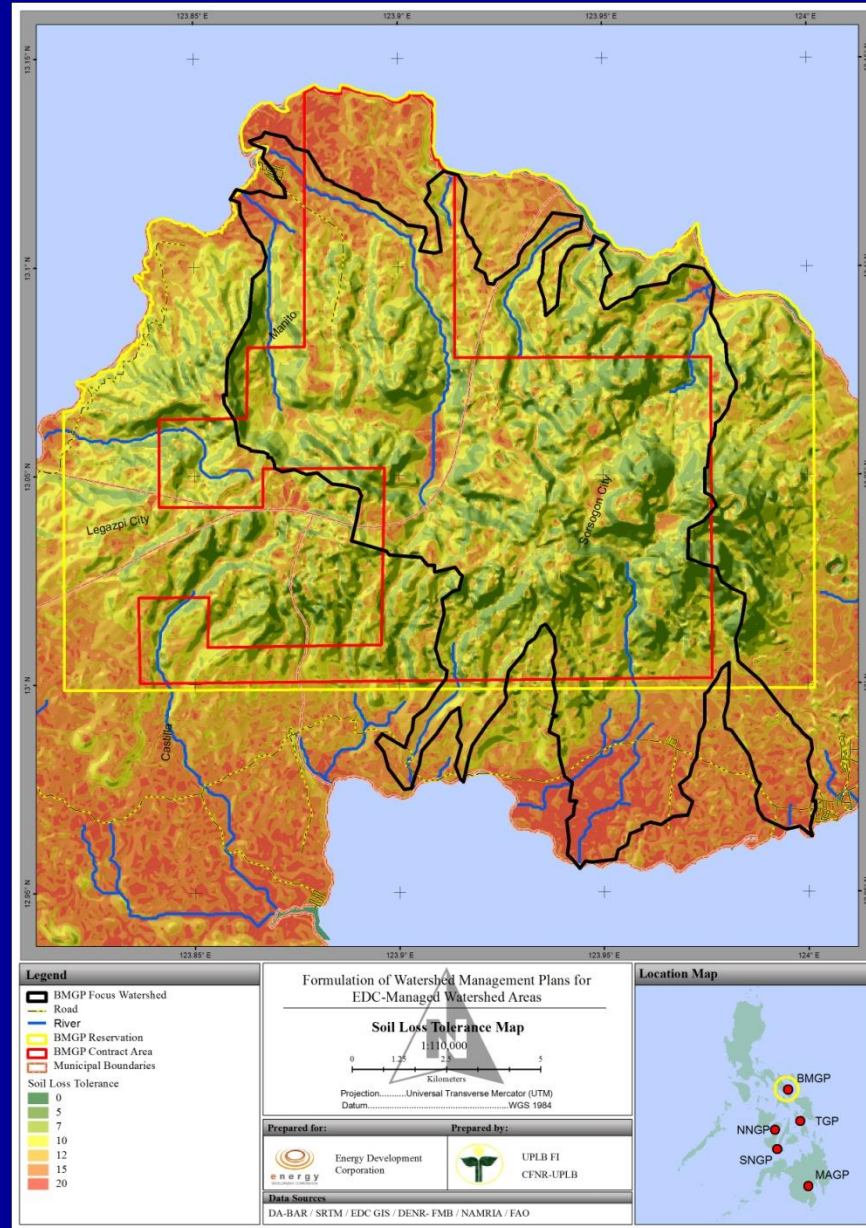
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Soil Erosion Index

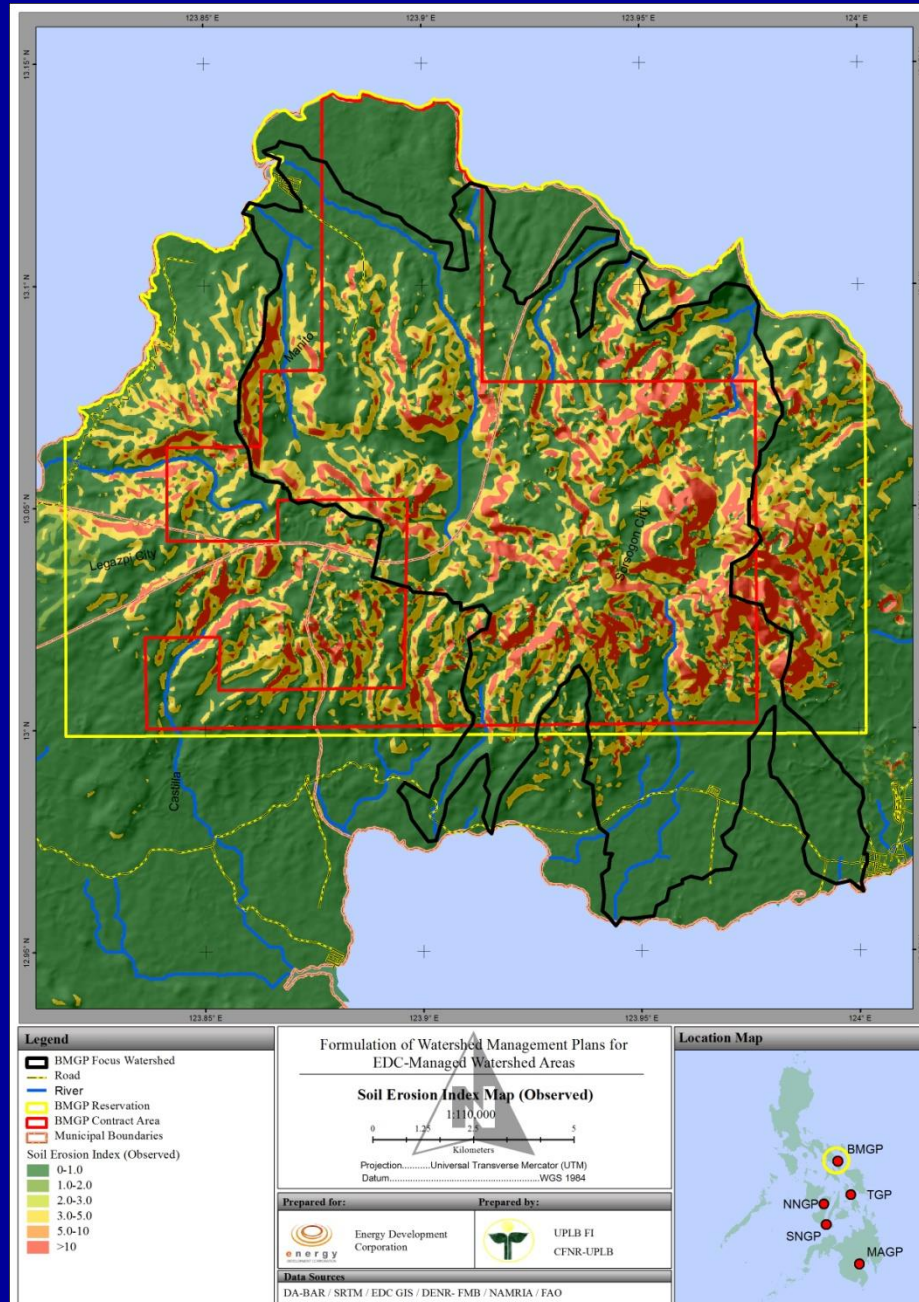
SOIL LOSS TOLERANCE		
Slope	Reclass	Hectares
No Data	0	913
50 and above	5	3127
30-50	7	7325
18-30	10	8726
8-18	12	15722
3-8	15	20842
0-3	20	8901
<i>TOTAL</i>		<i>65556</i>

BMGP Soil Loss Tolerance Map

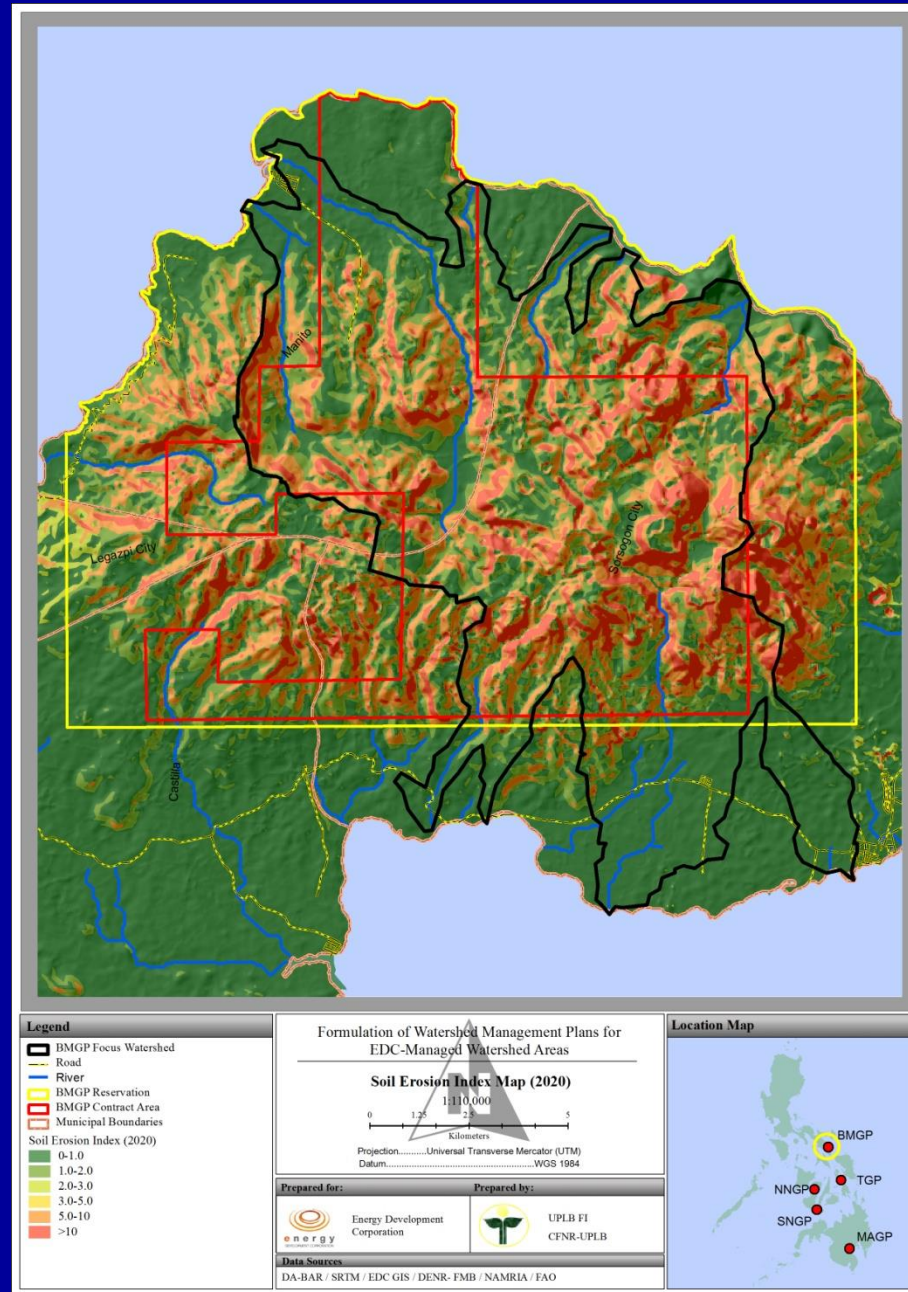


CLASSES	SOIL EROSION INDEX		
	Observed	2020	2050
0-1.0	54,677	46,581	46,581
1.0-2.0	542	8,107	8,107
2.0-3.0	2	531	531
3.0-5.0	7,204	2	2
5.0-10.0	27	7,230	7,230
>10	3,105	3,105	3,105
<i>TOTAL</i>	<i>65,556</i>	<i>65,556</i>	<i>65,556</i>

