International Journal of Computing Sciences Research (ISSN print: 2546-0552; ISSN online: 2546-115X)
Vol. 5, No. 1, pp. 613-628
doi: 10.25147/ijcsr.2017.001.1.62
https://stepacademic.net

Dataset in Focus

Risk Reality Geospatial Information Modeling: An Application in Lupi, Camarines Sur, Philippines

Ana Marie R. Abante
BUCENG, Bicol University, Philippines
anamarie.abante@bicol-u.edu.ph
(corresponding author)

Date received: September 20, 2020
Date received in revised form: December 7, 2020
Date accepted: December 13, 2020

Recommended citation:

Abante, A. M. R. (2021).Risk reality geospatial information modeling: An Application in Lupi, Camarines Sur, Philippines. *International Journal of Computing Sciences Research*, 5(1), 613-628.doi:10.25147/ijcsr.2017.001.1.62

Abstract

Purpose– This study sought to locate and visualize the land use constrained relative to its calamities and disaster risk reality in Lupi, Camarines Sur by developing a risk reality geospatial information model that constitutes the level of significance that signifies the consequences of natural calamities or man-made hazards an important point that local government units cannot afford to ignore.

Method – The Risk Reality Geospatial Information Model applied the hexagonal binning technique (Abante, 2020a; Abante, 2020b) and the Abante's Risk Reality Isosceles Triangle (ARRIT)with angle alpha 36°based on Schoen Golden Triangle which represents the risk-neutral stance equal to one unit was used to study the important factor that shaped the state of balance or stability where one asymptotic segment on receptiveness with an opposite angle of 72° which signifies the prevention, mitigation, and preparedness and the other is responsiveness which response and recovery stages of DRRM (Abante, 2020a, 2020b; Oksanen, 2013; Oat, Barczak & Shopf, 2008). The hexagonal binning technique leads to complexities in quantifying risk hotspots and coldspots (Abante, 2020a, 2020b; Gold, 2016; Oksanen, 2013; Oat et al., 2008; Worboys & Duckham, 2004; Getis & Getis, 1966). It is regarded as storing weighted values ranging from 1 which is the lowest to 5 which pertains to the highest value (Abante, 2020a, 2020b). The weights may be influenced by hazard return periods or proximity to the critical condition of the landscapes or seascapes that are highly prone or regularly impacted by hazards (Abante, 2020a, 2020b). The Binning Parameters following data binning parameters were created and applied to study variations of the six elements of risk reality (Abante, 2020a, 2020b).

Results –This study disclosed the risk hotspots in Lupi that are reckoned in the stability line (base) of an ARRIT that was based on Schoen's theory of the golden triangle and Fibonacci's golden ratio as it orbits the golden spiral (Abante, 2020a, 2020b). The risk-neutral stance represents the balance between receptive and responsive DRRM measured by the resulting z-scores derived from data on hazards, vulnerability, exposure, and capability (Abante, 2020a, 2020b). The capability in this study constitutes the preparedness in terms of land development, utilization, and base zones. (Abante, 2020a, 2020b) TheRisk Reality Geospatial Information Model for Lupi proved that visualization of land use constraints relative to base zones where restructuring of DRRM actions are needed to attain physical and environmental balance (Abante, 2020a, 2020b; Abante & Abante, 2019; Abante & Abante, 2018;Barua&Ansary, 2020).

Conclusion – The author concluded that an informed local government is prepared although it seems long term to achieve it but desire to make real progress towards risk reduction. It is also concluded that the model can mimic the municipality's risk reality extremes that need to be avoided and knowing it is something that matters to guide and control land use and local development to achieve physical and environmental balance. The DRRM cycle urges the LGUs to make land-use allocations free if not reduced risk through prevention, mitigation, and preparedness.

Recommendations – The author proposed to further apply hexagonal data mining techniques ideal for cities and municipalities to dig deep into the land utilization free from risk if not reduced risk through proper zoning the best-highest-land use(Abante, 2020a, 2020b;Abante& Abante, 2019; Abante & Abante, 2018; Fischel, 2000).Furthermore, a fine-tuned DRRM backed by an approved land use plan and zoning ordinance can be workable through continuous monitoring and evaluating the risk hotspot areas and areas with land development constraints to attain and sustain local development growth in cities and municipalities.

Keywords – hexagonal bin, risk hotspot, coldspot, risk reality quantity

---

Background of Risk Reality and Land Use Constraints Spatial Dataset

According to the World Bank, the Philippines is the third most disaster-prone country in the world and there is low uptake of research and analytic thinking to inform local decision-making on disaster risk management. Disaster risk is a function and result of combining hazards, vulnerability, exposure, and capability to withstand the negative consequences of the increase in temperature, susceptibility to landslide, flood, and other hazard events that will continue to happenagain and again affecting the natural resources of Lupi.All barangays in Lupi are generally agricultural lands with ample inland waterbodies that serve as natural water sources for farming. The Polantuna River interconnected with Solong-Colacling River and Bahi River as well as various streams or creeks is all part of the Libmanan-PolantunaWatershed which drains rainwaters in the Bicol River estuary in Naga City (Guiang, 2013).The increase in temperature relatively influences tropical cyclones which convey damages in crops, livestock, fisheries, and other agriculturally based products of Lupi (Lirag& Estrella, 2017).Low production gives rise to poverty and crime rates because of low income and food shortages. Damage trees may trigger soil erosion or landslides in steep and unstable slope areas as well as riverbanks. Based on the Nationwide Operational Assessment of Hazards (NOAH), the steep and unstable slopes, and riverbanks, and legal easements are categorized as no dwelling zones. Development can only allow a somewhat unstable slope area (moderately unsuitable) only if slope protections and interventions, and continued monitoring is in place because such areas are likely to collapse during heavy rainfall or strong earthquakes. According to the NOAH Project, the fan-shaped landforms most likely to experience flood and debris flow are also a no-build zone. Alluvial fans are also considered a natural hazard. The people and infrastructure are likely exposed to danger when their locations x and y coincides with the no-build zones, riverbanks, and legal easements or areas highly susceptible to natural hazards that are hydrological and geological in origin.

