



TO: Mekong ARCC Task 2 Team
FROM: ICEM – International Centre for Environmental Management
DATE: 26th June 2012
PROJECT: AAS1109 Mekong ARCC
RE: Basic ecozone descriptions

This memo provides a basic biophysical and development description of the twelve ecozones that are being used as the basis for analysis in the Mekong ARCC Task 2. The purpose of this description is to provide context for Task 2 team who are developing sector descriptions of the ecozones.

ECOZONE DEVELOPMENT

The original ecozones were developed by WWF in 2006. They are based on the following:

- Elevation;
- Historic land cover using WWF's terrestrial biomes; and
- Floodplain wetlands.

The Mekong ARCC Task 2 team members discussed the WWF ecozones during the first team meeting in May 2012. It was decided that the following changes would be made:

- Area previously classified as Mangrove/delta to be split into three areas – alluvial freshwater floodplain, low lying acidic area and delta mangroves and saline water;
- Area previously classified as High elevation broadleaf forest to be split into two areas – the Annamites area to the east of the LMB and the North Indochina area to the north of the LMB
- Join areas classified as Tonle Sap swamp forest and Lower floodplain, wetland (Kratie to delta) into one ecozone titled Tonle Sap swamp forest and lower floodplain (Kratie to Delta).

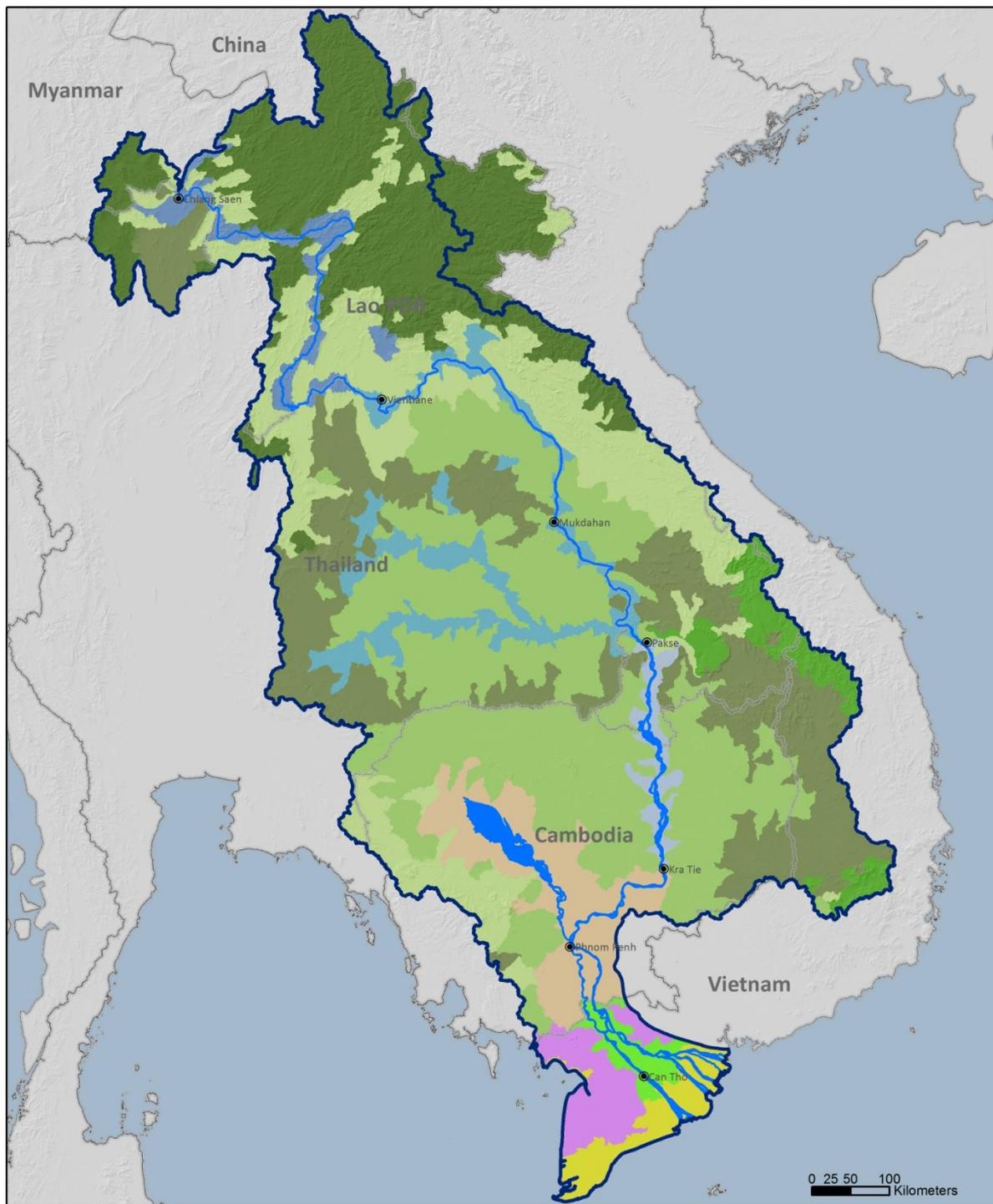
The final set of ecozones that will be used in the project is shown in Figure 1. Below is a list of the final ecozones in order of elevation:

1. Delta mangroves and saline water
2. Alluvial freshwater floodplain
3. Low lying acidic area of the delta
4. Tonle Sap swamp forest and lower floodplain (Kratie to Delta)
5. Lower floodplain, wetland, lake (Pakse to Kratie)
6. Low-elevation dry broadleaf forest
7. Mid floodplain, wetland, lake (Vientiane to Pakse)
8. Mid elevation dry broadleaf forest
9. Low-mid elevation moist broadleaf forest
10. Upper floodplain wetland, lake (Chiang Saen to Vientiane)
11. High elevation moist broadleaf forest – North Indochina
12. High elevation moist broadleaf forest - Annamites

SOURCES OF DATA

This basic analysis of ecozones of the LMB has been developed using the MRC database developed in 2001.

Figure 1. Ecozones to be used in the Mekong ARCC project



ECOZONES IN THE LOWER MEKONG BASIN

- | | | |
|---|---|---|
|  National Border |  High-elevation moist broadleaf forest Annamites |  Mid floodplain, wetland, lake (Vientiane to Pakse) |
|  LMB boundary |  High-elevation moist broadleaf forest North Indochina |  Lower floodplain, wetland, lake (Pakse to Kratie) |
|  Water body |  Mid-elevation dry broadleaf forest |  Tonle Sap swamp forest & lower floodplain (Kratie to delta) |
| |  Low-elevation dry broadleaf forest |  Alluvian freshwater floodplain |
| |  Low-elevation moist broadleaf forest |  Low lying acidic area |
| |  Upper floodplain wetland, lake (Chiang Saen to Vientiane) |  Delta mangroves and saline water |



Data Source: ICEM 2012,
WWF 2002-2006
MRC GIS Database

ECOZONE AREA

The most dominant ecozone in terms of area is the low elevation dry broadleaf forest (Figure 2). This ecozone covers over 17.5 million hectares and is centred on the Khorat Plateau. The smallest ecozone by area is the alluvial freshwater floodplain of the delta. This ecozone has an area of just over 750,000 ha but is unique due to its alluvial soils and location in the delta.

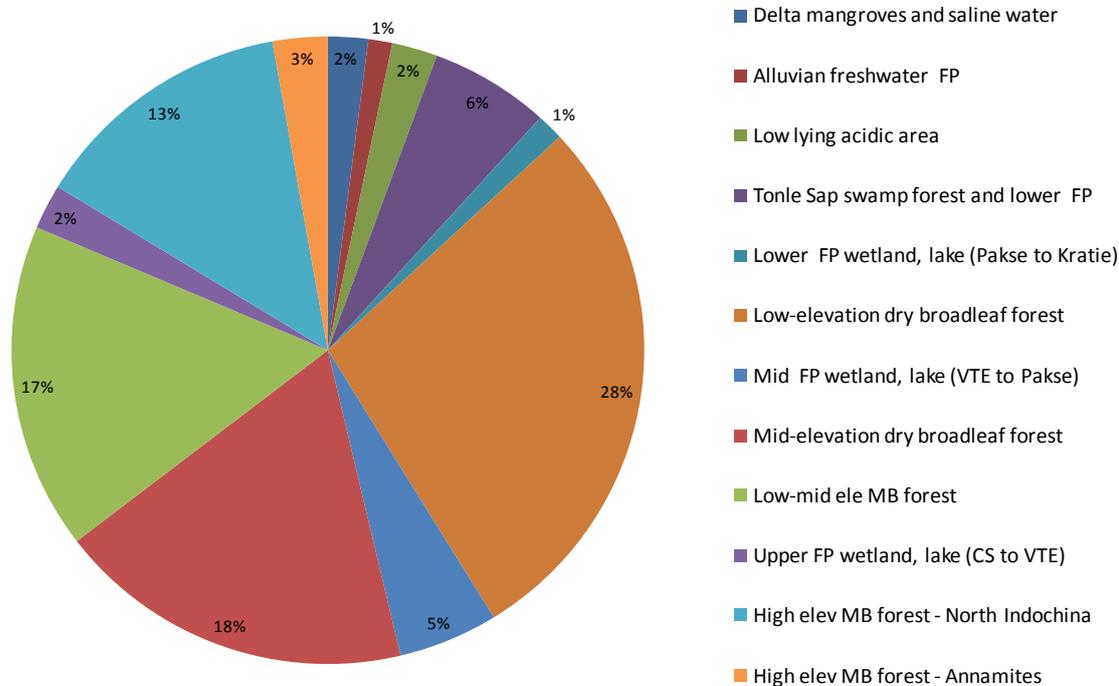


Figure 2. Area of coverage of each ecozone in the LMB (hectares)

If the ecozones are grouped according to their habitat type then broadleaf forest covers by far the largest percentage of the LMB, over 50 million hectares. The relatively small area of the delta zones covers only six percent of the LMB or 3.5 million hectares.