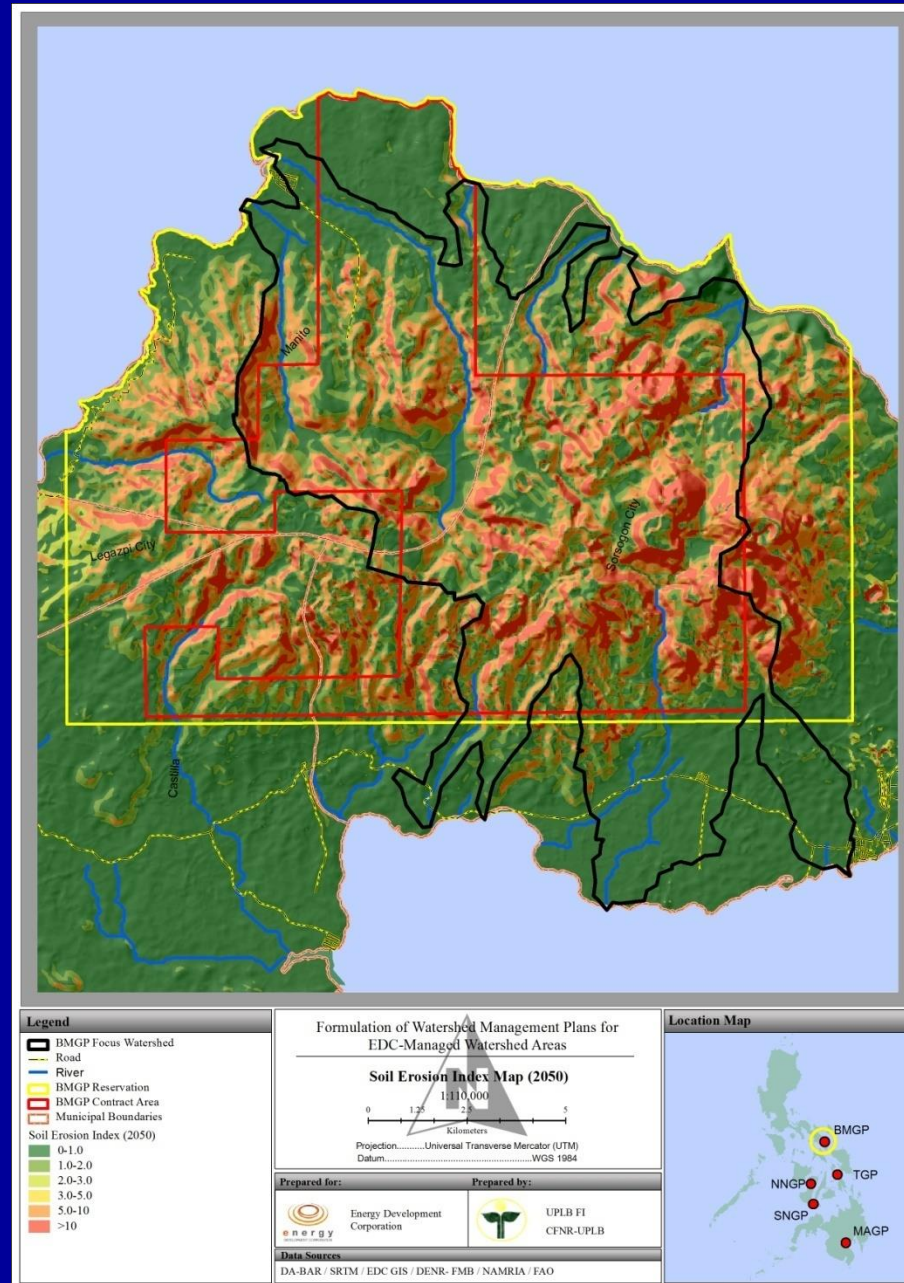
BMGP Soil Erosion Index Map (Observed)



BMGP Soil Erosion Index Map (2020)



BMGP Soil Erosion Index Map (2050)



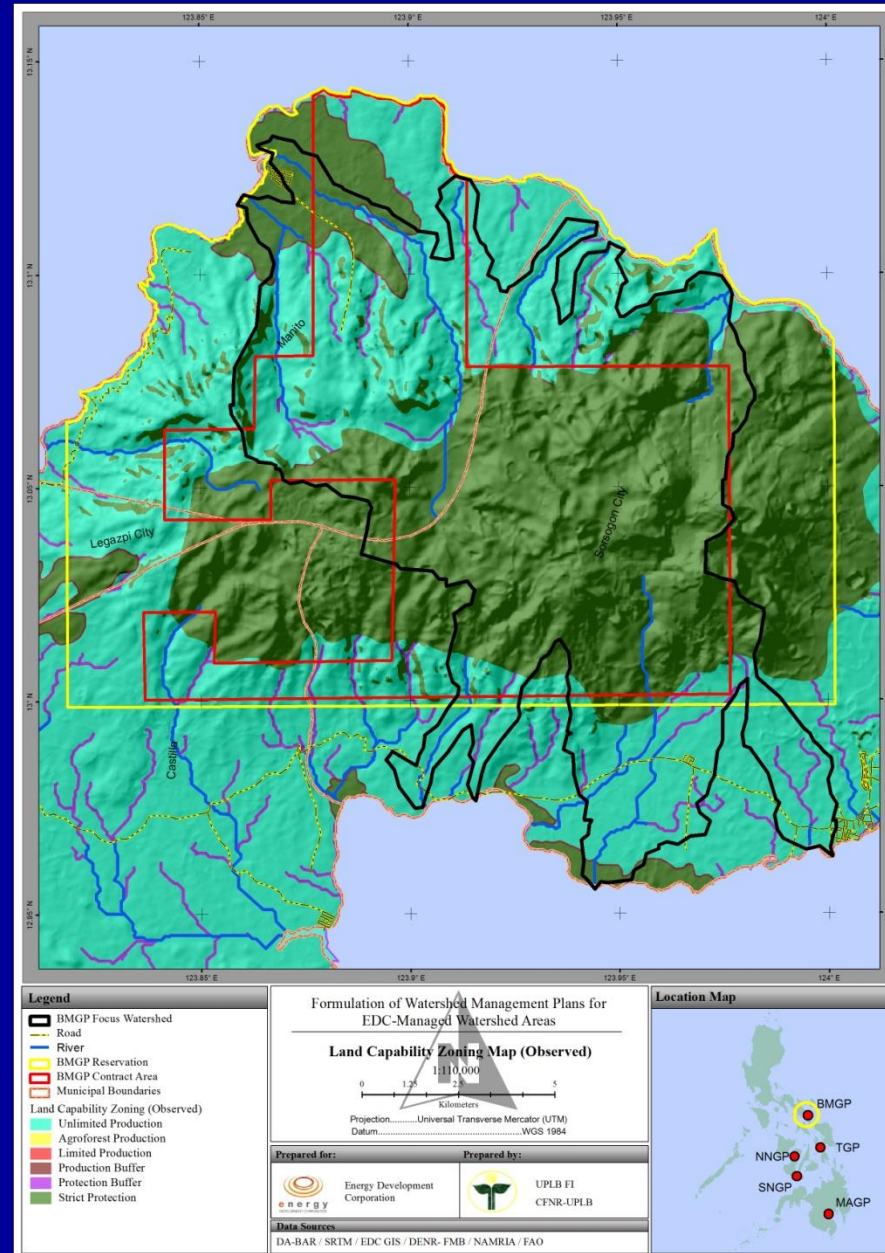
Land capability classification criteria.

Class	Land Use Zone	SEI	Indicative Land Uses
I	PROTECTION AREAS		
Ia	<i>Strict Protection</i> All remaining natural forests, all areas with high erosion potential and slope >50%, all areas (including grass and brush lands) known to support important wildlife and with high value for biodiversity conservation, all other areas with SEI > 5	>5	Strict protection, limited collection of ornamental plants, herbs, vines, fruits and other non-timber products may be allowed
Ib	<i>Protection Buffer</i> All areas within 40 m of stream banks, all areas within 50 m of major watershed divides		Permanent crops (fruit trees, bamboo), harvesting of fruits and bamboo shoots and culms will be allowed but no harvesting of trees will be allowed
II	PRODUCTION AREAS		
Ila	<i>Unlimited Production</i> Grasslands and brushlands; built up and cultivated areas	0-1	Timber and fruit tree plantations, agriculture and agroforestry can be allowed with suitable soil and water conservation measures, settlement can be allowed
IIb	<i>Agroforest Production</i> Grasslands and brushlands; built up and cultivated areas	1-3	Multistory timber and fruit tree plantations, agroforestry can be allowed with suitable soil and water conservation measures
IIc	<i>Limited Production</i> Grasslands and brushlands; built up and cultivated areas	3-5	Multistory timber and fruit tree plantations
IId	<i>Production Buffer</i> Areas within 50 m of remaining natural forest line		Permanent crops (fruit trees, bamboo) and compatible uses. Fuel wood and timber tree plantations can be allowed within 20-50 m band from the forest line