Risk reality and trends are important points that we cannot afford to ignore. (Abante, 2020a, 2020b) The impact of climate changes and upheavals needs to be explained in terms of reviewing risk hotspots and coldspots information that is reckoned in a balanced state or stability (Abante, 2020a, 2020b). Drawing where the stability line signifies an upcoming period of risk reality to re-examine the vertex of the resiliency of an Abante's Risk Reality Isosceles Triangle (ARRIT) that was based on Schoen's theory of golden triangle and Fibonacci's golden ratio as it orbits the golden spiral. The ARRIT constitutes a base segment with angle alpha 36° represents the risk-neutral stance equal to one unit as an important factor that we need to realize to achieve the state of balance of stability where one asymptotic segment on receptiveness with an opposite angle of 72° which signifies the prevention, mitigation, and preparedness and the other is responsiveness which response and recovery stages of DRRM (Abante, 2020a, 2020b). The risk-neutral stance equal to one unit represents the balance between receptive and responsive DRRM (Abante, 2020a, 2020b). Risk abstinence or coldspot is likely where there is a balance between receptiveness and responsiveness in risk governance by quantifying the risk reality to discover what is trending based on lessons we learned in past calamities and disasters (Abante, 2020a, 2020b).

The Municipality of Lupi, Camarines Sur is part of the Libmanan-Polantuna watershed often affected by flooding in Poblacion, Colacling, Bagangay Sr, Bagong SIkat, Bangon, Barerra Jr, Bel Cruz, Buenawerte, Bulawan Sr, Cristorey, Napolidan, Polantuna, San Isidro, San Jose, San Pedro, San Ramon, and Tapi. (Guiang, 2013). A flood can damage properties, bring health risks, low productivity, drowning incidents, increase poverty, and so on. According to geohazard maps published by the national government, all barangays are susceptible to earthquake-induced landslides. Similarly, based on Mines Bureau Geosciences, Department of Environment and Natural Resources geohazard maps, Lupi is rain-induced landslide susceptible specifically in Poblacion, Bangon, Barerra Jr, Barerra Sr, Bel Cruz, Belwang, Cristo Rey, Del Carmen, Haguimit, Hahluban, Lourdes, Polantuna, San Jose, San Rafael Norte, San Ramon, San Vicente, and Tible. Also, rain-induced landslides can bring damages to farm-to-market roads interconnecting Lupi to Sipocot, Del Gallego, and Libmanan which can displace students and the working force. Likewise, all barangays in Lupi are likely prone to earthquake-induced landslides and ground shaking.

Results of Spatial Data Analysis

Risk Reality Geospatial Information Model (RIM) offers visualization on where restructuringDRRM actions and land development are needed to attain physical and environmental balance (Abante, 2020a, 2020b; Paladin et al.,2014). The RRGIM mimicked the risk reality extremes derived from the risk elements: multiple hazards, landscape vulnerability, exposure, and capability measured in terms of base zones that signifies the preparedness that hinted at the collective capability of the Local Government of Lupi. The Abante hexagonal binning technique was used to store and sort the information on the elements of risk needed to estimate the risk using the formula R = HVE/C(Abante, 2020a, 2020b; Abante & Abante, 2019; Abante & Abante, 2018).