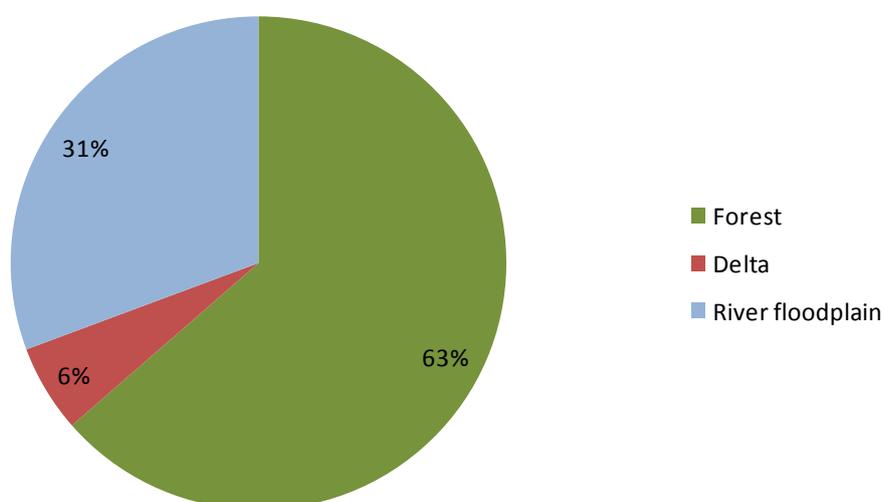


Figure 3. Area of coverage of each ecozone in the LMB (hectares)

PHYSICAL CHARACTERISTICS

Ecozone elevation

Analysis of the elevation of ecozones shows that the three ecozones of the delta have the lowest elevations (Figure 4) and the moist broadleaf forest ecozones in the mountainous North and East of the basin have the highest elevations.

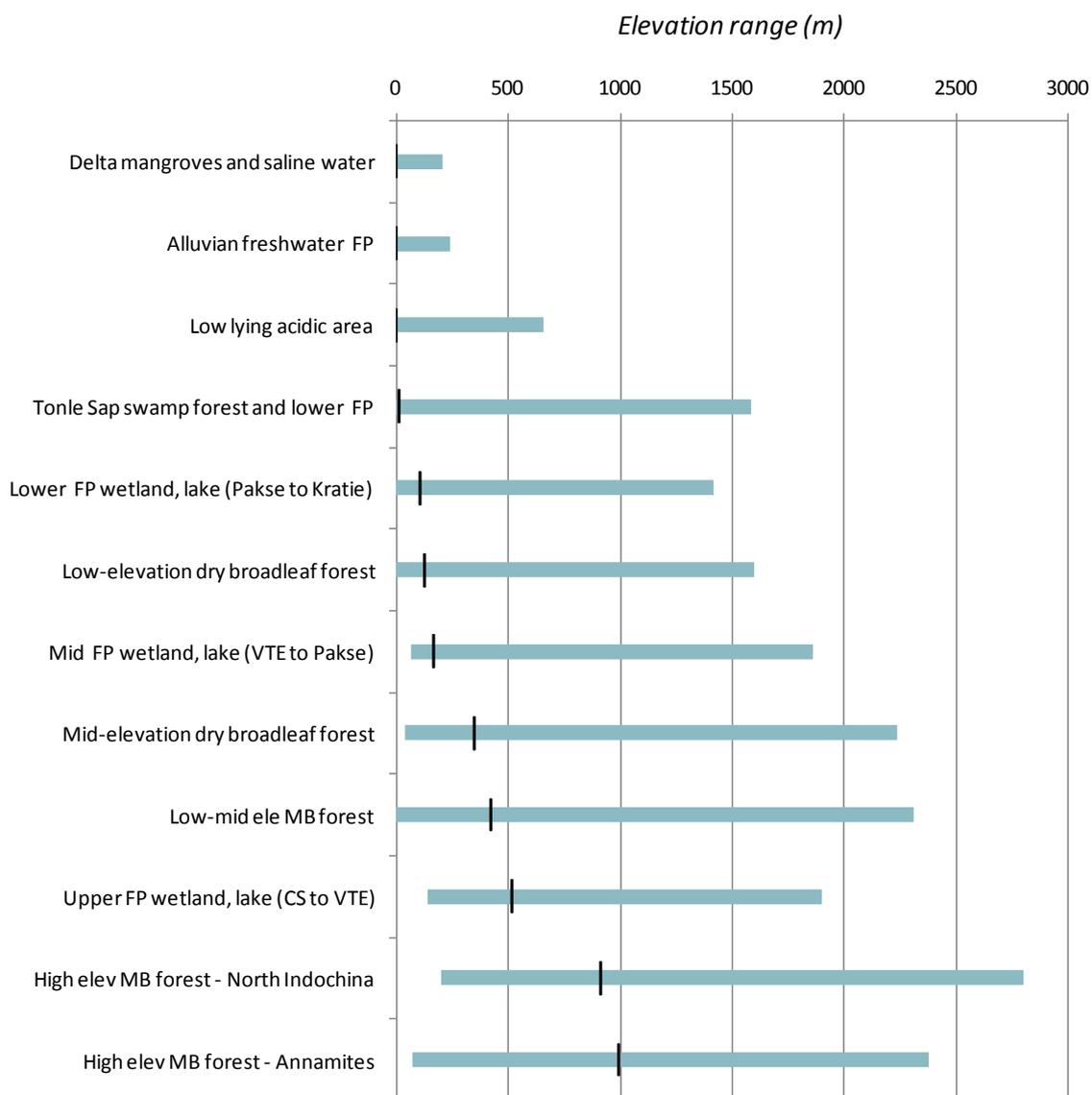


Figure 4. Ecozone elevation mean and range (degree) (Source MRC database, 2001).

Ecozone slope

The slope of the ecozones generally increases with increasing elevation (Figure 5). Therefore the low lying delta ecozones are flatter than the higher elevation broadleaf forest zones.