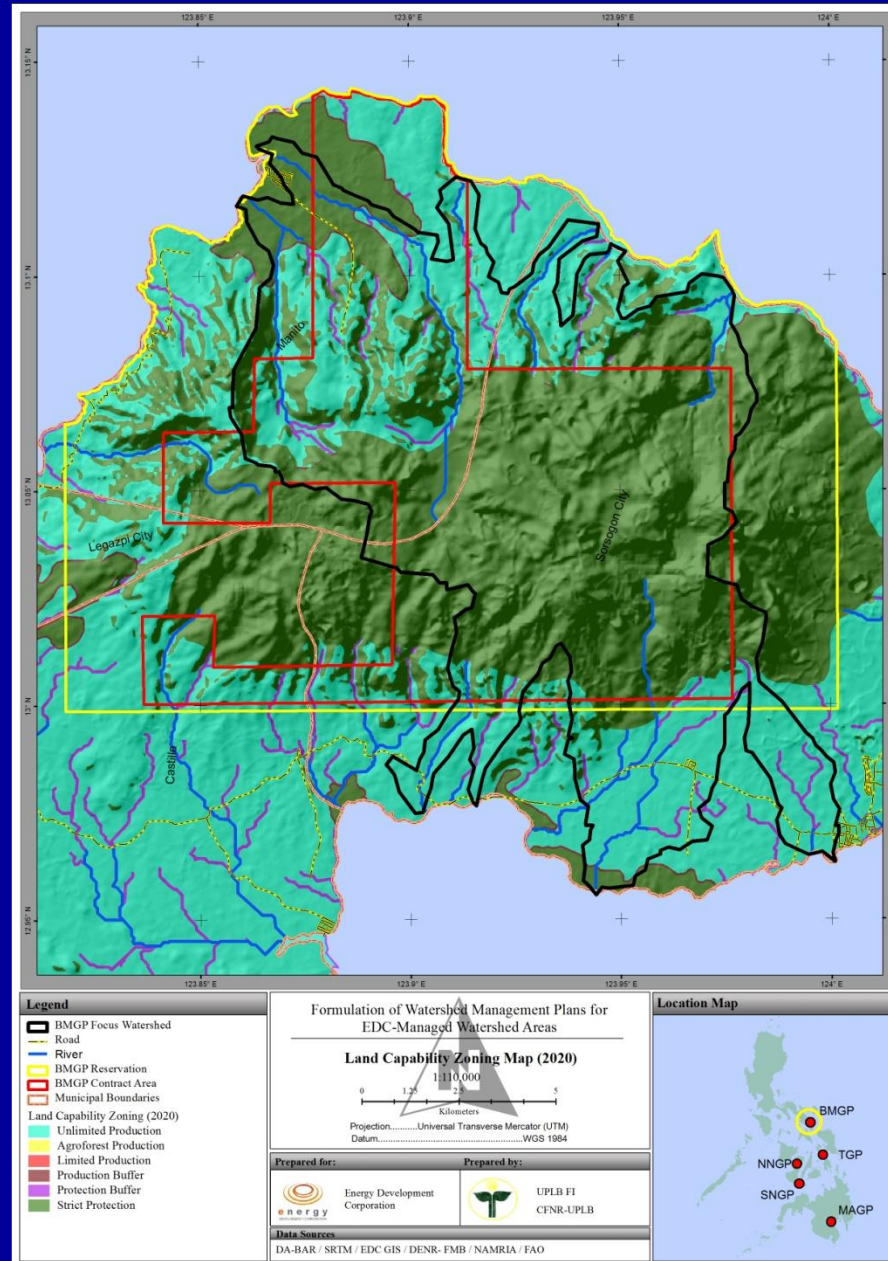
Land capability zone distribution (ha) for BMGP Watershed Reservation under various scenarios

Categories	LAND CAPABILITY ZONING		
	Observed	2020	2050
Unlimited Production	45,455	42,575	42,575
Agroforest Production	5	5	5
Limited Production	4		
Production Buffer	311	293	569
Strict Protection	15,850	18,789	18,513
Protection Buffer	3,932	3,894	3,894
<i>TOTAL</i>	<i>65,556</i>	<i>65,556</i>	<i>65,556</i>

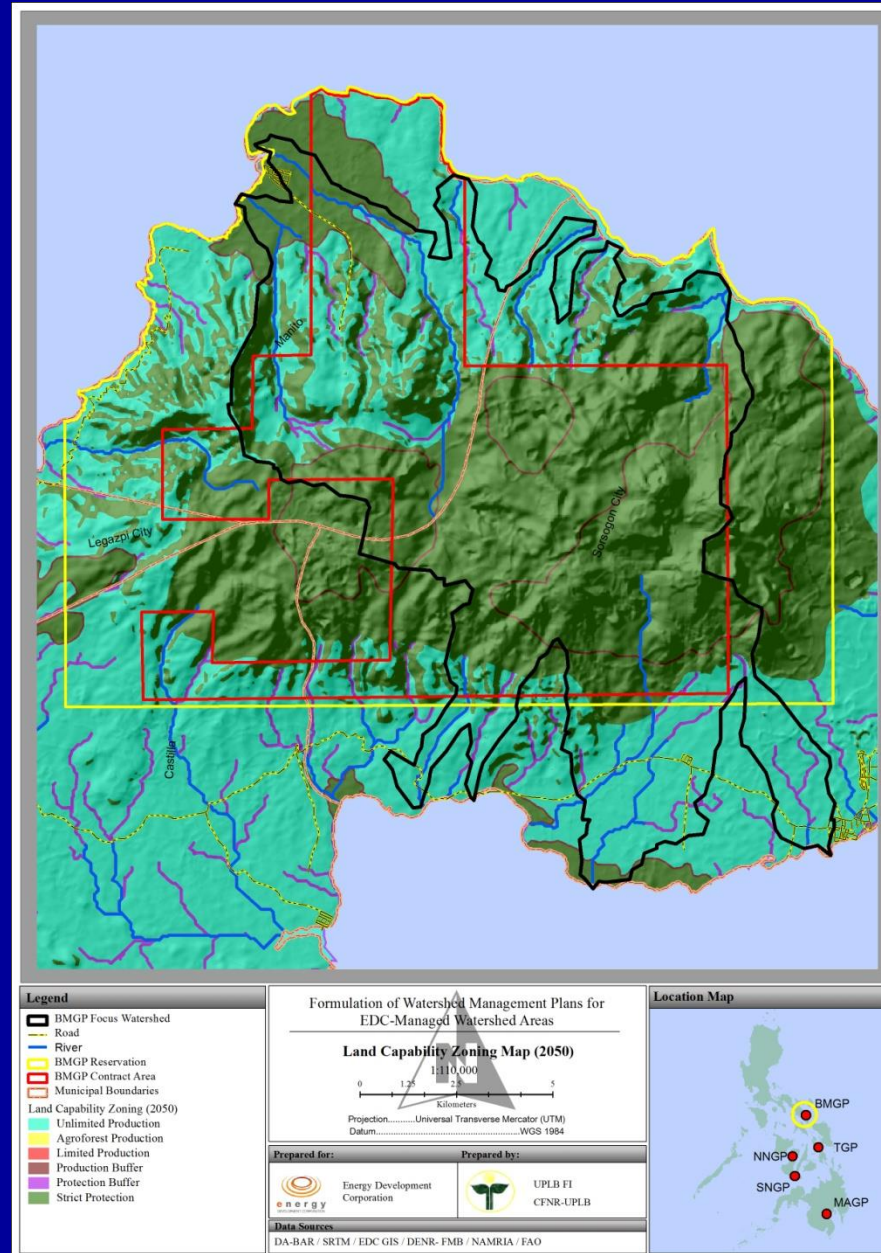
Land Capability Zoning of BMGP (Observed)



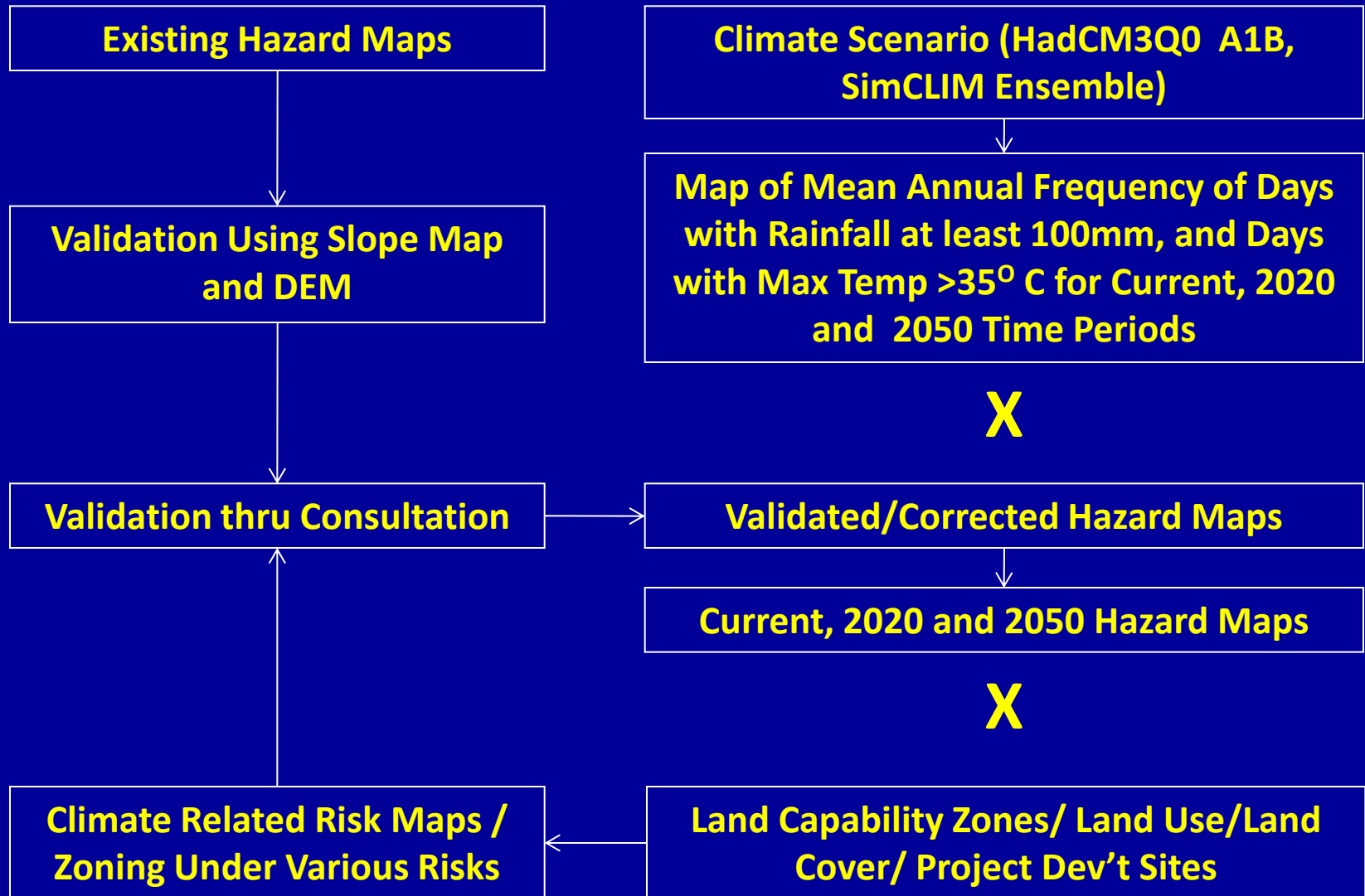
Land Capability Zoning of BMGP (2020)