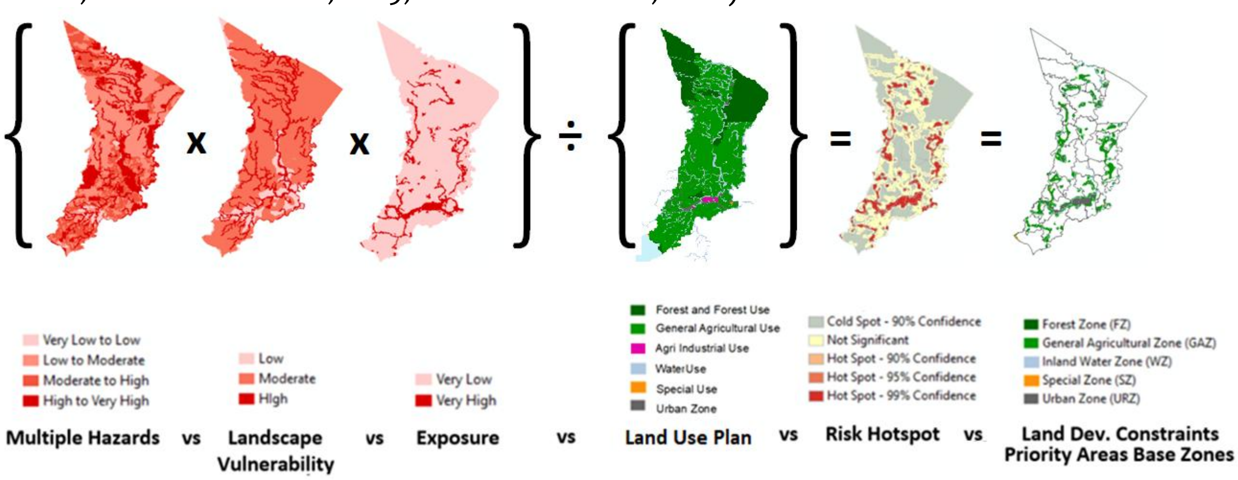
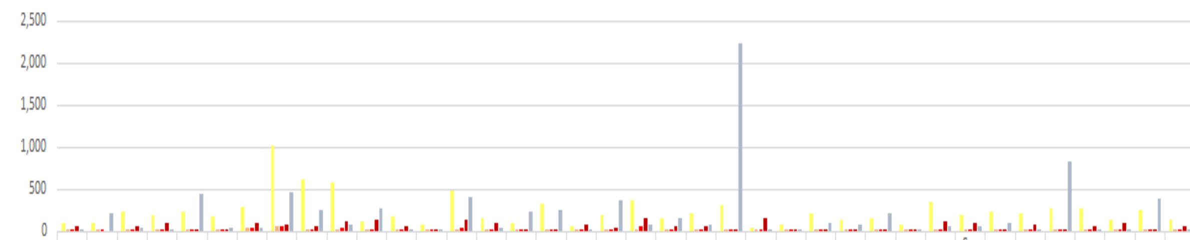


Figure 1. Disaster Risk Assessment and Zoning, Lupi Camarines Sur

Figure 1 presents the multiple hazards that were weighted and categorized into very low, low, moderate, high, and very high. Similarly, the landscape vulnerability in Lupi was expressed in terms of unstable slope, critical elevation, erosion, and river runoffs. The exposure was expressed in terms of the urban use areas including the special use areas. The consequences of the combined multiple hazards, landscape vulnerability, and exposure were equated to the highest-best-land use including the nonconforming uses which hints at the prevention and mitigation. Lupi is blessed for forests and vast agricultural areas in which it hinted at the highest-best-land uses and resilient areas (coldspots). The coldspot areas are inversely related to risk hotspots, wherein the risk hotspots are categorized into seven levels of significance dependent on the resulting risk z-scores.

Disaster Risk Assessment, Lupi Camarines Sur



	Alleomar	Bagangan Sr	Bagong Sikat	Bel Cruz	Bangon	Barerra Jr	Barerra Sr	Belwang	Buenaswerte	Bulawan Jr	Bulawan Sr	Cabutagan	Kaibigan	Casay	Colacling	Cristo Rey	Del Carmen	Haguimit	Haluban
Insignificant	101	100	230	193	232	168	287	1,016	621	589	111	167	72	487	160	95	334	66	194
Hotspot90	9	3	19	8	2	6	42	57	16	21	6	8	3	19	8	4	16	8	9
Hotspot95	19	2	24	7	8	11	34	56	21	39	3	5	2	35	19	2	18	18	16
Hotspot99	61		57	95	25	5	98	75	53	120	129	59	12	145	107	4	29	79	39
Coldspot90	5	222	46	27	445	42	35	463	253	74	264	21	24	413	34	237	259	30	376

	LA Purizima	Lourdes	Mangcawayan	Napolidan	Poblacion	Polantuna	Sagrada	Salvacion	San Isidro	San Jose	San Pedro	San Rafael Norte	San Rafael Sur	San Ramon	San Vicente	Sooc	Tanawan	Tible	Tapi
Insignificant	365	155	222	309	35	85	214	139	157	79	359	196	231	212	273	277	133	257	130
Hotspot90	26	15	12	3	2	6	15	3	5	9	14	12	7	10	7	12	11	7	7
Hotspot95	52	13	20	5	8	8	21	3	12	5	24	21	7	13	3	19	23	9	11
Hotspot99	165	55	52	18	153	22	29	22	5	30	111	103	21	77	3	60	93	23	69
Coldspot90	81	151	85	2,245	7	2	107	75	214	16	66	62	99	16	837	28	10	387	20

Insignificant Hotspot90 Hotspot95 Hotspot99 Coldspot90

Figure 2.Hotspot and Coldspots Areas in Lupi, Camarines Sur

Figure 2 presents the graphical representation of risk hotspot as shown in Figure 1 that constitutes the hectarage of risk hotspot at 90%, 95%, 99%, -90%, and the insignificant level of significance. The barangays Napolidan(inside the Bicol National Park) and San Vicente (the southeast portion of Mount Labo) are the top 2 highest counts of -90% risk reality (coldspot or areas where risk is absent, or it hinted at highest-best-land use) as these areas are protected forests both located near the provincial boundaries of Camarines Sur and Camarines Norte.

Table 1 presents the results of the spatial data overlay analyses in hectarage. It disclosed the multiple hazards, landscape vulnerability, exposure, as well as the risk reality in terms of hotspots. Table 2 presents a pattern that disclosed the linkage of the results of the spatial data overlay analyses in hectarage. It disclosed the multiple hazards, landscape vulnerability, exposure, as well as the risk reality in terms of hotspots.