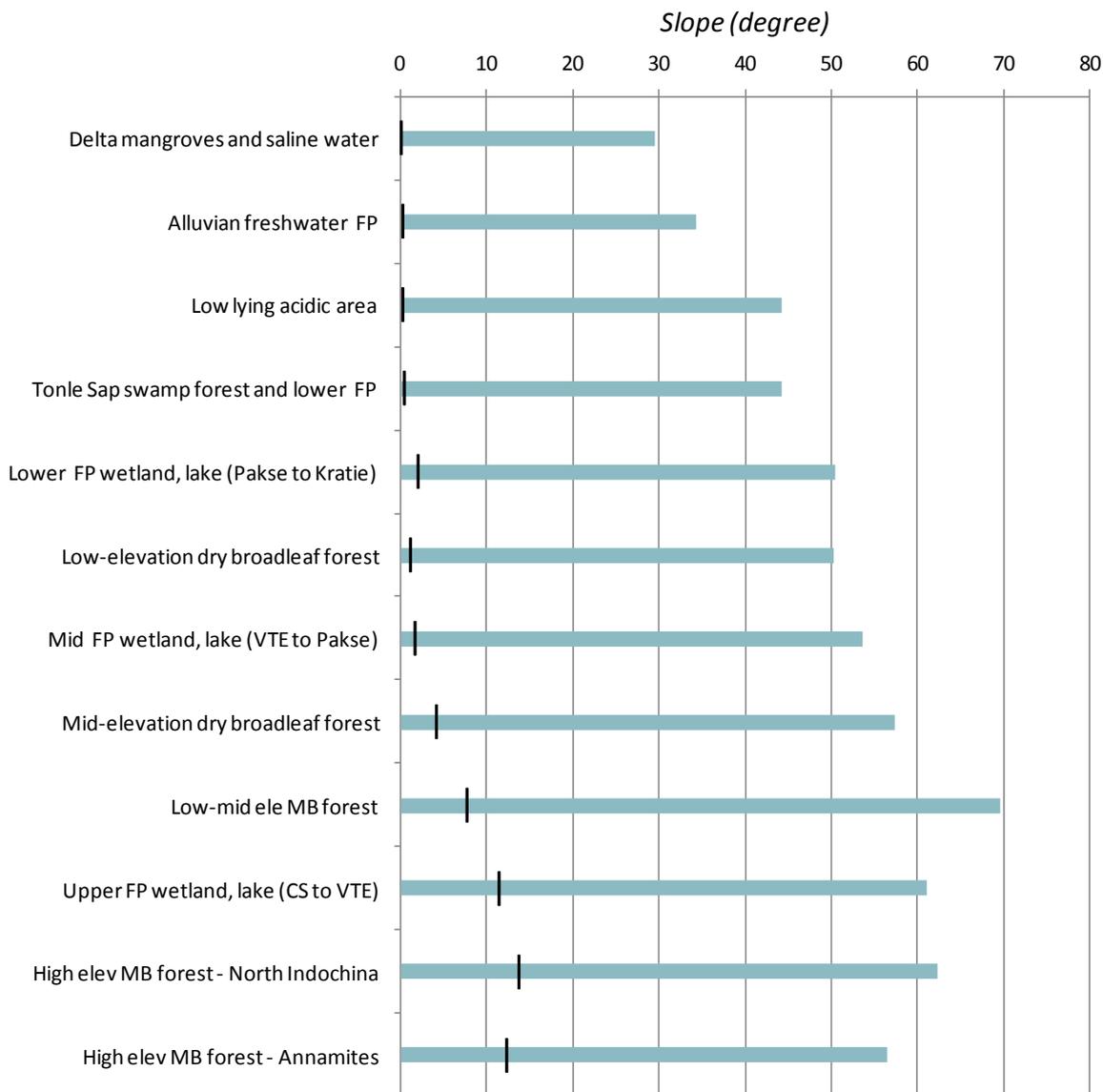


Figure 5. Ecozone slope mean and range (degree) (Source MRC database, 2001).

Soil characteristics

FAO level 1 classification

Analysis of the percentage coverage of FAO level 1 soil types shows that the three delta ecozones are dominated by Gleysol soil whilst Acrisol dominates the broadleaf forest and floodplain ecozones (Figure 6, Figure 7 and Figure 8). Gleysol are water saturated soils that are not salty. Acrisol are acidic soils with a layer of clay accumulation. For further descriptions of the soil types see <http://cals.arizona.edu/OALS/soils/fao.html>.

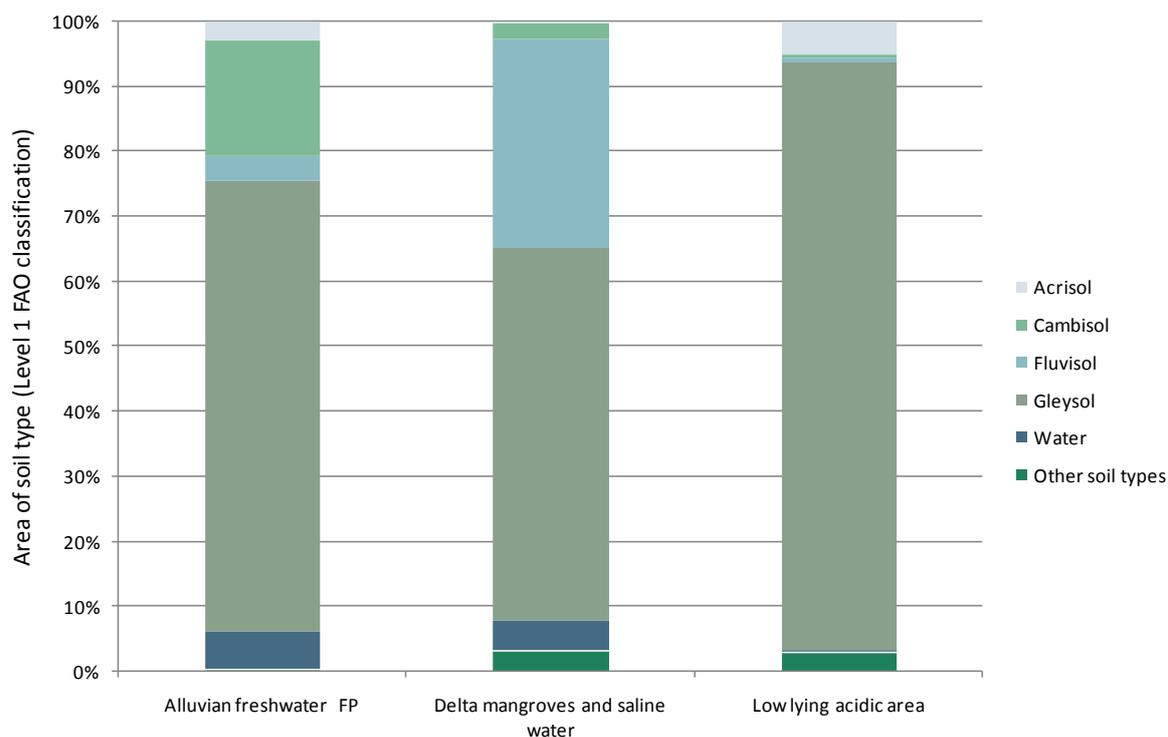


Figure 6. Delta ecozones - Percentage of ecozone area for FAO Level 1 soil types (Source MRC database, 2001). Soil types with % area of less than 5% have been grouped into “other soil types”

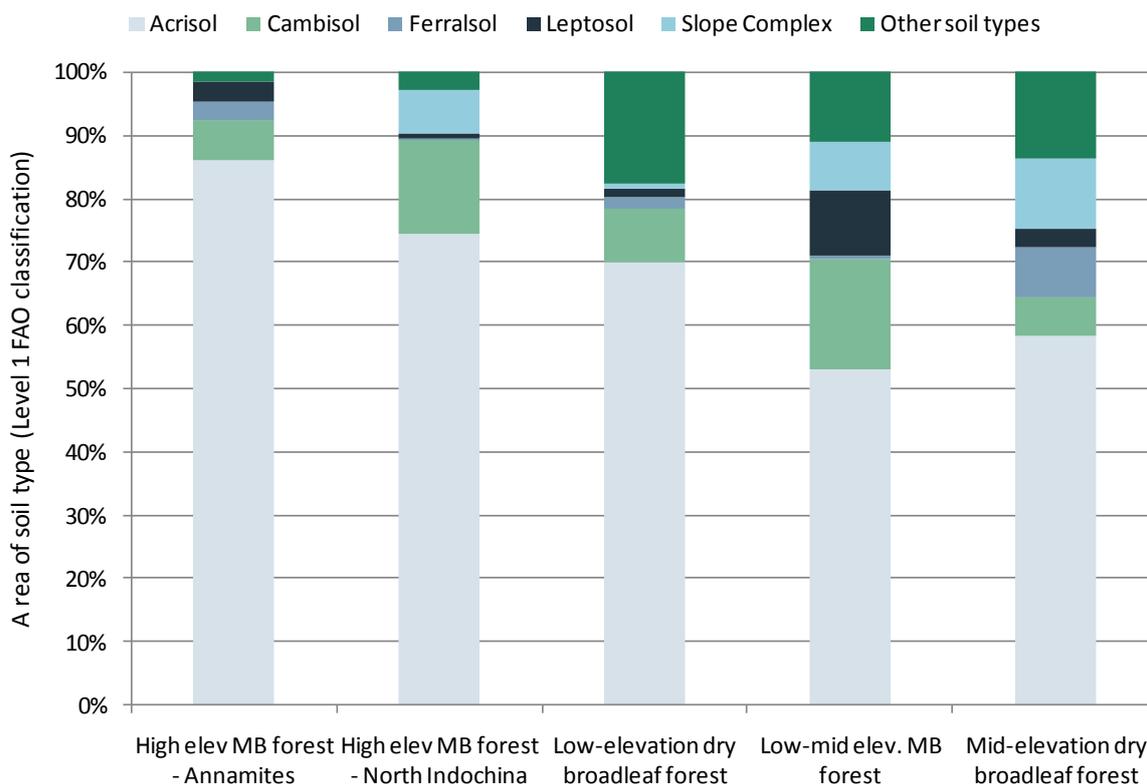


Figure 7. Broadleaf forest ecozones - Percentage of ecozone area of FAO Level 1 soil types (Source MRC database, 2001). Soil types with % area of less than 5% have been grouped into “other soil types”