Land Capability Zoning of BMGP (2050)



Framework



GCM (Climate) Models

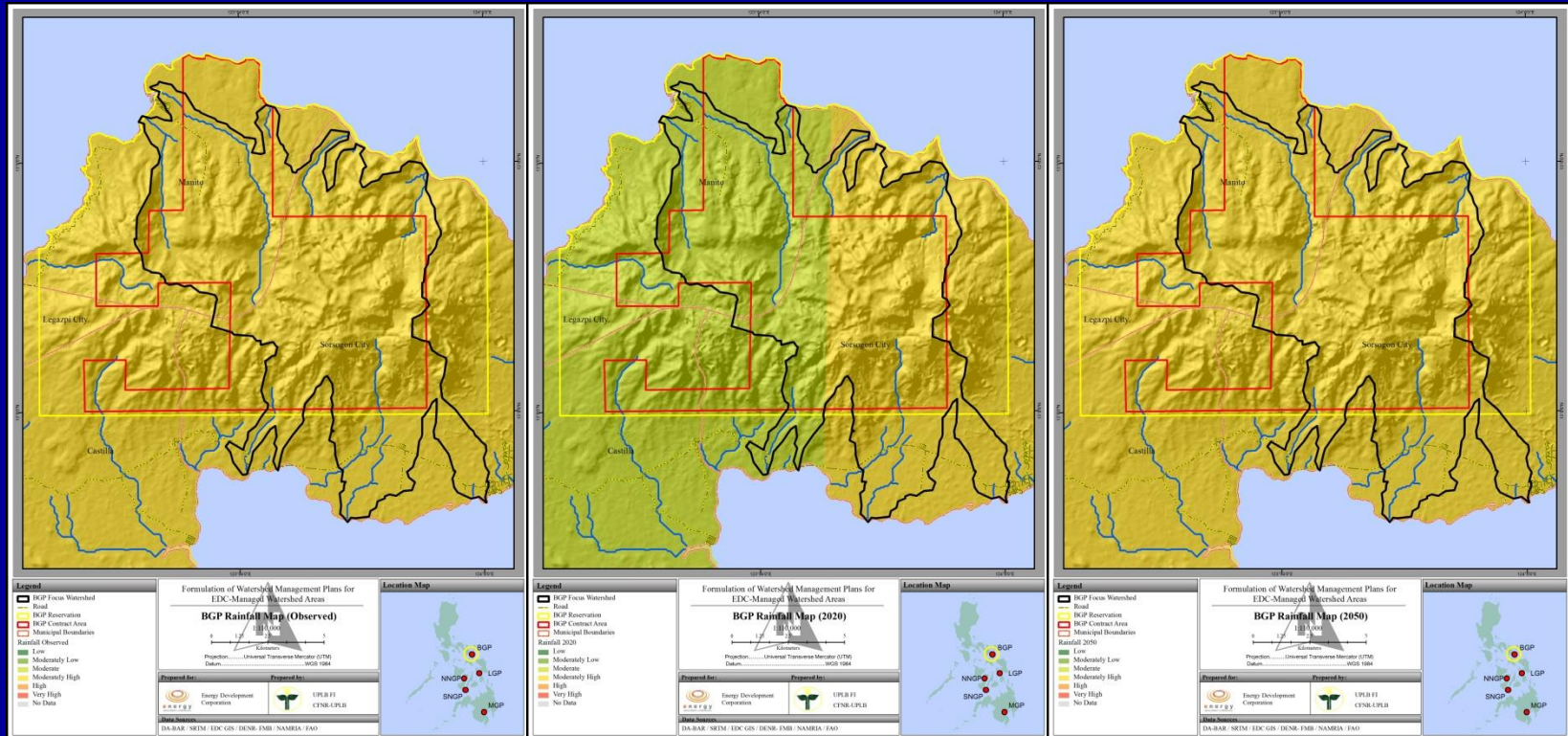
1.HadCM3Q0 A1B

2.ECHAM4 A2

Emissions Scenario

- A1: a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and rapid introduction of new and more efficient technologies
- A2: a very heterogeneous world with continuously increasing global population and regionally oriented economic growth that is more fragmented and slower than in other storylines
- B1: a convergent world with the same global population as in the A1 storyline but with rapid changes in economic structures toward a service and information economy, with reductions in materials intensity, and the introduction of clean and resource efficient technologies
- B2: a world in which the emphasis is on local solutions to economic, social, and environmental sustainability, with continuously increasing population (lower than A2) and intermediate economic development

MEAN ANNUAL FREQUENCY OF DAYS WITH RAIN OF AT LEAST 100 mm (Observed, 2020, 2050)



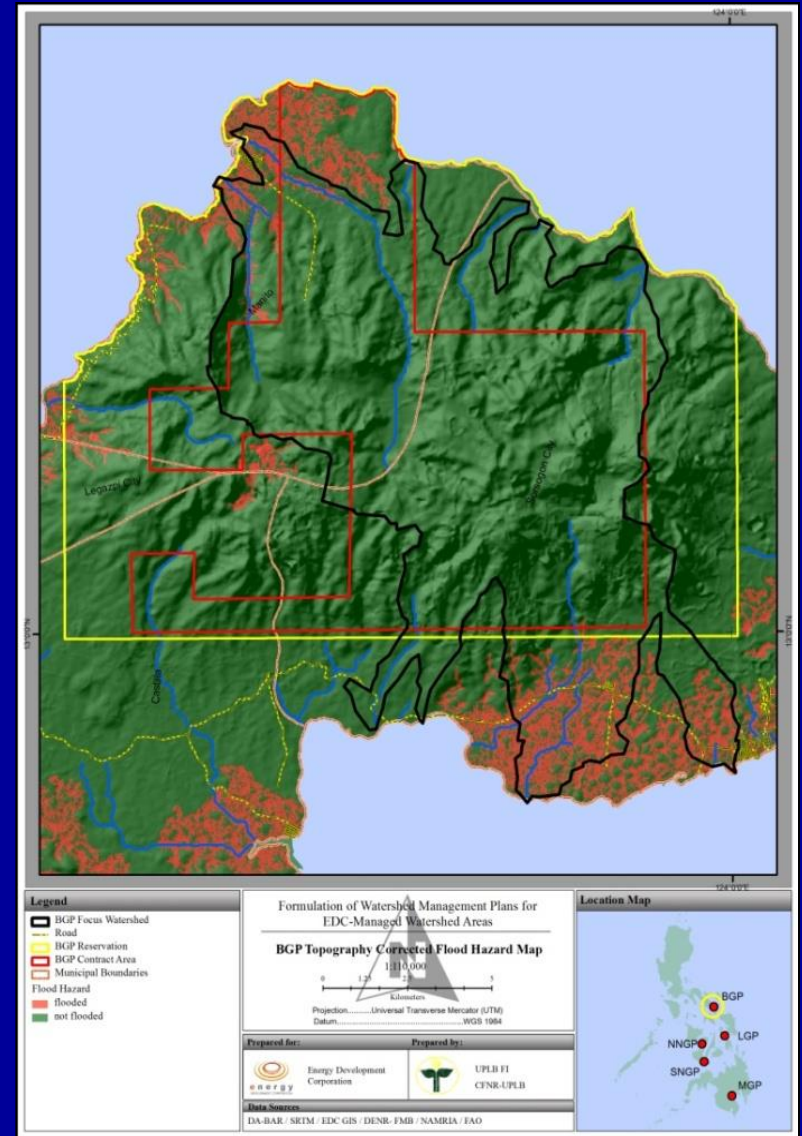
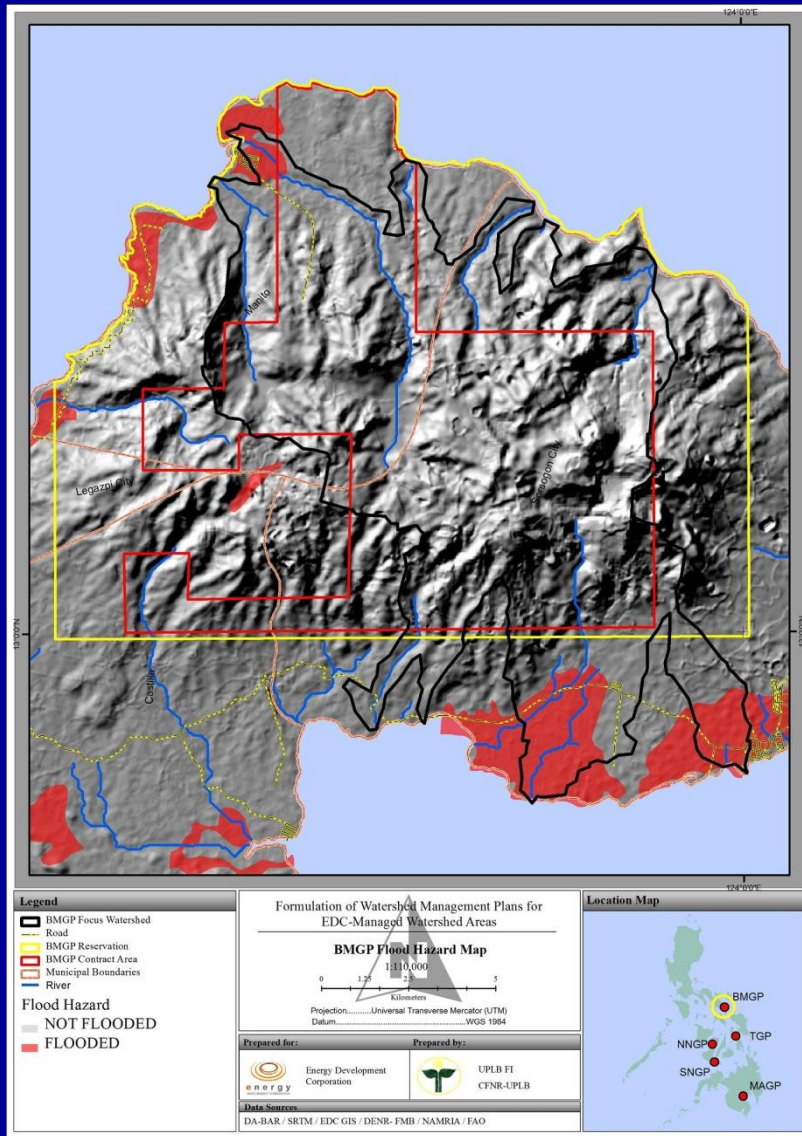
MEAN ANNUAL FREQUENCY OF DAYS WITH RAIN OF AT LEAST 100 mm (Observed, 2020, 2050)