Table 3 presents a summarized hectarage of land with development constraints that are zoned according to land use. The base zones with development constraints in terms of risk hotspots z-scores are categorized into seven levels of significance. In the case of the Municipality of Lupi, the risk quantification disclosed the risk hotspots which hinted at the 90%, 95%, and 99% level of significance, not significant, and -90% level of significance (coldspot or resilient areas with highest-best and conforming land use).

Table 1. Elements of Risk and Hotspot Count in Hectares

Barangays of Lupi, Camarines Sur	*Multiple Hazards in Ha*				*Landscape Vulnerability in Ha*			*Exposure in Ha*	*Risk Hotspot in Ha*				
	Low	Mod	High	Very High	Very Low	Mod	Very High	High	90% Hotspot	Insignificant	-90% Hotspot	-95% Hotspot	-99% Hotspot
Alomar	0	0	0	183	118	1,393	438	471	5	101	9	19	61
Bagangan Sr	51	79	118	79	446	2,390	437		222	100	3	2	0
Bagong Sikat	0	93	201	82	467	2,636	654	604	46	230	19	24	57
Bel Cruz	55	129	66	79	1,128	1,367	793	968	27	193	8	7	95
Bangon	25	217	320	148	429	6,344	335	331	445	232	2	8	25
Barerra Jr	1	4	45	182	889	802	623	188	42	168	6	11	5
Barerra Sr	0	234	146	116		3,955	1,006	1170	35	287	42	34	98
Belwang	7	704	450	504	431	11,986	4,238	804	463	1,016	57	56	75
Buenaswerte	0	693	0	271		7,475	2,158	573	253	621	16	21	53
Bulawan Jr	114	135	348	246	1,945	4,159	2,328	1124	74	589	21	39	120
Bulawan Sr	31	162	247	74	1,038	3,360	744	1110	264	111	6	3	129
Cabutagan	0	96	92	72	838	1,224	538	737	21	167	8	5	59
Kaibigan	0	9	51	53	240	459	437	40	24	72	3	2	12
Casay	0	738	76	285	469	8,669	1,857	1267	413	487	19	35	145
Colacling	36	100	78	114	1,044	1,440	801	1281	34	160	8	19	107
Cristo Rey	0	100	175	68	568	2,633	226	49	237	95	4	2	4
Del Carmen	6	525	28	95	320	5,180	1,050	525	259	334	16	18	29
Haguimit	0	108	57	36	183	1,256	570	690	30	66	8	18	79
Haluban	3	469	30	133	100	5,696	552	552	376	194	9	16	39
LA Purizima	2	324	25	338	60	5,068	1,763	1266	81	365	26	52	165
Lourdes	0	209	58	123	240	3,326	324	531	151	155	15	13	55
Mangcawayan	0	310	0	81	10	3,025	882	552	85	222	12	20	52
Napolidan	4	1601	471	503	21	24,936	841	50	2,245	309	3	5	18
Poblacion	0	57	103	46	612	984	461	1537	7	35	2	8	153
Polantuna	0	4	11	118	15	636	575	117	2	85	6	8	22
Sagrada	0	300	65	75		3,126	734	517	107	214	15	21	29
Salvacion	0	105	142	72		1,988	433	194	75	139	3	3	22
San Isidro	5	68	227	178	1,336	1,843	745	30	214	157	5	12	5
San Jose	0	64	0	75	1,520	831	551	205	16	79	9	5	30
San Pedro	0	73	0	274		2,402	1,816	786	66	359	14	24	111
San Rafael Norte	0	145	59	189		2,680	1,253	537	62	196	12	21	103
San Rafael Sur	0	91	175	99	1,376	1,385	899	190	99	231	7	7	21
San Ramon	0	203	0	124	1,534	2,166	1,104	691	16	212	10	13	77

Table 1. Elements of Risk and Hotspot Count in Hectares (continuation)

Barangays of Lupi, Camarines Sur	*Multiple Hazards in Ha*				*Landscape Vulnerability in Ha*			*Exposure in Ha*	*Risk Hotspot in Ha*				
	Low	Mod	High	Very High	Very Low	Mod	Very High	High	90% Hotspot	Insignificant	-90% Hotspot	-95% Hotspot	-99% Hotspot
San Vicente	11	332	575	203	523	8,748	935	12	837	273	7	3	3
Sooc	1	233	0	163	249	2,891	1,065	671	28	277	12	19	60
Tanawan	12	111	79	79	1,417	1,390	788	723	10	133	11	23	93
Tible	0	506	116	61		6,068	514	390	387	257	7	9	23
Tapi	0	52	58	127		351	605	888	20	130	7	11	69

Table 2. Lupi Risk Areas vs. Land Use Matrix

Risk Areas	**Risk Level of Significance**	**Land Use**	**DRRM**
Very High-Risk Areas	95% to99%	Non-Conforming (No-build zone)	Recovery
High-Risk Areas	90% to 95%	Land Development Constraints	Mitigation
Risk of Insignificant Areas	Random	Suitable for Development	Preparedness
Resilient Areas	-90% and below	Highest-best-land use	Prevention

Table 3. Lupi Risk-Zoning Monitoring Matrix

Lupi RISK-ZONING Matrix	Risk Hotspots in Ha				
	90% level of Significance Coldspot (Resilient)	Insignificant	90% level of Significance Risk Hotspot	95% level of Significance Risk Hotspot	99% level of Significance Risk Hotspot
Forest Zone (FZ)	4,023	1,335	14	17	64
General Agricultural Zone (GAZ)	3,741	7,128	363	517	1,611
Inland Water Zone (WZ)		488	56	45	132
Parks and Open Spaces Zone (POSZ)					5
Special Zone (SZ)		1		1	8
Urban Zone (URZ)		68	13	32	480

Table 4 disclosed the Base Zones measured in hectares by barangays concerning the desired DRRM actions and interventions before utilizing and developing the lands of the municipality.