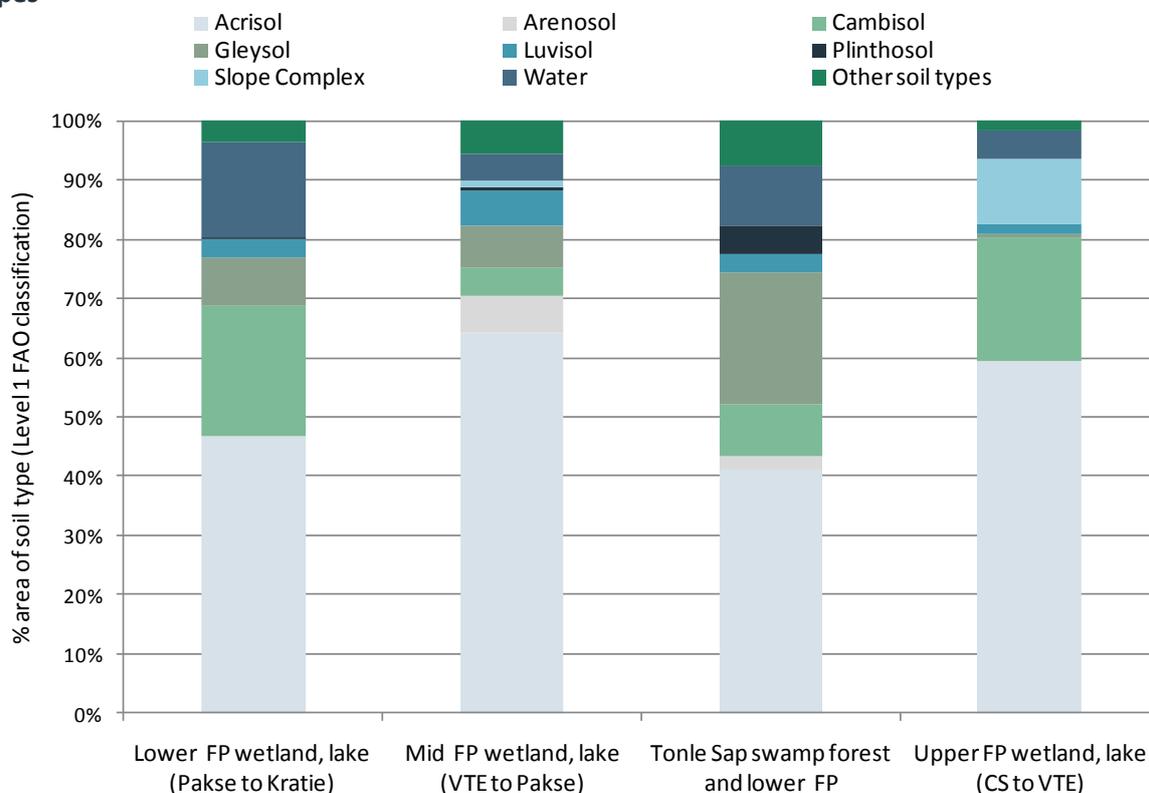


Figure 8. Floodplain ecozones - Percentage of ecozone area of FAO Level 1 soil types (Source MRC database, 2001). Soil types with % area of less than 5% have been grouped into “other soil types”

Soil sulphur toxicity

It can be clearly seen in Figure 9 that the delta zones have a significant coverage of soil with sulphur toxicity, particularly in the Low lying acidic areas in which 65% of the soil is affected. The Tonle Sap and Low elevation dry broadleaf forest zones also contain very small amounts of affected soil.

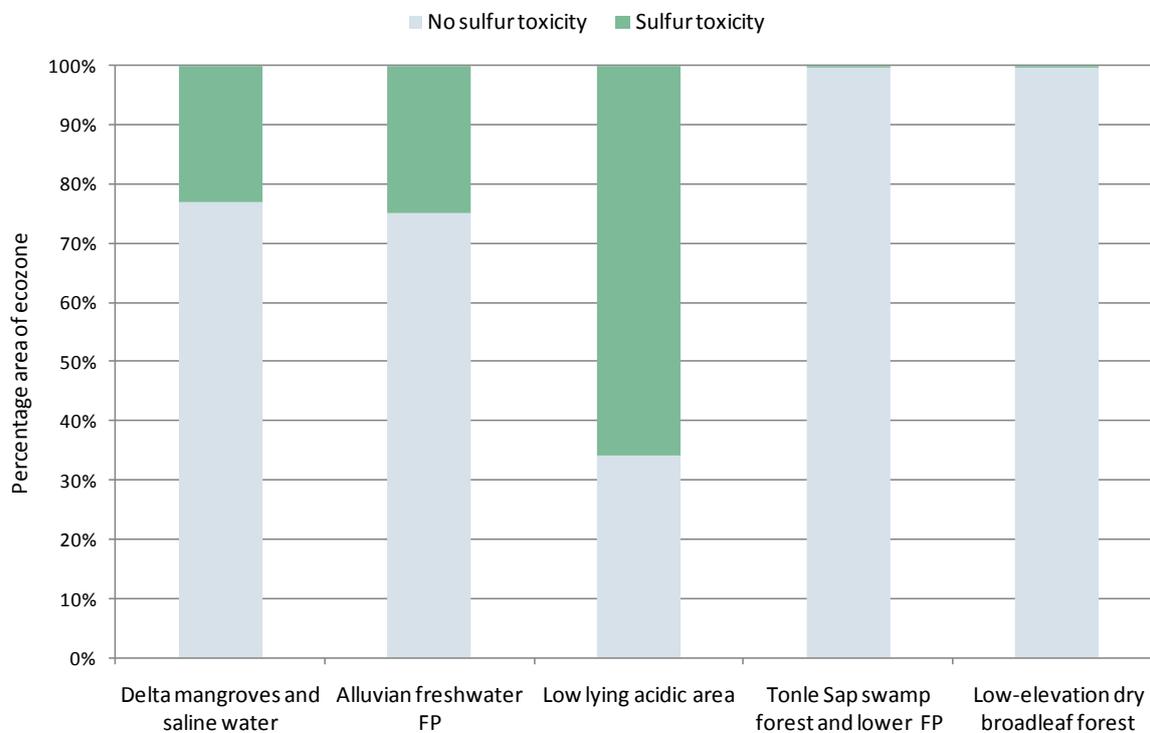


Figure 9. Percentage of ecozone area that has soil sulphur toxicity (Source MRC database, 2001). Note that only ecozones with some soil sulphur toxicity are shown

METEOROLOGICAL CHARACTERISTICS

Ecozone precipitation

The average annual precipitation of the delta ecozones and the zone around the Tonle Sap is 1200mm which is lower than the rest of the LMB (Figure 10). The remaining zones are relatively consistent except for the High elevation dry broadleaf forest zone which is almost 500 mm a year wetter than any other ecozone.