Number of days with at least 100 mm of rain	Nominal Rating
0-1	Low
1-2	Mod Low
2-3	Mod
3-4	Mod High
4-5	High
>5	Very High

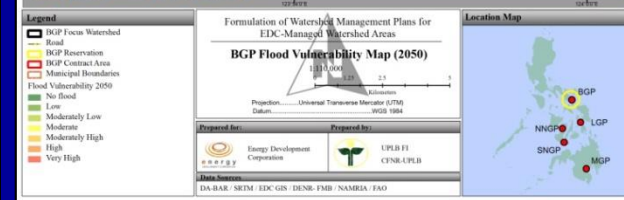
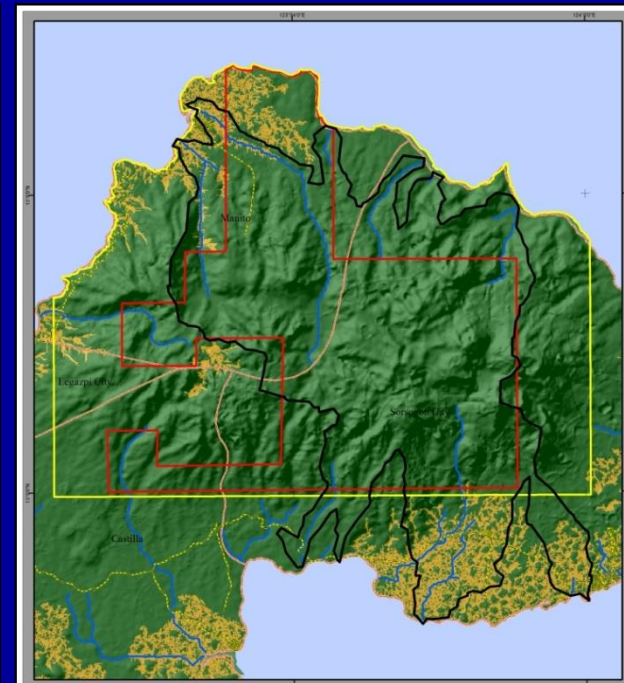
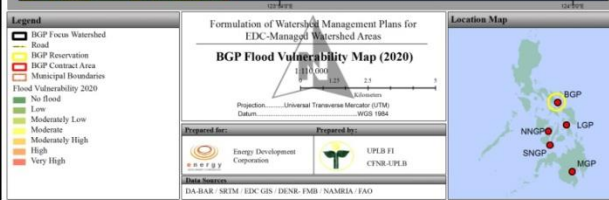
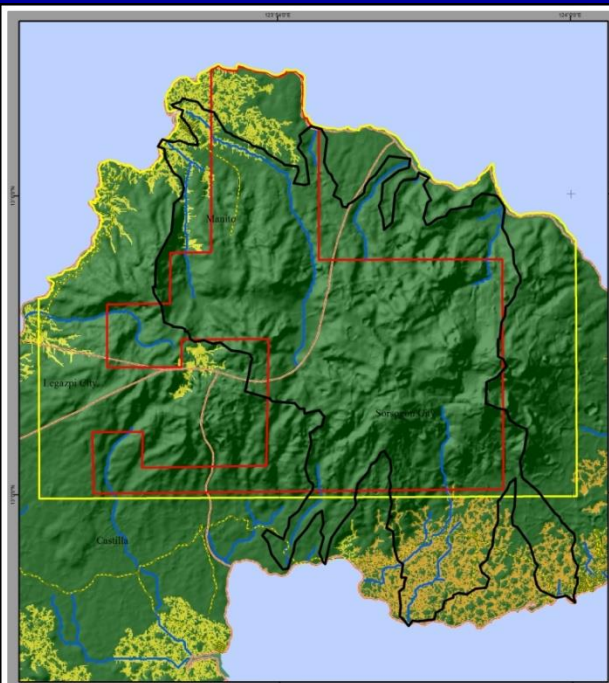
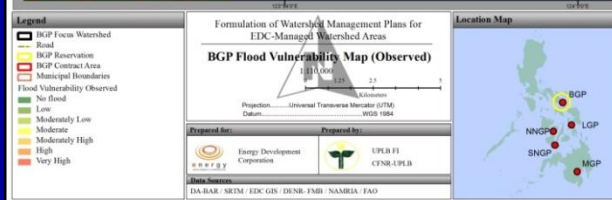
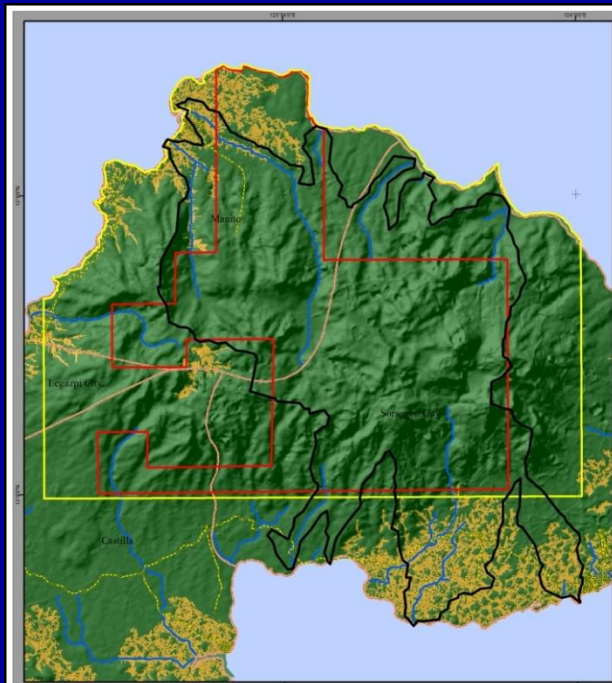
MEAN ANNUAL FREQUENCY OF DAYS WITH RAIN OF AT LEAST 100 mm (Observed, 2020, 2050)

Mean Annual Freq of Days with Rain at least 100mm (observed, 2020 and 2050)	DEM Adjusted Flood Hazard Map	
	Flooded	Not Flooded
Low	Low	None
Mod Low	Mod Low	None
Mod	Mod	None
Mod High	Mod High	None
High	High	None
Very High	Very High	None

Topography Corrected Flood Hazard Maps



Flood Hazard Map



Land Cover 2003	BMGP Flood Risk						
	Moderately Low	Moderate		Moderately High			High
	2020	2020	2050	OBS	2020	2050	2050
Close Forest, Broadleaves		6		6		6	
Cultivated, Annual		1883	1316	3083	1200	908	859
Cultivated, Perennial	35	3741	2524	5782	2005	3001	257
Fishponds				37	37		37
Grasslands		23	23	23			
Open Forest, Broadleaves		127		250	123	250	
Open Forest, Coniferous		500		500		500	
Wooded lands, grasslands		39		369	331	53	317
TOTAL	35	6319	3863	10051	3696	4718	1471

Generating Rain-Induced Landslide Maps (Observed, 2020, 2050)

DEM Adjusted Rain-induced Landslide Hazard Map	Observed Mean Annual Frequency of Daily Rainfall 100 mm and above (2020, 2050)					
	Low (=1)	Mod Low (=2)	Mod (=3)	Mod High (=4)	High (=5)	Very High (=6)
Low (=2)	2	4	6	8	10	12
Moderate (=4)	4	8	12	16	20	24
High (=6)	6	12	18	24	30	36

Generating Rain-Induced Landslide Maps (Observed, 2020, 2050)