Table 4. Lupi Barangay Base Zones and DRRM Hectarage

Barangay Name	Barangay ID	Base Zones	DRRM in Ha Prevention	DRRM in Ha Preparedness	DRRM in Ha Mitigation
Alleomar	51719001	General Agricultural Zone (GAZ)	4.9998	96.1762	81.307
		Inland Water Zone (WZ)	6.4639		
		Urban Zone (URZ)		0.327	5.6491
Bagangan Sr	51719003	General Agricultural Zone (GAZ)	221.8127	83.9113	1.128
		Inland Water Zone (WZ)	20.3707		
Bagong Sikat	51719004	General Agricultural Zone (GAZ)	46.4141	223.4638	91.8424
		Inland Water Zone (WZ)	7.5312		
		Urban Zone (URZ)		0.1916	6.25
Bel Cruz	51719005	General Agricultural Zone (GAZ)	26.7561	184.8048	77.0338
		Inland Water Zone (WZ)	7.4494		
		Urban Zone (URZ)		3.2617	29.5145
Bangon	51719006	Forest Zone (FZ)	4.3749		2.1227
		General Agricultural Zone (GAZ)	440.4438	225.4774	28.157
		Inland Water Zone (WZ)	2.9905		
		Special Zone (SZ)			4.8007
		Urban Zone (URZ)		1.1223	1.3535
Barerra Jr	51719007	General Agricultural Zone (GAZ)	42.1778	150.5291	14.8974
		Inland Water Zone (WZ)	20.872		
		Urban Zone (URZ)		2.4026	0.5746
Barerra Sr	51719008	General Agricultural Zone (GAZ)	35.0104	264.6325	155.5497
		Inland Water Zone (WZ)	32.5263		
		Urban Zone (URZ)		0.4458	7.9308
Belwang	51719009	Forest Zone (FZ)	687.0938		0.9972
		General Agricultural Zone (GAZ)	86.4492	651.2349	148.7068
		Inland Water Zone (WZ)	82.3567		
		Urban Zone (URZ)		1.4742	11.6889
Buenaswerte	51719010	Forest Zone (FZ)	143.5147		11.2412
		General Agricultural Zone (GAZ)	197.4134	505.9131	66.3544
		Inland Water Zone (WZ)	29.4405		
		Urban Zone (URZ)		1.6469	7.7646
Bulawan Jr	51719011	General Agricultural Zone (GAZ)	74.3948	565.0882	164.9532
		Inland Water Zone (WZ)	29.0163		
		Urban Zone (URZ)		5.7019	4.8016

Table 4. Lupi Barangay Base Zones and DRRM Hectarage (continuation)

Barangay		Base Zones	DRRM in Ha		
Name	ID		Prevention	Preparedness	Mitigation
Bulawan Sr	51719012	General Agricultural Zone (GAZ)	263.9103	109.7	59.3636
		Inland Water Zone (WZ)	9.7617		
		Urban Zone (URZ)		1.5191	69.9789
Cabutagan	51719013	General Agricultural Zone (GAZ)	20.7572	152.03	53.531
		Inland Water Zone (WZ)	55.548		
		Urban Zone (URZ)		8.419	16.4864
Kaibigan	51719014	General Agricultural Zone (GAZ)	24.3774	56.4419	11.5635
		Inland Water Zone (WZ)	21.0238		
		Urban Zone (URZ)			0.7062
Casay	51719015	General Agricultural Zone (GAZ)	412.5412	476.175	172.1283
		Inland Water Zone (WZ)	19.7175		
		Urban Zone (URZ)		0.3516	18.635
Colacling	51719016	Forest Zone (FZ)	43.0065		
		General Agricultural Zone (GAZ)	30.8602	102.7933	55.1562
		Inland Water Zone (WZ)	10.0042		
		Special Zone (SZ)			0.211
		Urban Zone (URZ)		14.4144	72.2576
Cristo Rey	51719017	General Agricultural Zone (GAZ)	237.1862	91.8181	9.3013
		Inland Water Zone (WZ)	3.848		
		Urban Zone (URZ)		0.0636	0.4544
Del Carmen	51719018	General Agricultural Zone (GAZ)	258.7289	314.7331	59.8194
		Inland Water Zone (WZ)	20.4575		
		Urban Zone (URZ)		0.3906	0.7693
Haguimit	51719019	General Agricultural Zone (GAZ)	29.7075	61.9639	92.2604
		Inland Water Zone (WZ)	10.3645		
		Urban Zone (URZ)		0.3625	6.2257
Haluban	51719020	Forest Zone (FZ)	127.815		
		General Agricultural Zone (GAZ)	314.9832	106.6595	60.8514
		Inland Water Zone (WZ)	20.9491		
		Urban Zone (URZ)		0.3805	3.0217
LA Purizima	51719021	Forest Zone (FZ)	2.1594		
		General Agricultural Zone (GAZ)	80.1339	337.4479	214.4149
		Inland Water Zone (WZ)	39.2741		
		Urban Zone (URZ)		0.5478	15.0647