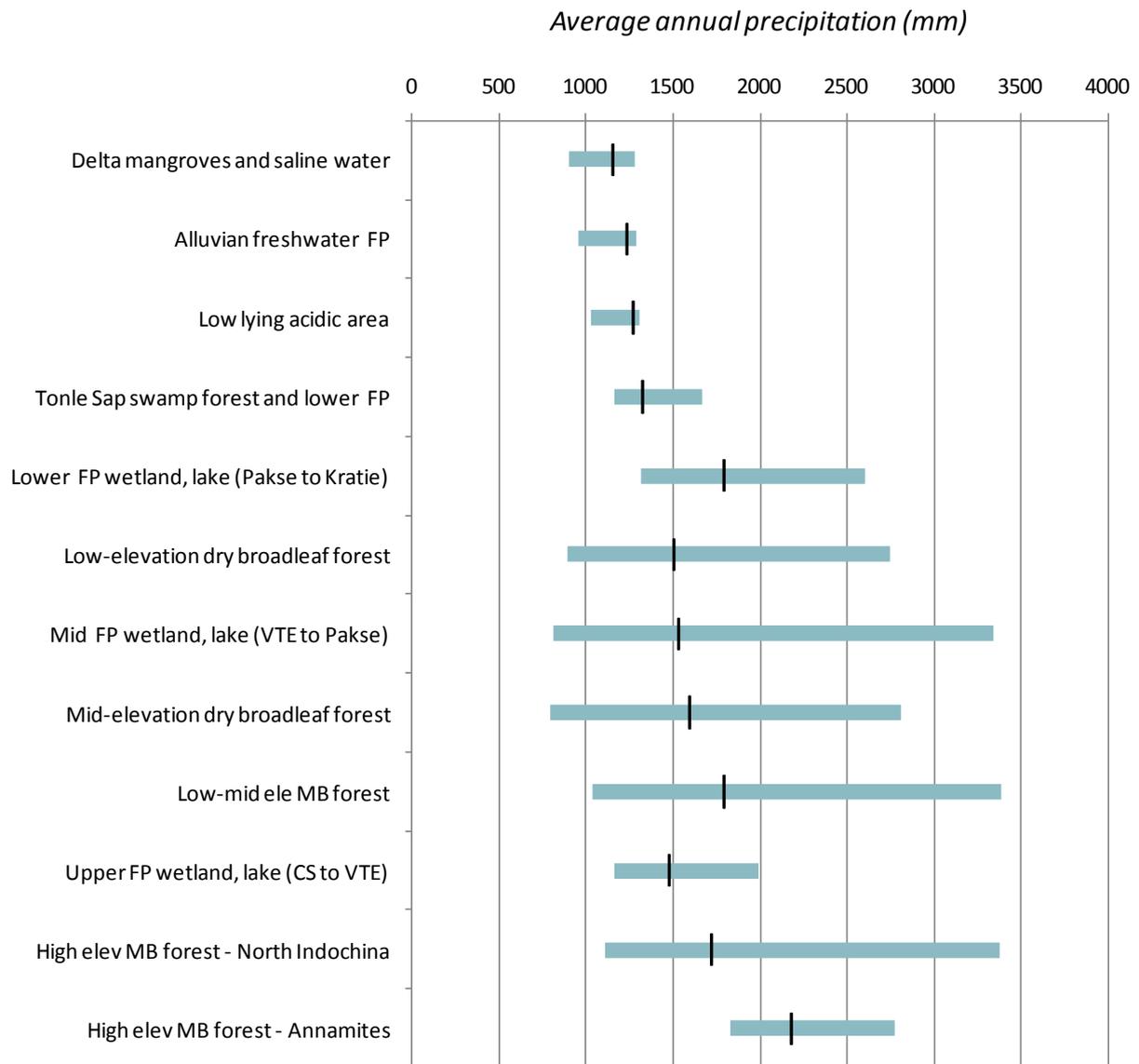


Figure 10. Ecozone annual precipitation mean and range (degree) (Source: ICEM, 2012)

Ecozone temperature

Annual average daily maximum temperature of the ecozones generally decreases with elevation (Figure 11). The warmer ecozones are the delta areas and the colder ecozones are the higher elevation moist broadleaf forest zones in the North and East of the basin.

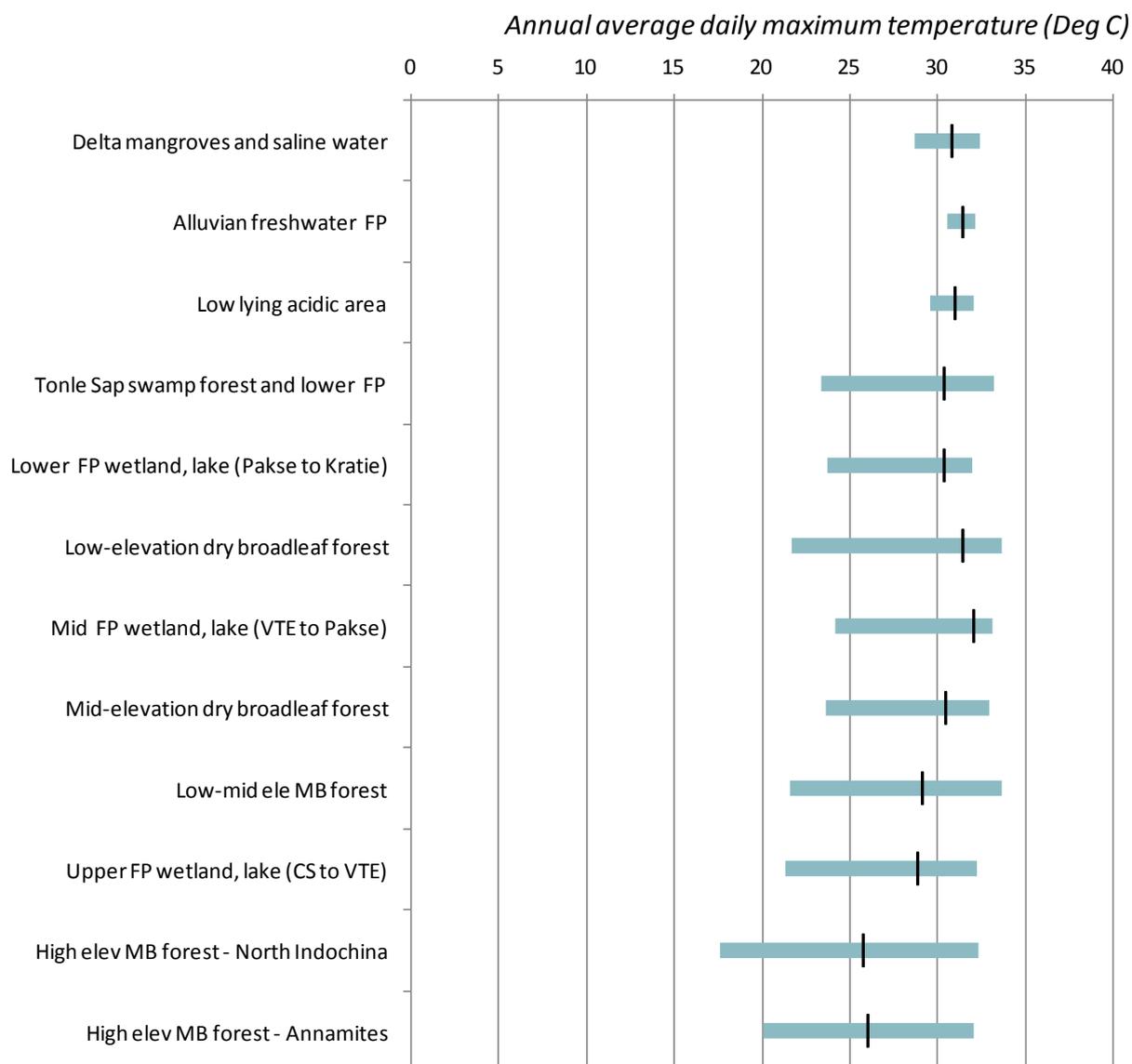
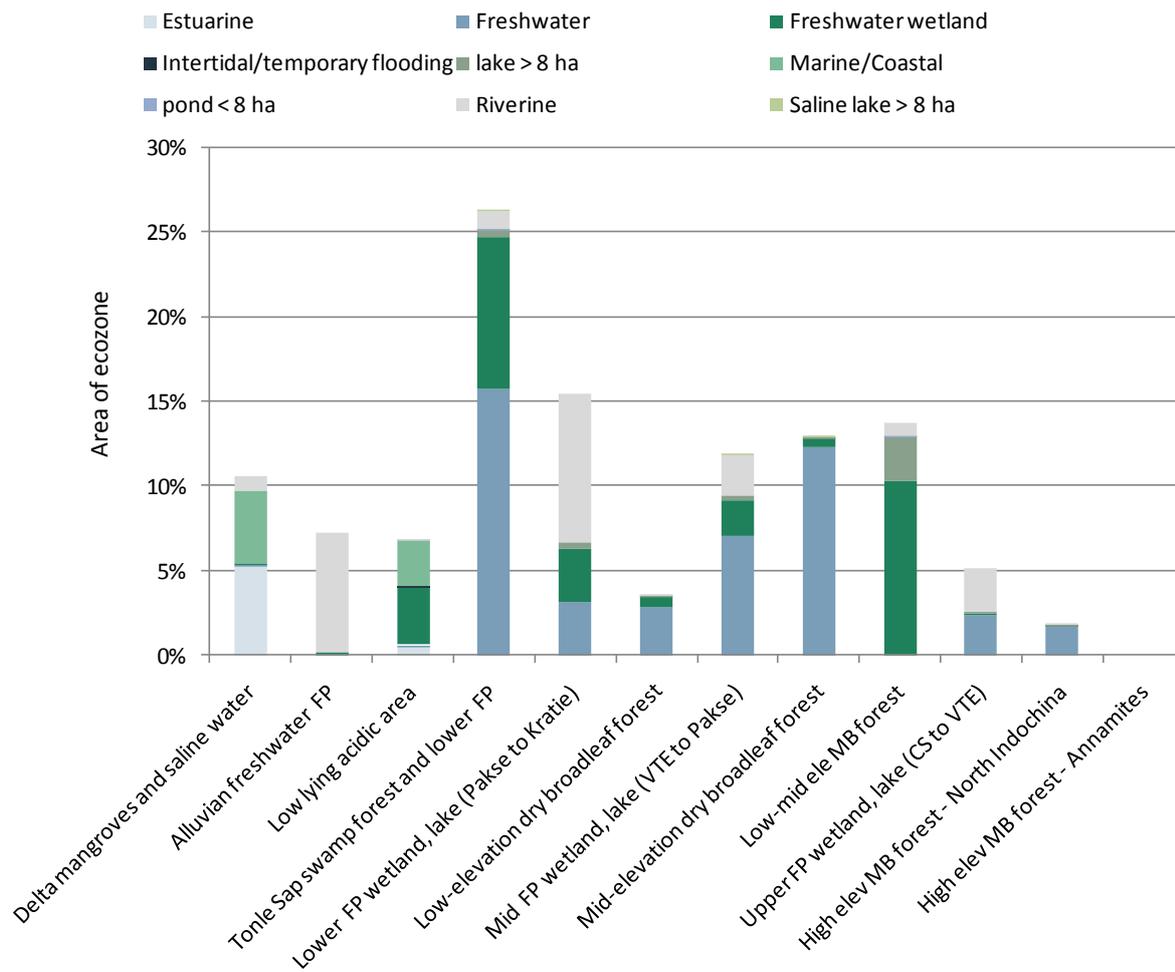


Figure 11. Ecozone annual average daily maximum temperature mean and range (deg C) (Source: ICEM, 2012)

NATURAL SYSTEMS

Wetlands

Analysis of wetland types in the LMB shows that the Tonle Sap forest and lower floodplain ecozone has the highest percentage coverage of wetlands. Due to the large freshwater Tonle Sap lake over a quarter of this ecozone is defined as freshwater and freshwater wetland. The High elevation moist broadleaf forest – Annamites is the only zone which does not contain any wetlands, even the High elevation moist broadleaf forest – North Indochina zone contains a small amount of the freshwater wetland type.