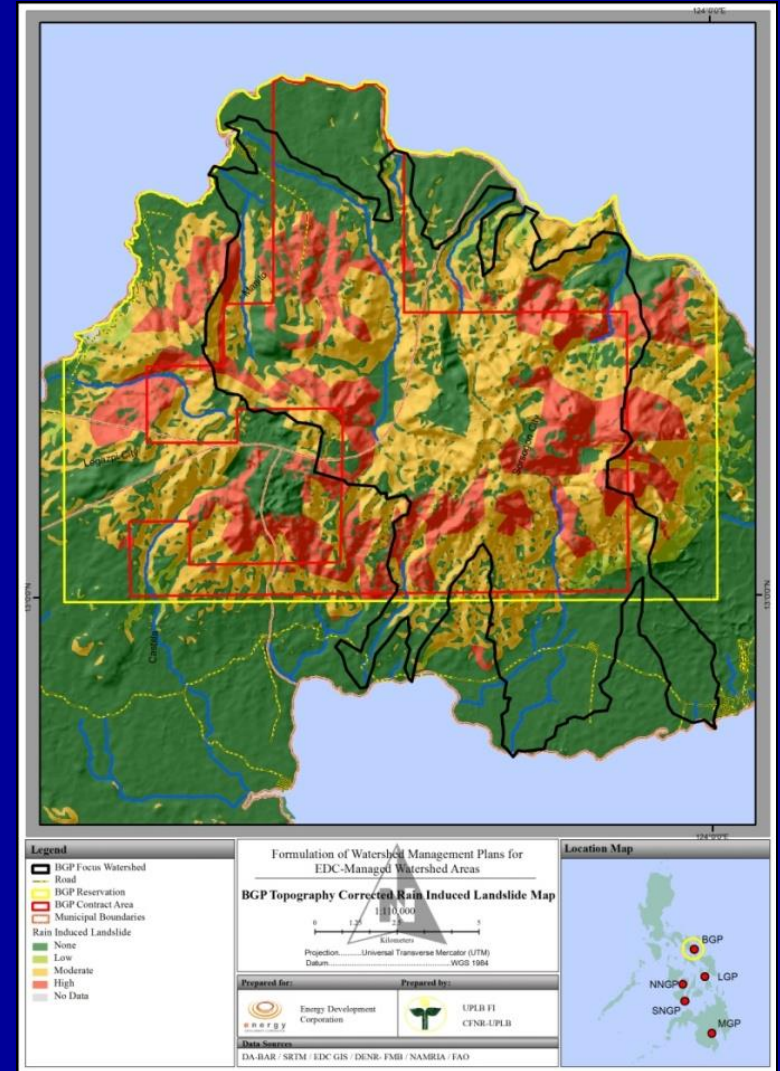
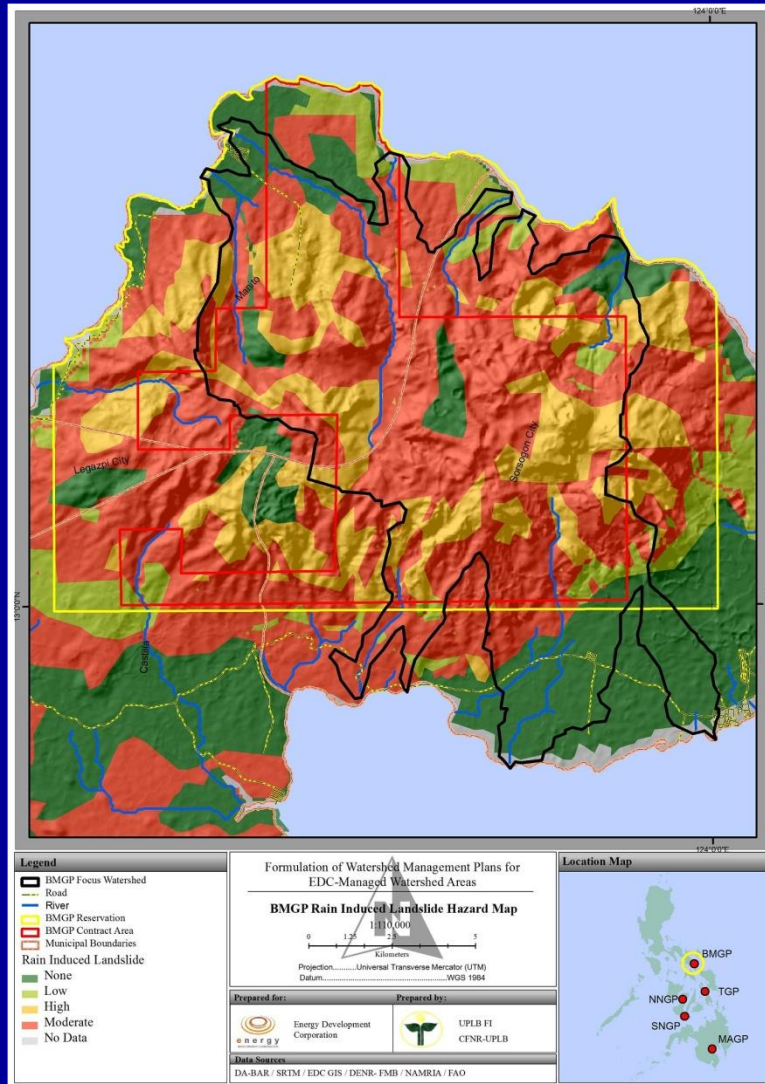
Xtabs of Corrected Existing RIL Map and Freq Map Values	Rain-Induced Landslide Hazard Level
0-6	Low
7-12	Mod Low
13-18	Mod
19-24	Mod High
25-30	High
>30	Very High

Freq – mean frequency of days with rainfall of at least 100 mm

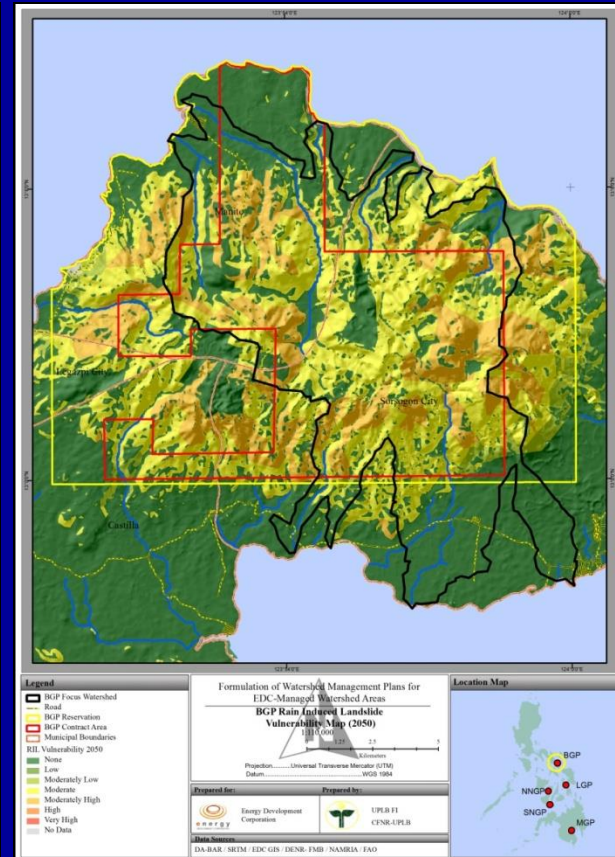
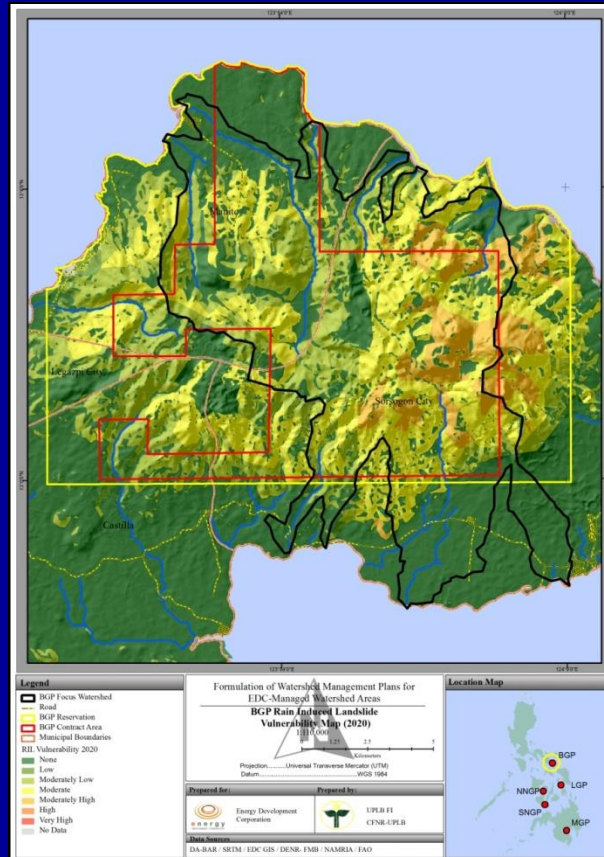
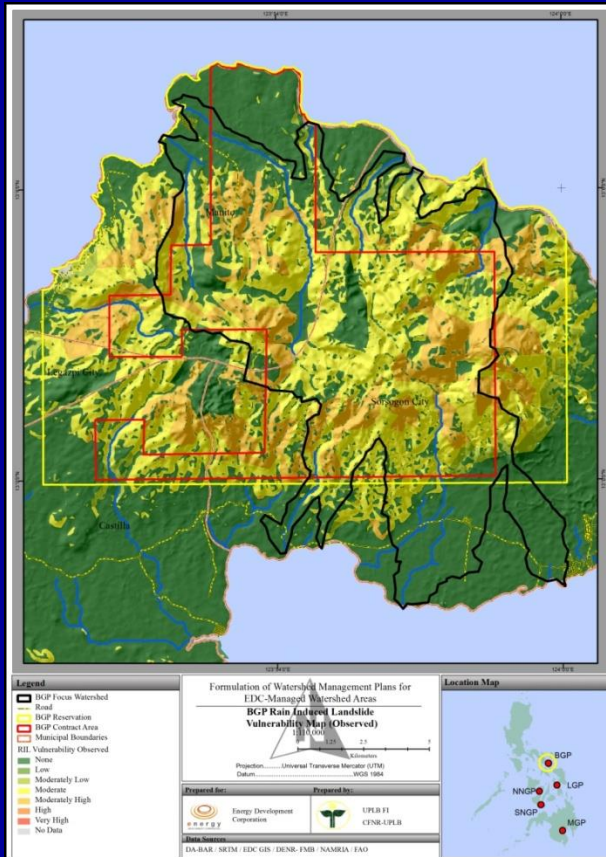
Generating Rain-Induced Landslide Maps (Observed, 2020, 2050)

DEM Adjusted Rain-induced Landslide Hazard Map	Observed Mean Annual Frequency of Daily Rainfall 100 mm and above (2020, 2050)					
	Low	Mod Low	Mod	Mod High	High	Very High
Low	Low	Low	Low	Mod Low	Mod Low	Mod Low
Moderate	Low	Mod Low	Mod Low	Mod	Mod High	Mod High
High	Low	Mod Low	Mod	Mod High	High	Very High

Topography Corrected Rain Induced Landslide



Rain Induced Landslide



Land Cover 2003	BGP Rain Induced Landslide											
	Low			Moderately Low			Moderate			Moderately High		
	OBS	2020	2050	OBS	2020	2050	OBS	2020	2050	OBS	2020	2050
Close Forest, Broadleaves					164		480	445	480	604	476	604
Cultivated, Annual		22		22	974	25	980	1108	1014	1102		1064
Cultivated, Perennial		231	3	293	1883	416	2496	1859	2560	1212	28	1022
Fishponds												
Grasslands		0	0	0	2	2	2					
Open Forest, Broadleaves					2		2		2			
Open Forest, Coniferous		4		23	241	23	1506	1691	1506	1629	1222	1629
Wooded lands, grasslands		80		669	3504	669	4891	2844	4891	1374	507	1374
TOTAL	0	337	3	1007	6770	1136	10357	7946	10453	5921	2231	5693