Table 4. Lupi Barangay Base Zones and DRRM Hectarage (continuation)

Barangay Name	Barangay ID	Base Zones	DRRM in Ha Prevention	DRRM in Ha Preparedness	DRRM in Ha Mitigation
Lourdes	51719022	General Agricultural Zone (GAZ)	150.948	151.8541	69.4781
		Inland Water Zone (WZ)	3.9844		
		Parks and Open Spaces Zone (POSZ)			0.4713
		Special Zone (SZ)			2.0429
		Urban Zone (URZ)		0.045	10.6144
Mangcawayan	51719024	General Agricultural Zone (GAZ)	84.8283	207.4998	68.258
		Inland Water Zone (WZ)	19.5933		
		Urban Zone (URZ)		0.4911	11.0103
Napolidan	51719025	Forest Zone (FZ)	2,551.42		
		Inland Water Zone (WZ)	28.5135		
Poblacion	51719027	General Agricultural Zone (GAZ)	6.6557	28.8137	34.8285
		Inland Water Zone (WZ)	10.2223		
		Urban Zone (URZ)		2.7659	122.4269
Polantuna	51719028	General Agricultural Zone (GAZ)	1.9999	73.1411	26.023
		Inland Water Zone (WZ)	18.7424		
		Special Zone (SZ)			0.0257
		Urban Zone (URZ)		0.0123	2.6043
Sagrada	51719029	General Agricultural Zone (GAZ)	106.866	202.0517	55.4597
		Inland Water Zone (WZ)	14.3909		
		Urban Zone (URZ)		0.868	6.388
Salvacion	51719030	General Agricultural Zone (GAZ)	75.2462	135.0601	21.5358
		Inland Water Zone (WZ)	5.0394		
		Urban Zone (URZ)		0.2852	4.8973
San Isidro	51719031	General Agricultural Zone (GAZ)	213.5421	134.2434	8.3644
		Inland Water Zone (WZ)	36.9757		
		Urban Zone (URZ)		0.0339	

Table 4. Lupi Barangay Base Zones and DRRM Hectarage (continuation)

Barangay		Base Zones	DRRM in Ha		
Name	ID		Prevention	Preparedness	Mitigation
San Jose	51719032	Forest Zone (FZ)	0.4293		
		General Agricultural Zone (GAZ)	15.7218	67.3977	25.2902
		Inland Water Zone (WZ)	16.1759		
		Urban Zone (URZ)		0.0827	13.079
San Pedro	51719033	General Agricultural Zone (GAZ)	65.6555	330.8935	125.2335
		Inland Water Zone (WZ)	43.2629		
		Urban Zone (URZ)		2.3317	6.5235
San Rafael Norte	51719035	Forest Zone (FZ)	111.5025		43.5438
		General Agricultural Zone (GAZ)	33.868	106.9264	82.8062
		Inland Water Zone (WZ)	9.1193		
		Urban Zone (URZ)		0.6764	4.8198
San Rafael Sur	51719036	Forest Zone (FZ)	65.7738		2.6673
		General Agricultural Zone (GAZ)	61.833	187.7429	26.5893
		Inland Water Zone (WZ)	19.2863		
		Urban Zone (URZ)		2.0535	0.0767
San Ramon	51719037	Forest Zone (FZ)	6.9871		5.6063
		General Agricultural Zone (GAZ)	15.9993	189.7791	66.8115
		Inland Water Zone (WZ)	21.3984		
		Urban Zone (URZ)		1.8933	18.559
San Vicente	51719038	Forest Zone (FZ)	1,003.55		
		General Agricultural Zone (GAZ)	10.3153	90.5802	8.4577
		Inland Water Zone (WZ)	21.1669		
		Urban Zone (URZ)			0.0362
Sooc	51719039	Forest Zone (FZ)	23.944		3.2876
		General Agricultural Zone (GAZ)	27.5026	236.5282	78.5888
		Inland Water Zone (WZ)	20.1424		
		Urban Zone (URZ)		1.465	4.0848

Table 4. Lupi Barangay Base Zones and DRRM Hectarage (continuation)

Barangay		Base Zones	DRRM in Ha		
Name	ID		Prevention	Preparedness	Mitigation
Tanawan	51719040	General Agricultural Zone (GAZ)	10.2882	126.9667	105.3906
		Inland Water Zone (WZ)	11.3116		
		Urban Zone (URZ)		0.2924	16.4301
Tible	51719041	Forest Zone (FZ)	603.9348		7.3953
		General Agricultural Zone (GAZ)	1.4084	30.3955	24.0645
		Inland Water Zone (WZ)	7.4587		
		Special Zone (SZ)			0.3615
		Urban Zone (URZ)		0.3284	7.7071
Tapi	51719042	General Agricultural Zone (GAZ)	20.3219	112.1309	55.1996
		Inland Water Zone (WZ)	13.2747		
		Parks and Open Spaces Zone (POSZ)			4.0505
		Special Zone (SZ)			2.8952
		Urban Zone (URZ)		12.085	17.3646

Figure 4 presents the prioritization of areas that are consistent with the land protection, production, settlement, and infrastructure for local development requires spatial information to identify and prioritize actions to avoid land degradation or habitat losses with the greatest effect on biota and ecosystems.