Protected areas

Consideration of the percentage coverage of Protected Areas in the ecozones can give an indication of the importance of NTFP's for the communities living in the zone. The relatively sparsely populated and undeveloped High elevation moist broadleaf forest zone of the Annamites has over 25 % of its area designated as Protected Areas. The heavily populated and agriculture dependent area of the Alluvial freshwater floodplain ecozone does have contain any Protected Areas.

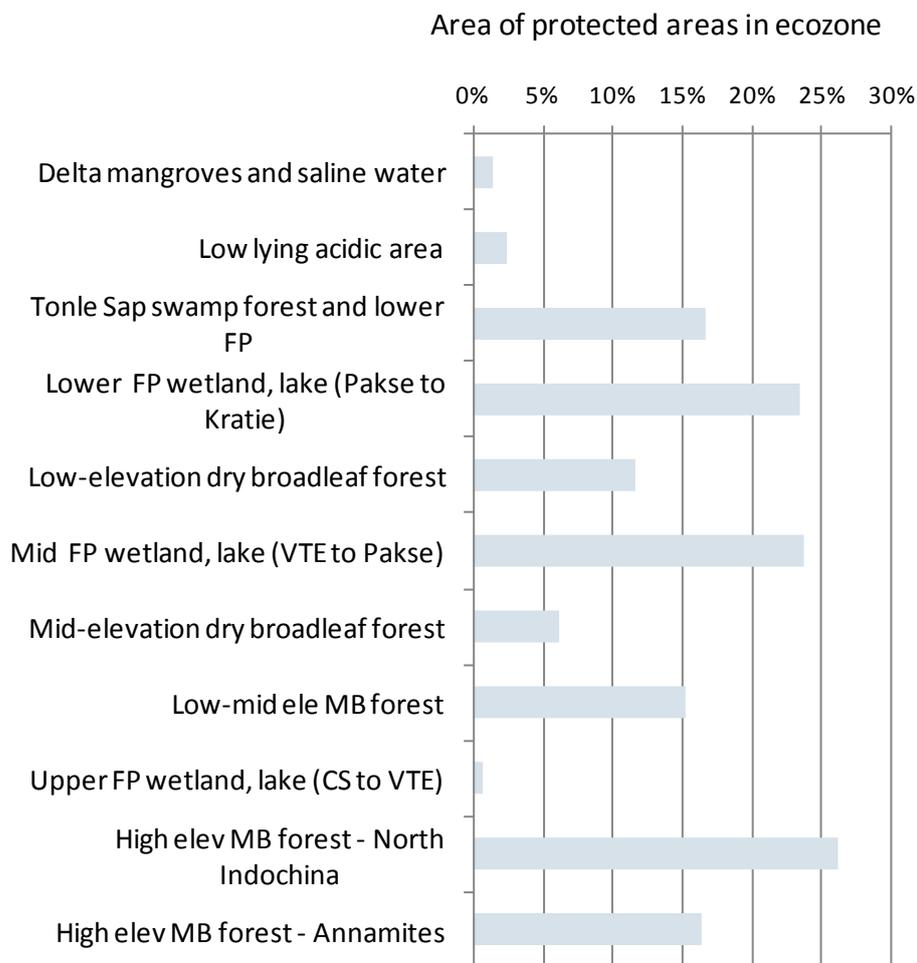


Figure 12. Percentage of ecozone area that is located in a Protected Area (Source MRC database, 2001; Birdlife, 2010 and WWF, 2010)

DEVELOPMENT PRESSURES

Irrigation density

Analysis of the irrigation canal density and irrigated area gives an indication of the level of development of agriculture in each of the ecozones. Figure 13 shows that the three ecozones of the delta are almost completely covered by irrigation which reflects their status as Vietnam's "Breadbasket". The reliance on irrigation drops dramatically further north with some concentration in the floodplain zones due to their close proximity to the Mekong.

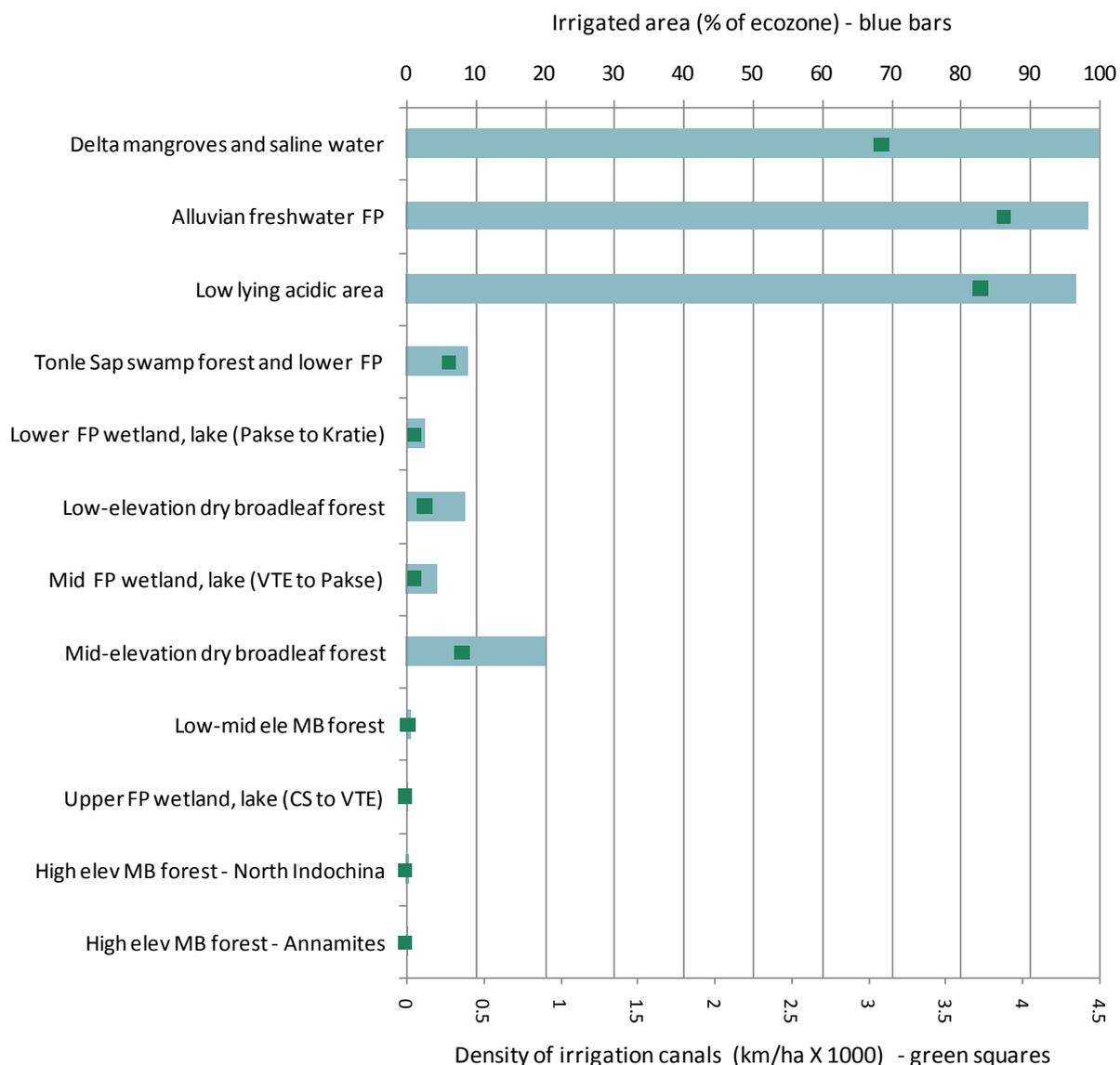


Figure 13. Percentage of ecozone area that is irrigated (Source MRC database, 2001)

Road density

Analysis of the road density gives an indication of the level of development of each ecozones. Figure 14 shows that the highly populated and developed Lower floodplain wetland (Pakse to Kratie) has the highest road density and the relatively sparsely populated High elevation moist broadleaf forest North Indochina zone has the lowest.