Project Development	BMGPRain-Induced Landslide Risk										
	Observed			2020				2050			
	Mod Low	Mod	Mod High	Low	Mod Low	Mod	Mod High	Low	Mod Low	Mod	Mod High
Access Road		0.6			0.6					0.6	
ADMIN COMPLEX		3.3			3.3					3.3	
BOTONG CONTROL CENTER			0.1				0.1				0.1
BOTONG PIPELINE	0.0	0.0	0.1		0.0	0.0	0.1		0.0	0.0	0.1
BOTONG POWER PLANT		1.1				1.1				1.1	
BOTONG ROAD		0.0	0.2			0.0	0.2			0.0	0.2
BOTONG THERMAL POND			0.3				0.3				0.3
BRIDGE		0.0			0.0	0.0				0.0	
BRINE-DISPOSAL		0.0				0.0				0.0	
CANAL		0.0				0.0				0.0	
CAWAYAN CONTROL CENTER		0.1				0.1				0.1	
CAWAYAN MUFFLER		0.0				0.0				0.0	
CAWAYAN PIPELINE		0.0				0.0				0.0	
CAWAYAN PPLANT		1.1				1.1				1.1	
CAWAYAN SEPARATOR											
CAWAYAN THERMAL POND		0.5				0.5				0.5	
CONTROL CENTER Municipality											
No Data	1014.4	10417.8	5930.5	338.1	6784.9	8009.0	2230.8	2.9	1146.8	10512.2	5700.8
OPTION2		0.6				0.6				0.6	
OPTION3		1.4				1.4				1.4	
PIPELINE		0.0				0.0				0.0	
pnoc-edc		2.3			2.3					2.3	
POWER PLANT		0.0				0.0				0.0	
SepVessels		0.0				0.0				0.0	
THERMAL POND		0.4			0.2	0.2				0.4	
TN		0.0				0.0				0.0	
TP		0.2				0.2				0.2	
WELLHEAD		0.0				0.0				0.0	
TOTAL	1014.4	10429.5	5931.2	338.1	6791.3	8014.3	2231.4	2.9	1146.8	10523.8	5701.5

MEAN ANNUAL FREQUENCY OF DAYS WITH RAIN OF AT LEAST 100 mm (Observed, 2020, 2050)

Probability of days with max temp >35°C	Nominal Rating
0-0.1	Low
0.1-0.2	Mod Low
0.2-0.3	Mod
0.3-0.4	Mod High
0.4-0.5	High
> 0.5	Very High

Generating Drought Hazard Maps for Observed, 2020 and 2050 Time Periods

Validated Drought Hazard Map	Mean Frequency of Daily Maximum Temperature >35°C (Observed, 2020, 2050)					
	Low (=1)	Mod Low (=2)	Mod (=3)	Mod High (=4)	High (=5)	Very High (=6)
Low (=2)	2	4	6	8	10	12
Moderate (=4)	4	8	12	16	20	24
High (=6)	6	12	18	24	30	36

Generating Drought Hazard Maps for Observed, 2020 and 2050 Time Periods

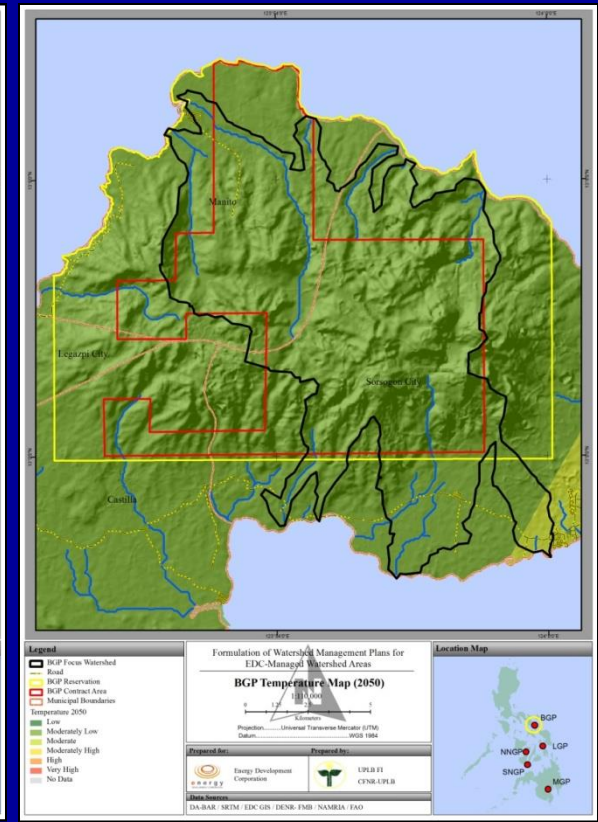
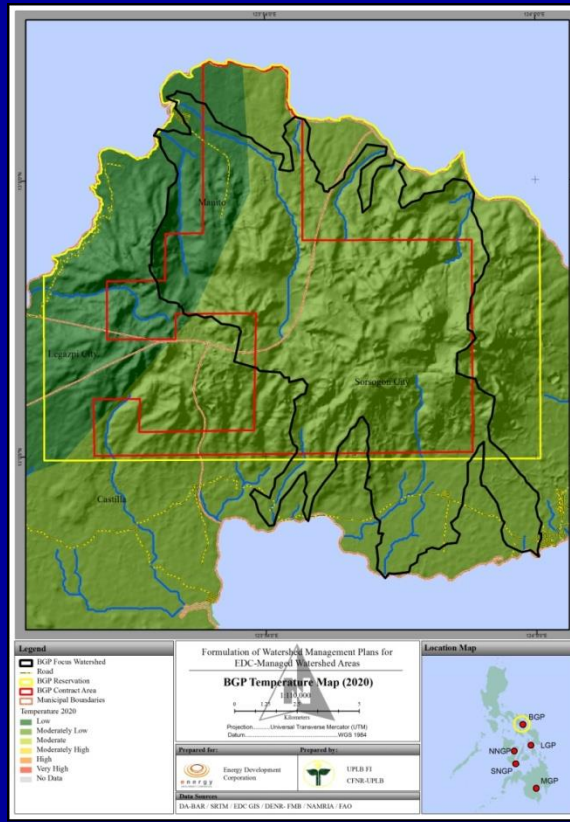
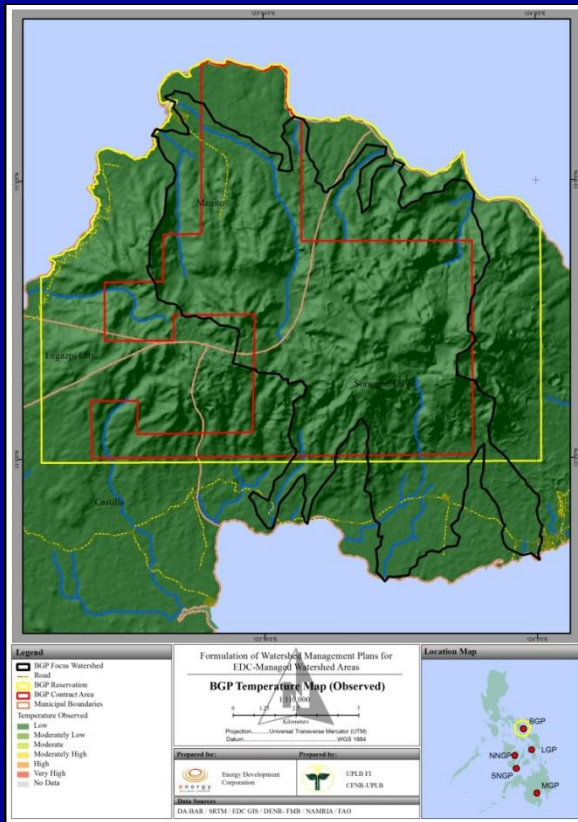
Product of Validated Existing Drought Map and Freq Map	Nominal Rating
0-6	Low
7-12	Mod Low
13-18	Mod
19-24	Mod High
25-30	High
>30	Very High

NOTE: Freq – mean frequency of daily maximum temperature
>35°C

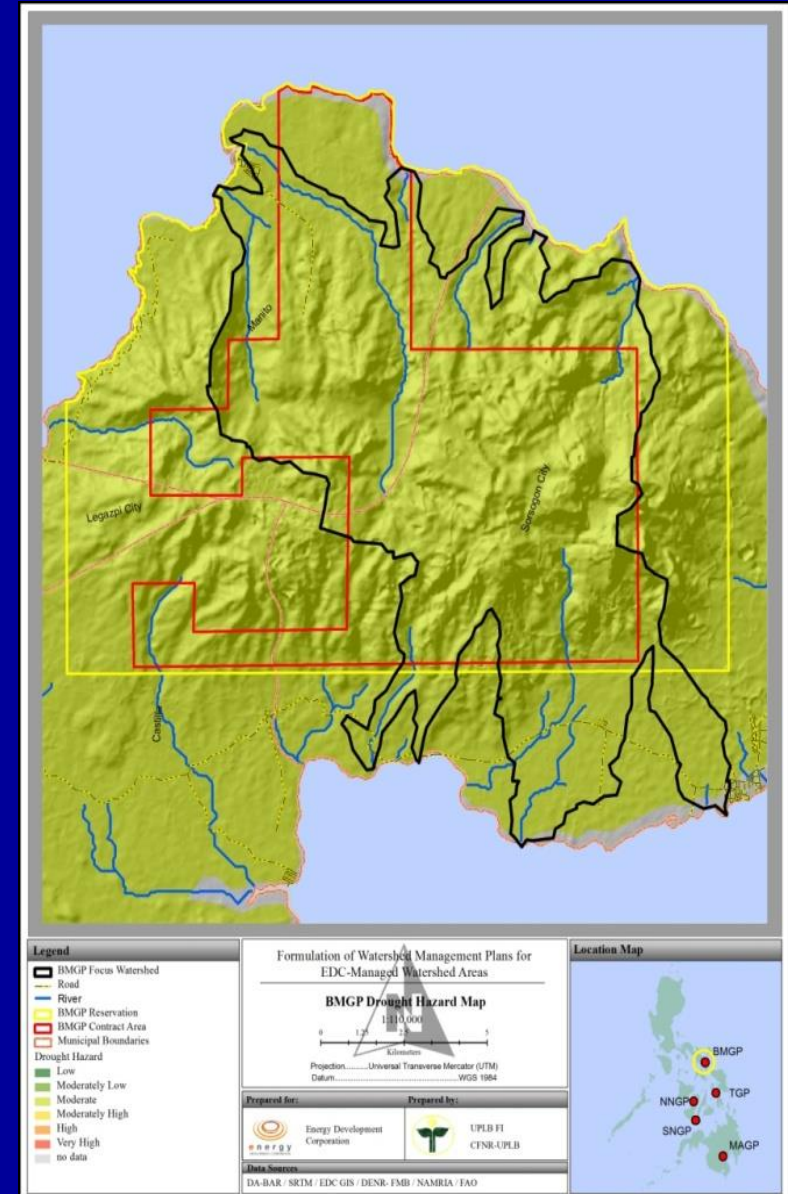
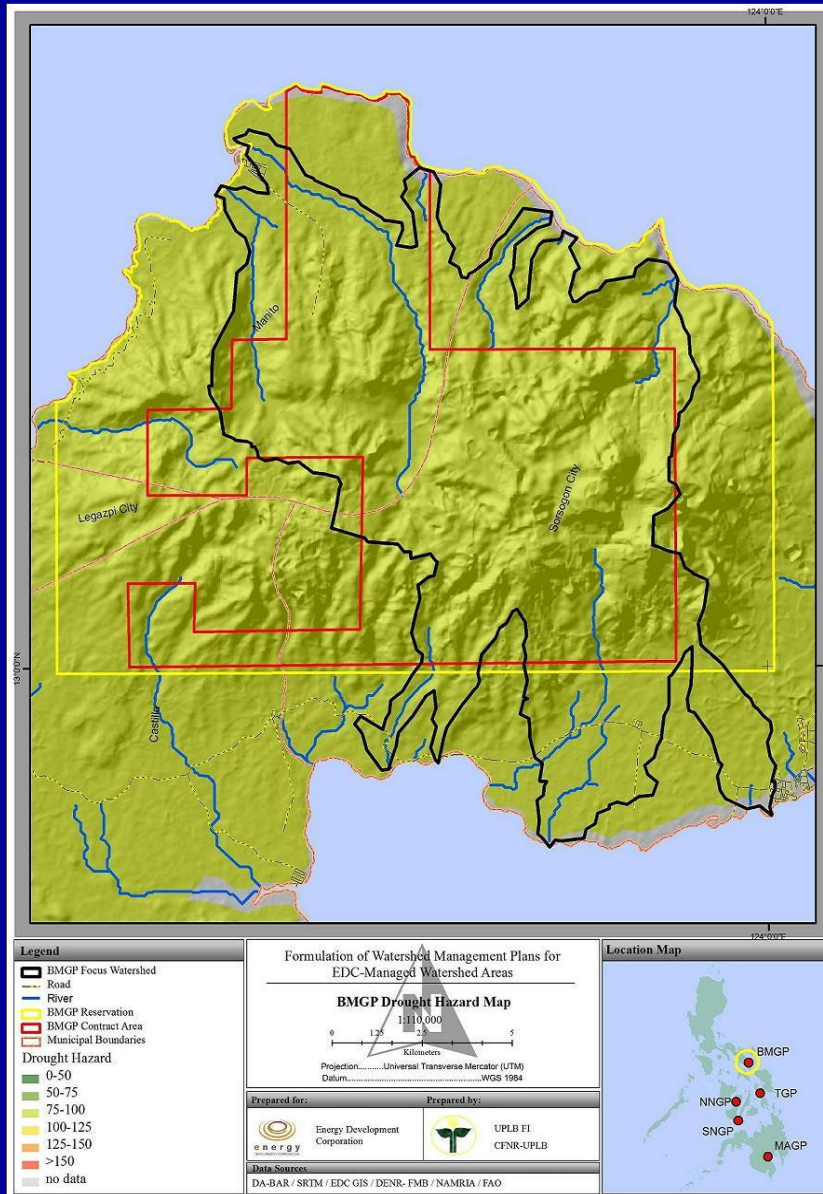
Generating Drought Hazard Maps for Observed, 2020 and 2050 Time Periods