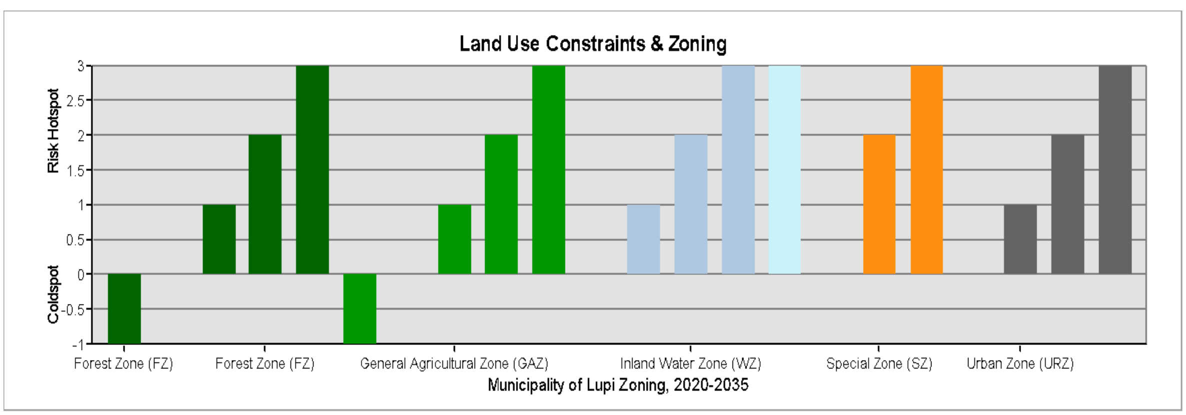


Figure 4. Land Use Constraints and Zoning, Lupi, Camarines Sur

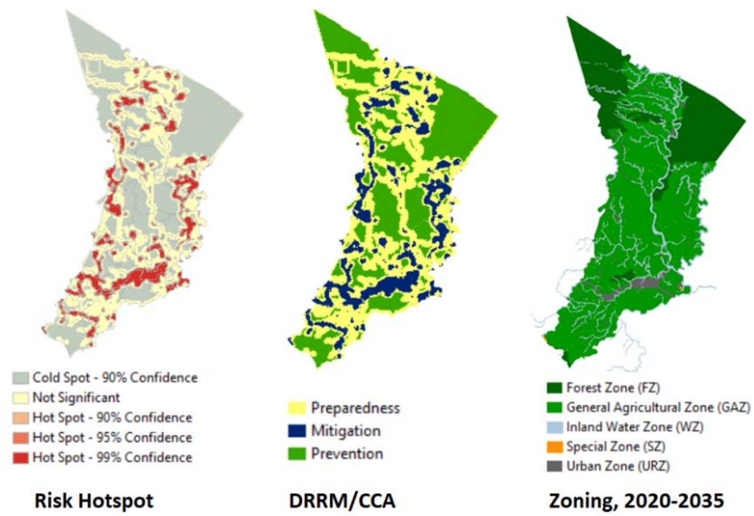


Figure 5. Mainstreaming Land Use Constraints into Zoning, Lupi Camarines Sur

Figure 5 presents the risk z-scores are regarded where risk reality is regarded as the function (multiple hazards, landscape vulnerability, passive exposure, preparedness, competency, and coping capacity). The z-scores equal to one-unit risk constitute stability (state of balance) and any value greater than one-unit represents a risk hotspot contained in hexagonal bins mimicking the geographical aspects of the risk realness. This underlines the z-score for coldspot less than one-unit of risk hints at a resilience state. Although the author acknowledges the limitations of the spatial data modeling only accurate for 1:50000 scale input maps suitable for macro planning and rapid risk assessment, this study infers that the more detailed information and smaller hexagonal bins can lead to greater variations of risk and its elements. Moreover, the same hexagonal binning technique may be adopted for micro development planning or comprehensive risk assessment, or health risk and trend assessment and monitoring. The researcher concluded that disaster risk reduction entails interdisciplinary thinking to apply hexagonal to determine where the natural and man-made hazards, landscape vulnerable, and passive and active exposure hotspots or coldspots exist.

CONCLUSION AND RECOMMENDATIONS

The data model practically implies that risk is measurable and actionable in terms of allocating the highest-best-land use and zonification of danger zones to prevent potential risks by regulating the uses of risk hotspots and vulnerable areas and to protect the remaining forests that are regarded as coldspots.

As our world changes, in times of extreme weather effects inept to traditional disaster risk reduction actions are no longer working to resist the changing climate. The author concluded that an informed local government is prepared although it seems long term to achieve it but desire to make real progress towards risk reduction. It is also concluded that the model can mimic the municipality's risk reality extremes that need to be avoided and knowing it is something that matters to guide and control land use and local development to achieve physical and environmental balance. The DRRM cycle urges the LGUs to make land-use allocations free if not reduced risk through prevention, mitigation, and preparedness. She proposed to further apply hexagonal data mining techniques to dig deep into the land utilization free from risk if not reduced risk through proper zoning the highest-best-land use. Furthermore, a fine-tuned DRRM backed by an approved land use plan and zoning ordinance can be workable risk governance through continuous monitoring and evaluating of the risk hotspot areas and areas with land development constraints to attain and sustain local development growth in cities and municipalities.