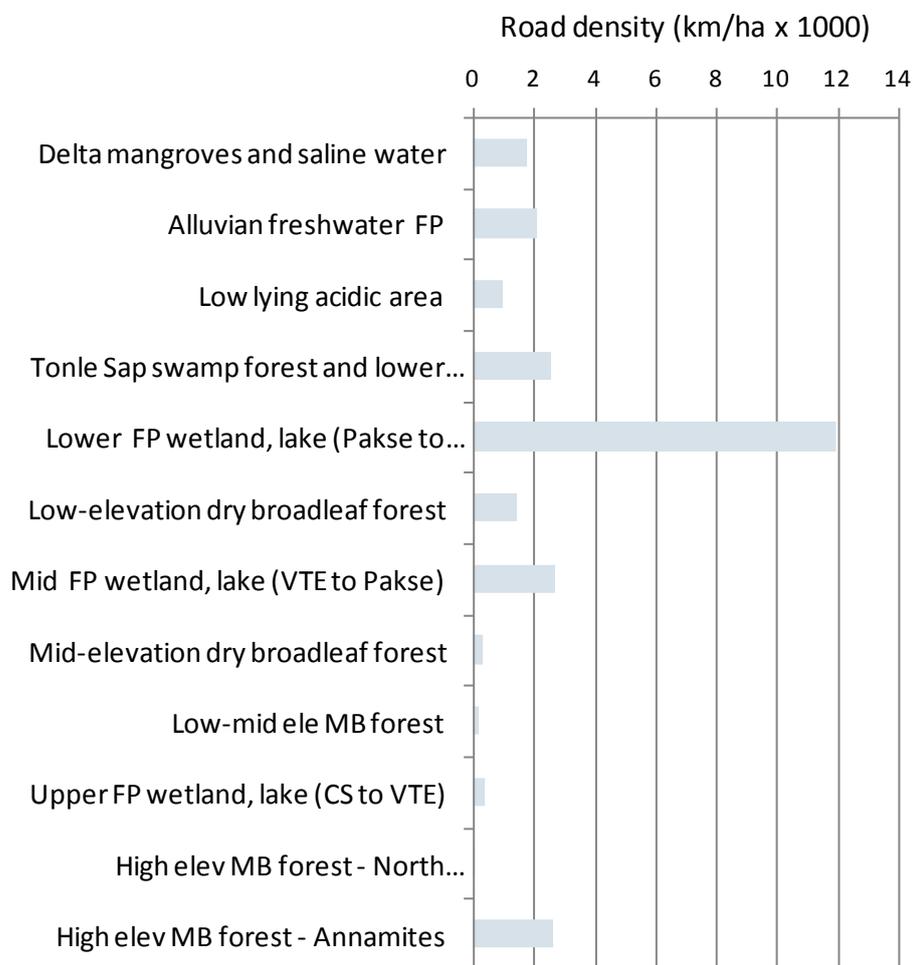


Figure 14. Ecozone road density (Source MRC database, 2001)

ECOZONE DATA TABLES**Delta mangroves and saline water**

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	1,270,215			
Elevation (m)	1	0	206	206
Slope (deg)	0.17	0	29.4372	29.4
Average annual precipitation (mm)	1,159	900.7	1276.83	376.2
Annual average daily maximum temperature (deg C)	30.9	28.7	32.4493	3.7
Area irrigated (%)	100			
Area irrigated (ha)	1,262,452			
Length of irrigation canals (km)	3,883			
Density of irrigation canals (km/ha x 1000)	3.08			
Length of roads (km)	2,236			
Density of roads (km/ha x 1000)	1.76			
Protected areas (%)	1			
Protected areas (ha)	18,831			

Alluvial freshwater floodplain

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	755,301			
Elevation (m)	1	0	240	240
Slope (deg)	0.25	0	34.2827	34.3
Average annual precipitation (mm)	1,241	959.5	1290.29	330.8
Annual average daily maximum temperature (deg C)	31.5	30.6	32.197	1.6
Area irrigated (%)	98			
Area irrigated (ha)	754,053			
Length of irrigation canals (km)	2,974			
Density of irrigation canals (km/ha x 1000)	3.88			
Length of roads (km)	1,572			
Density of roads (km/ha x 1000)	2.08			
Protected areas (%)	0			
Protected areas (ha)	0			

Low lying acidic area

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	1,438,636			
Elevation (m)	3	0	657	657
Slope (deg)	0.37	0	44.108	44.1
Average annual precipitation (mm)	1,271	1023.3	1307	283.7
Annual average daily maximum temperature (deg C)	31.0	29.6	32.0995	2.5
Area irrigated (%)	97			
Area irrigated (ha)	1,404,944			
Length of irrigation canals (km)	5,412			
Density of irrigation canals (km/ha x 1000)	3.72			
Length of roads (km)	1,406			
Density of roads (km/ha x 1000)	0.98			
Protected areas (%)	2			
Protected areas (ha)	34,475			

Tonle Sap swamp forest and lower floodplain (Kratie to delta)

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	3,787,544			
Elevation (m)	17	0	1587	1587
Slope (deg)	0.55	0	44.226	44.2
Average annual precipitation (mm)	1,327	1161.7	1669.17	507.5
Annual average daily maximum temperature (deg C)	30.4	23.3	33.1862	9.8
Area irrigated (%)	9			
Area irrigated (ha)	340,544			
Length of irrigation canals (km)	1,060			
Density of irrigation canals (km/ha x 1000)	0.28			
Length of roads (km)	9,723			
Density of roads (km/ha x 1000)	2.57			
Protected areas (%)	17			
Protected areas (ha)	632,548			

Lower floodplain, wetland, lake (Pakse to Kratie)

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	851,590			
Elevation (m)	109	0	1419	1419
Slope (deg)	1.98	0	50.4516	50.5
Average annual precipitation (mm)	1,795	1315.4	2603.59	1288.2
Annual average daily maximum temperature (deg C)	30.4	23.8	31.9575	8.2
Area irrigated (%)	3			
Area irrigated (ha)	273,537			
Length of irrigation canals (km)	604			
Density of irrigation canals (km/ha x 1000)	0.06			
Length of roads (km)	10,167			
Density of roads (km/ha x 1000)	11.94			
Protected areas (%)	23			
Protected areas (ha)	2,431,906			

Low elevation dry broadleaf forest

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	17,395,341			
Elevation (m)	127	0	1597	1597
Slope (deg)	1.21	0	50.2896	50.3
Average annual precipitation (mm)	1,508	893.8	2750.79	1857.0
Annual average daily maximum temperature (deg C)	31.5	21.7	33.6725	11.9
Area irrigated (%)	8			
Area irrigated (ha)	1,481,358			
Length of irrigation canals (km)	2,012			
Density of irrigation canals (km/ha x 1000)	0.11			
Length of roads (km)	24,975			
Density of roads (km/ha x 1000)	1.44			
Protected areas (%)	12			
Protected areas (ha)	2,013,788			

Mid floodplain, wetland, lake (Vientiane to Pakse)

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	3,153,304			
Elevation (m)	172	63	1859	1796
Slope (deg)	1.69	0	53.5724	53.6
Average annual precipitation (mm)	1,540	813.3	3339.02	2525.7
Annual average daily maximum temperature (deg C)	32.1	24.2	33.1175	8.9
Area irrigated (%)	4			
Area irrigated (ha)	504,267			
Length of irrigation canals (km)	711			
Density of irrigation canals (km/ha x 1000)	0.06			
Length of roads (km)	8,571			
Density of roads (km/ha x 1000)	2.72			
Protected areas (%)	24			
Protected areas (ha)	2,673,943			

Mid elevation dry broadleaf forest

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	11,311,211			
Elevation (m)	351	40	2238	2198
Slope (deg)	4.27	0	57.3513	57.4
Average annual precipitation (mm)	1,599	797.3	2813.67	2016.3
Annual average daily maximum temperature (deg C)	30.5	23.6	32.9888	9.4
Area irrigated (%)	20			
Area irrigated (ha)	632,544			
Length of irrigation canals (km)	1,131			
Density of irrigation canals (km/ha x 1000)	0.36			
Length of roads (km)	4,096			
Density of roads (km/ha x 1000)	0.36			
Protected areas (%)	6			
Protected areas (ha)	194,902			

Low-mid ele moist broadleaf forest

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	10,405,966			
Elevation (m)	423	0	2310	2310
Slope (deg)	7.72	0	69.6077	69.6
Average annual precipitation (mm)	1,797	1036.2	3387.33	2351.1
Annual average daily maximum temperature (deg C)	29.2	21.6	33.63	12.0
Area irrigated (%)	1			
Area irrigated (ha)	5,442			
Length of irrigation canals (km)	3			
Density of irrigation canals (km/ha x 1000)	0.00			
Length of roads (km)	1,817			
Density of roads (km/ha x 1000)	0.17			
Protected areas (%)	15			
Protected areas (ha)	129,354			