Validated Drought Hazard Map	Mean Frequency of Daily Maximum Temperature >35°C (Observed, 2020, 2050)					
	Low	Mod Low	Mod	Mod High	High	Very High
Low	Low	Low	Low	Mod Low	Mod Low	Mod Low
Moderate	Low	Mod Low	Mod Low	Mod	Mod High	Mod High
High	Low	Mod Low	Mod	Mod High	High	Very High

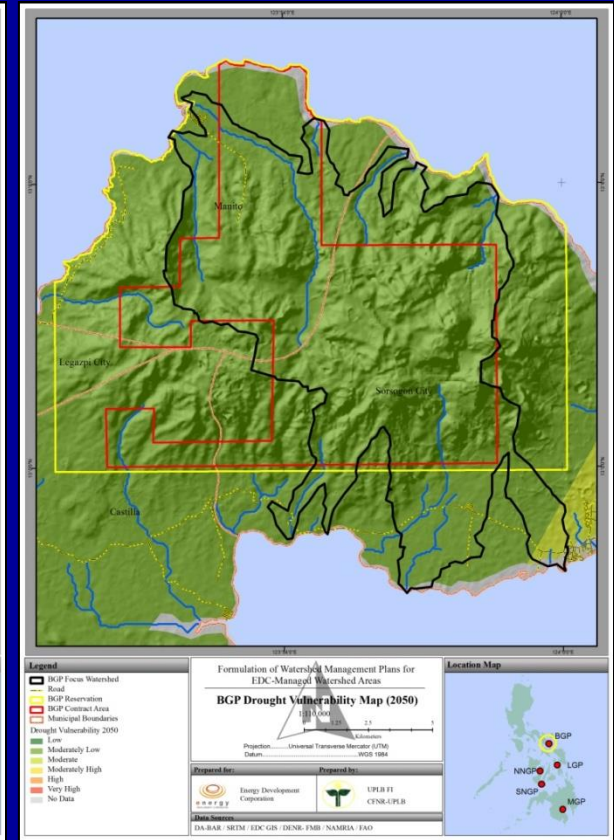
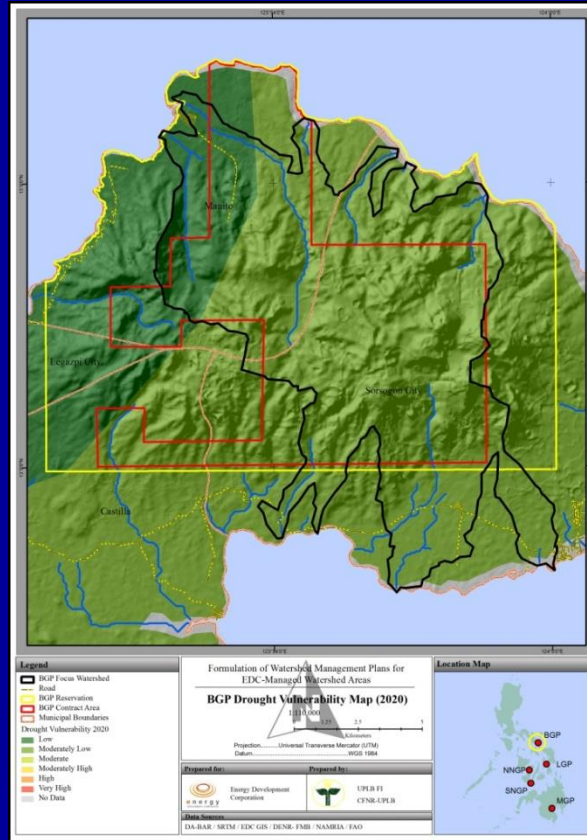
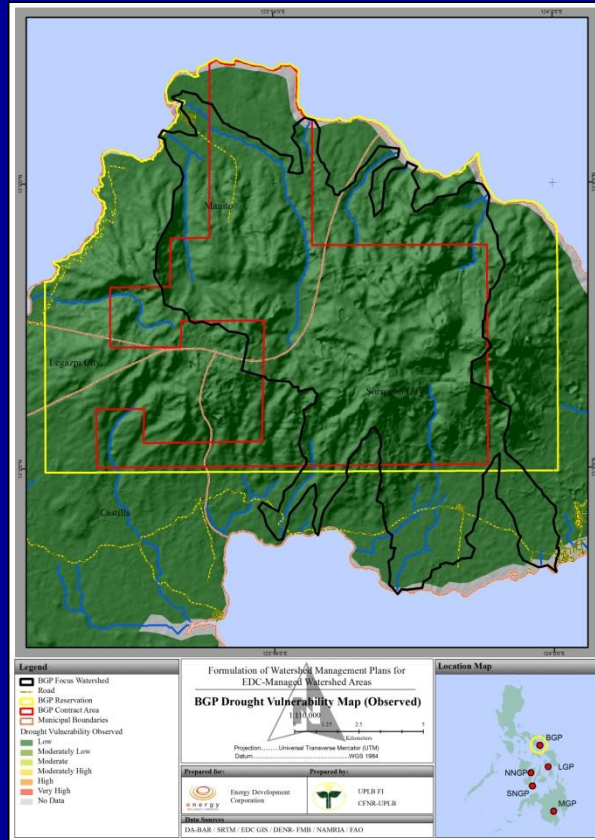
Mean Frequency of Daily Max Temp Maps (Observed, 2020,2050)



Validated Drought Hazard Maps



Drought Hazard Maps (Observed, 2020, 2050)



Land Cover 2003	BMGP Drought Risk								
	Low			Moderately Low			Moderate		
	OBS	2020	2050	OBS	2020	2050	OBS	2020	2050
Close Forest, Broadleaves	1359				1359	1359			
Cultivated, Annual	12215	4209			8007	9663			2552
Cultivated, Perennial	30967	10661			20306	29621			1346
Fishponds	117				117				117
Grasslands	350	350				350			
Open Forest, Broadleaves	403	197			206	403			
Open Forest, Coniferous	5859	1606			4253	5859			
Wooded lands, grasslands	10255	1177			9078	9704			551
TOTAL	61526	18200	0	0	43326	56960	0	0	4567

Project Development	BMGP Drought Risk				
	Observed	2020		2050	
	Low	Low	Mod Low	Mod Low	Mod
Access Road	0.9		0.9	0.9	
ADMIN COMPLEX	5.1		5.1	5.1	
BOTONG CONTROL CENTER	0.1		0.1	0.1	
BOTONG PIPELINE	0.1		0.1	0.1	
BOTONG POWER PLANT	1.1		1.1	1.1	
BOTONG ROAD	0.2		0.2	0.2	
BOTONG THERMAL POND	0.3		0.3	0.3	
BRIDGE	0.0		0.0	0.0	
BRINE-DISPOSAL	0.0		0.0	0.0	
CANAL	0.1		0.1	0.1	
CAWAYAN CONTROL CENTER	0.1		0.1	0.1	
CAWAYAN MUFFLER	0.0		0.0	0.0	
CAWAYAN PIPELINE	0.0		0.0	0.0	
CAWAYAN PPLANT	1.1		1.1	1.1	
CAWAYAN SEPARATOR	0.0		0.0	0.0	
CAWAYAN THERMAL POND	0.5		0.5	0.5	
CONTROL CENTER	0.3		0.3	0.3	
Municipality	42.8	21.0	21.8	27.9	14.9
No Data	63218.7	18831.9	44386.9	58135.2	5083.5
OPTION2	0.6		0.6	0.6	
OPTION3	1.5		1.5	1.5	
PIPELINE	0.0		0.0	0.0	
pnoc-edc	2.7		2.7	2.7	
POWER PLANT	0.9		0.9	0.9	
SenVessels	0.0		0.0	0.0	