ACKNOWLEDGEMENT

This paper acknowledges all the data downloaded from the source: National Mapping and Resource Information Authority at http://www.namria.gov.ph/use.htm; *OpenStreetMap* (OSM) *at* http://download.geofabrik.de/asia/philippines-latest-free.shp.zip; Geofabrik extended shapefiles in http://download.geofabrik.de/osm-data-in-gis-formats-free.pdf; PhilGIS through the UN-Spider Knowledge Portal offers Philippine GIS data at http://www.philgis.org/search/node/terms%20of%20use or http://www.un-spider.org/links-and-resources/data-sources/data; Project NOAH of the Department of Science and Technology's (DOST) on Geohazards Lidar, coastal Hazards and Storm Surge maps, and flood maps which were downloaded from http://noah.up.edu.ph/#/; and *MGB Geoportal Data at* https://www.gov.ph/data. I would like to express my gratitude to the project team Atty. Joseph L. Barlotata, PhD., EnP. Carlo Gabriel R. Abante, EnP. Erwin Torres, EnP. Francia Octeza, PhD, Engr. Michael Cobilla and Engr. John Patrick Rosaladaforcompleting our project entitled "CLUP and Zoning Ordinance of the Municipality of Lupi, Camarines Sur" by working on our respective and individual studies collaboratively. Our project would not be realized without the research funding from the Local Government unit under the leadership of Mayor Lilian S.A. Matamorosa, Vice Mayor Josie S. Aceroand members of the Sangguniang Bayan ng Lupi. I humbly offer this work to The Almighty God, the source of all that I have. May my work, public service, and my achievements in life always serve the benefit of his creation.

REFERENCES

Abante, A. M. R. (2020a). *Geophilosophical perspective on socio-spatial fuzzy reality phenomenon* (unpublished manuscript). Bicol University, Legazpi City, Philippines.

Abante, A. M. R. (2020b). Risk hotspot conceptual space characterized by hexagonal data binning technique: An application in Albay, Philippines. *International Journal of Computing Sciences Research*, 5(1), 550-567.doi: 10.25147/ijcsr.2017.001.1.58

Abante, A. M. R., & Abante, C. G. R. (2018). Sensitive land use planning, Malinao, Albay, Philippines. *IOP Conference Series: Earth and Environmental Science*, *123*(1), 012001.
Abante, A. M. R., & Abante, C. G. R. (2019). Topophilia-exposure central space concept model. *International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences*, *XLII* (4-WW19),1-8.
Barua, U., Islam, I., &Ansary, M. A. (2020). Integration of earthquake risk-sensitivity into land-use planning: An approach for a local level area at the development phase. *International Journal of Disaster Risk Reduction*, *50*, 101836.
Fischel, W. A. (2000). Zoning and land use regulation. *Encyclopedia of law and economics,* 2, 403-423.
Getis, A.& Getis, J. (1966).Christaller's Central Place Theory.*Journal of Geography, 65*(5), 220-226.doi: 10.1080/00221346608982415
Gold, C. (2016). Tessellations in GIS: Part I—putting it all together. *Geo-spatial Information Science*, *19*(1), 9-25.
Guiang, E. S. (2013). A proposed DENR road map for replicating and scaling up of governance-oriented integrated ecosystems management. Retrieved from http://faspselib.denr.gov.ph/node/1514
Lirag, M. T. B., & Estrella, A. B (2017). Adaptation measures of farmers in response to climate change in Bicol Region, Philippines*. International Journal of Advanced Science, Engineering, Information Technology, 7*(6), 2308-2315.
Oat, C., Barczak, J., &Shopf, J. (2008). Efficient spatial binning on the GPU. *SIGGRAPH Asia*. Retrieved from http://chrisoat.com/papers/EfficientSpatialBinning.pdf
Oksanen, J. (2013). Can binning be the key to understanding the uncertainty of DEMs? In *Proceedings of the GIS Research UK (GISRUK),* 3-5.
Paladin, K. C., &Capulong-Reyes, R. (2015). " Meron o Wala": a study on the usefulness of Twitter during typhoon as perceived by the students of the selected Intramuros-based schools.*International Journal of Social Science and Humanity*, *5*(1),130-133.
Worboys, M. F., & Duckham, M. (2004). *GIS: A computing perspective*. CRC Press.

Author's Biography

The author completed her Doctor of Philosophy in Development Management at the Jesse M. Robredo Institute, Bicol University on July 4, 2020. She completed her Professional Masters in Geoinformatics with a Specialization in Development and Maintenance of Geographic Information Systems at the International Institute for Aerospace Surveys and Earth Sciences (now ITC, University of Twente), Enschede, The Netherlands through the Netherlands Fellowship Program in 1997. She completed a special course on Applied Geodesy and Photogrammetry at the Training Center for Applied Geodesy and Photogrammetry, University of the Philippines in 1992. She completed her Bachelor of Science in Civil Engineering at Bicol University College of Engineering, Legazpi City in 1989. She is currently on faculty in the BU College of Engineering. She conducts research that focuses on applying geoinformatics in environmental planning and disaster risk reduction. She published four papers in 2018-2019. She received awards for the 2 best papers at Bicol University in 2018-2019 and recently attended various training programs on basic meteorology, flood risk modeling, safe and resilient cities, geomatics and planning, remote sensing, unmanned aerial vehicle road mapping, space science, and technology. The author is licensed to practice environmental planning, geodetic engineering, and civil engineering in the Philippines. She is the team leader and senior land use planner of the research, development, and extension project of Bicol University entitled "CLUP and Zoning Ordinance of the Municipality of Lupi, Camarines Sur”.