Upper floodplain wetland, lake (Chiang Saen to Vientiane)

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	1,433,942			
Elevation (m)	519	137	1904	1767
Slope (deg)	11.51	0	61.0538	61.1
Average annual precipitation (mm)	1,480	1162.8	1988.67	825.9
Annual average daily maximum temperature (deg C)	28.9	21.3	32.2463	10.9
Area irrigated (%)	0			
Area irrigated (ha)	2,398			
Length of irrigation canals (km)	0			
Density of irrigation canals (km/ha x 1000)	0.00			
Length of roads (km)	584			
Density of roads (km/ha x 1000)	0.41			
Protected areas (%)	1			
Protected areas (ha)	10,190			

High-elevation moist broadleaf forest - North Indochina

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	8,333,984			
Elevation (m)	916	203	2804	2601
Slope (deg)	13.85	0	62.2993	62.3
Average annual precipitation (mm)	1,723	1111.9	3377.83	2265.9
Annual average daily maximum temperature (deg C)	25.8	17.6	32.3592	14.7
Area irrigated (%)	0			
Area irrigated (ha)	6,451			
Length of irrigation canals (km)	2			
Density of irrigation canals (km/ha x 1000)	0.00			
Length of roads (km)	807			
Density of roads (km/ha x 1000)	0.10			
Protected areas (%)	26			
Protected areas (ha)	453,641			

High elevation moist broadleaf forest - Annamites

Parameter	TOTAL/MEAN	MIN	MAX	RANGE
Area (ha)	1,738,841			
Elevation (m)	997	73	2380	2307
Slope (deg)	12.31	0	56.4014	56.4
Average annual precipitation (mm)	2,183	1831.8	2776.16	944.3
Annual average daily maximum temperature (deg C)	26.1	20.1	32.0736	12.0
Area irrigated (%)	0			
Area irrigated (ha)	12,506			
Length of irrigation canals (km)	0			
Density of irrigation canals (km/ha x 1000)	0.00			
Length of roads (km)	4,543			
Density of roads (km/ha x 1000)	2.61			
Protected areas (%)	16			
Protected areas (ha)	1,366,098			

Soil Group according Level 1 FAO classification

Delta zones

Ecozone	Percentage of ecozone area					
	Acrisol	Cambisol	Fluvisol	Gleysol	Water	Other soil types
Alluvian freshwater FP	2.89	17.81	3.80	69.37	5.95	0.18
Delta mangroves and saline water	0.14	2.52	32.25	57.36	4.64	3.09
Low lying acidic area	5.11	0.53	0.70	90.46	0.44	2.77

Ecozone	Area (ha)					
	Acrisol	Cambisol	Fluvisol	Gleysol	Water	Other soil types
Alluvian freshwater FP	21,853	134,553	28,685	523,915	44,958	1,337
Delta mangroves and saline water	1,841	32,033	409,621	728,557	58,952	39,211
Low lying acidic area	73,445	7,559	10,103	1,301,362	6,289	39,879

Soil Group according Level 1 FAO classification

Broadleaf forest zones

Ecozone	Percentage of ecozone area					
	Acrisol	Cambisol	Ferralsol	Leptosol	Slope Complex	Other soil types
High elev MB forest - Annamites	85.89	6.53	2.71	3.29	0.00	1.57
High elev MB forest - North Indochina	74.37	14.99	0.03	0.74	7.05	2.82
Low-elevation dry broadleaf forest	70.00	8.37	1.76	1.43	0.70	17.74
Low-mid elev. MB forest	53.10	17.28	0.53	10.48	7.62	10.98
Mid-elevation dry broadleaf forest	58.28	6.04	8.06	2.85	10.94	13.83

Ecozone	Area (ha)					
	Acrisol	Cambisol	Ferralsol	Leptosol	Slope Complex	Other soil types
High elev MB forest - Annamites	1,493,567	113,557	47,121	57,233		27,363
High elev MB forest - North Indochina	6,198,248	1,249,647	2,289	61,473	587,487	234,841
Low-elevation dry broadleaf forest	12,177,078	1,455,155	306,695	249,243	122,091	3,085,080
Low-mid elev. MB forest	5,525,564	1,797,956	55,318	1,090,813	793,379	1,142,936
Mid-elevation dry broadleaf forest	6,591,860	682,646	912,031	322,568	1,237,988	1,564,117

Soil Group according Level 1 FAO classification
Floodplain zones

Ecozone	Percentage of ecozone area								Other soil types
	Acrisol	Arenosol	Cambisol	Gleysol	Luvisol	Plinthosol	Slope Complex	Water	
Lower FP wetland, lake (Pakse to Kratie)	46.80	0.00	21.87	8.31	3.16	0.03	0.00	16.22	3.62
Mid FP wetland, lake (VTE to Pakse)	64.23	6.13	4.72	7.30	5.68	0.56	1.36	4.52	5.49
Tonle Sap swamp forest and lower FP	41.09	2.28	8.83	22.10	3.07	5.01	0.00	9.97	7.64
Upper FP wetland, lake (CS to VTE)	59.43	0.00	20.75	0.64	1.62	0.00	11.04	4.84	1.68

Ecozone	Area (ha)								Other soil types
	Acrisol	Arenosol	Cambisol	Gleysol	Luvisol	Plinthosol	Slope Complex	Water	
Lower FP wetland, lake (Pakse to Kratie)	398,534		186,273	70,743	26,870	216		138,108	30,845
Mid FP wetland, lake (VTE to Pakse)	2,025,342	193,238	148,952	230,339	179,154	17,600	42,992	142,425	173,262
Tonle Sap swamp forest and lower FP	1,556,338	86,392	334,462	837,045	116,141	189,904		377,748	289,514
Upper FP wetland, lake (CS to VTE)	852,168		297,474	9,207	23,282		158,323	69,451	24,037

MRC wetland types

Ecozone	Area (ha)								
	Estuarine	Freshwater	Freshwater wetland	Intertidal/temporary flooding	lake > 8 ha	Marine/Coastal	pond < 8 ha	Riverine	Saline lake > 8 ha
Delta mangroves and saline water	68,241	48	1,487			53,448		11,275	
Delta fresh water swamp forest	275		1,278					53,509	
Delta peat swamp forest	8,909	271	48,903	361		40,161		91	
Low-elevation dry broadleaf forest	66	597,137	339,213		18,356		258	40,085	3,933
Lower floodplain, wetland, lake (Pakse to Kratie)	674	26,324	26,880		3,303			74,726	
Low-mid ele moist broadleaf forest		499,442	114,072		5,955			4,302	
Mid floodplain, wetland, lake (VTE to Pakse)		222,270	67,334		9,159			75,815	1,622
Mid-elevation dry broadleaf forest		1,392,861	66,204		3,806			3,652	1,068
Tonle Sap swamp forest and lower floodplain	136	3,339	1,070,890		279,200		1,261	72,580	
Upper floodplain wetland, lake (CS to VTE)		34,405	1,566		352			37,947	
High elevation moist broadleaf forest - North Indochina		152,992	136		91			3,347	
High elev MB forest - Annamites									

Ecozone	Percentage of ecozone area								
	Estuarine	Freshwater	Freshwater wetland	Intertidal/temporary flooding	lake > 8 ha	Marine/Coastal	pond < 8 ha	Riverine	Saline lake > 8 ha
Delta mangroves and saline water	5.37	0.00	0.12			4.21		0.89	
Alluvian freshwater FP	0.04		0.17					7.08	
Low lying acidic area	0.62	0.02	3.40	0.03		2.79		0.01	
Tonle Sap swamp forest and lower FP	0.00	15.77	8.96		0.48		0.01	1.06	0.10
Lower FP wetland, lake (Pakse to Kratie)	0.08	3.09	3.16		0.39			8.77	
Low-elevation dry broadleaf forest		2.87	0.66		0.03			0.02	
Mid FP wetland, lake (VTE to Pakse)		7.05	2.14		0.29			2.40	0.05
Mid-elevation dry broadleaf forest		12.31	0.59		0.03			0.03	0.01
Low-mid ele MB forest	0.00	0.03	10.29		2.68		0.01	0.70	
Upper FP wetland, lake (CS to VTE)		2.40	0.11		0.02			2.65	
High elev MB forest - North Indochina		1.84	0.00		0.00			0.04	
High elev MB forest - Annamites									



ECOZONE CHARACTERISTICS MAPS

Ecozone elevation

Ecozone slope

Ecozone precipitation

Ecozone temperature

Ecozone irrigation areas and canals

Ecozone soil

- FAO level 1 classification

- Soil depth

- Soil stability

- Sulfur soil toxicity – delta area

- Salt soil toxicity

- Top soil texture

- Inundation depth

- Inundation duration

- Presence of iron pan

Ecozone protected areas and wetlands