Draft Environment and Social Impact Assessment

Project Number: 55205-001
29 April 2022

Lao PDR: Monsoon Wind Power Project
Part 16: Appendix F (part 2)

Prepared by Impact Energy Asia Development Limited (IEAD) for the Asian Development Bank.

Monsoon Wind Power Project, Sekong and Attapeu Provinces, Lao PDR

Environmental and Social Impact Assessment

29 April 2022

Project No.: 0598121

The business of sustainability

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APPENDIX F BIODIVERSITY BASELINE SURVEY REPORTS

Sample Point: 27 Nearest location: Ban Dak Sieng

Forest type/Ecosystem: Semi-evergreen forest ecosystem

Latitude (N)	Longitude (E)	Altitude	Date
1707606	731359	1,285 m a.s.l.	Dec 30, 2020

Initial Field Assessment:

Low **Moderate** High Exceptional
(Flora & Fauna)

Reason for initial assessment:

Upper semi-evergreen forests and as part of Dakcheung plateau which would support some important forest habitats for fauna species.

Habitat Description:

Upper semi-evergreen forest and some young fallow, the habitat condition remains quite good especially to the east. This plot of 500m radius is considered fairly good ecological status as original forest remains with some diversity of flora and fauna.

Characteristic flora (composition):

Mainly semi-evergreen forest, with mostly medium and some large trees. The trees are quite high (height 35m and DBH 60m), including a large pine tree. The forest structure has only 2 layers, the higher layer is highly dominant by Mai kor (*Quercus and and Lithocarpus*) and pines.

Flora species or interest (present or likely to be present):

Dominance: Mai kor, Mai Meuad, Mai Paek (see the list).

Key species: Mai Khaenhin (Hopea, EN)

Native species: None

Fauna species (present or highly likely to be present):

Species/signs of species recorded for:

Key species: None

Other species/native species: some number of small forest birds especially bulbul, flycatchers, bargets, bushchats and warblers (see the list).

Species of interest likely to be present:

Key species: None

Other species/native species: squirrel, flying squirrel, Red junglefowl, mongoose etc., (see the list).

Ecosystems Services comments

Watershed and NTFPs.

Woodpeecker

List of some flora species at the sample plot

No	Local Name	Scientific Name	Family Name	IUCN RedList	Remarks
1	Mai Paek	*Pinus kesiya*	PINACEAE		
2	Mai kham pom	*Phyllanthus emblica L*	PHYLLANTHACEAE		
3	Mai kor nok	*Lithocarpus polystachyus (Wall.) Rehd*	FAGACEAE		
4	Mai kor nam	*Castancea mollissima Blume*	FAGACEAE		
5	Mai meaud	*Aporosa tetrapleura Hance*	EUPHORBIACEAE		
6	Mai kor houm	*Quercus fabrei*	FAGACEAE		
7	Mai kor ban	*Lithocarpus corneus (Lour.) Rehder*	FAGACEAE		
8	Mai kor noy	*Morella cerifere (L.) small*	MYRICACEAE		
9	Mai san	*Dillenia turbinata Finet&Gagnep*	DILLNIACEAE		
10	Wai	*Calamus sp.*	CALAMOIDEAE		
11	Mai hing luang	*Dacrydium elatum (Roxb.) Wall. ex.*	PODOCARPACEAE		
12	Mai Chuang	*Cinnamomum iners Reinw. ex Blume*	LAURACEAE		
13	Mai khaen hin	*Hopea pierrei Hance*	DIPTEROCARPCEAE		
14					
15					

List of some fauna species at the sample plot

No	Local Name	Common Name	Scientific Name	IUCN RedList	Remarks
1	Chon phon	Small Asian Mongoose	*Herpestes javanicus*		L, suitability, report
2	Seua meo	Leopard cat	*Prio. bengalensis*		L, suitability, report
3	Ngen	Civet sp.			L, suitability, report
4	Nok khao	Asian Barred Owlet	*Glaucidium cuculoides*		L, suitability, report
4	Leo ta luang	Crested Serpent Eagle	*Spilornis cheela*		L, sighting
4	Ka tae	Indo. ground squirrel	*Menetes berdmorei*		L, feeding site seen
5	Bang nai	Phayrei's Flying squirrel	*Hylopetes sp.*		L, feeding site seen
6	Nok Eing mong	Black collared Starling	*Gracupica nigricollis*		L, sighting
7	Kai pa	Red junglefowl	*Gallus gallus*		L, feeding site seen
8	Nok jib	Warbler sp.	*Phyloscopus sp.*		L, sighting

9	Nok ka thad deng	Red-whiskered Bulbul	*Pycnonotus jocosus*		L, sighting
10	Nok khiew	Common Iora	*Aegithina tiphia*		L, sighting
11	Nok ka thad dam	Black crested Bulbul	*Rubigula flaviventris*		L, sighting
12	Nok keo	Blossom-headed Parakeet	*Psittacula roseata*		L, suitability, report
13					
14					
15					

- **Rating of the ecosystem integrity at location** (1 = Poor to 5 = excellent)

Key Parameter	Rating	Justification
Habitat/forest structure	**3.5**	Forest habitat condition remains quite good, but some parts of the sample plot is were pine tree forest. It has 2 layers of canopy, with some pine tree species.
Flora	**3.5**	Flora species remains as pretty good status except some part was fallow, also quite mixed with some pine community.
Fauna	**3.5**	Some few medium and small wildlife species are present in the area, probably some globally threatened species but highly possible away to northeast from the plot as habitat suitability, also Red-shanked Douc Langur and Gibbon were reported.
Ecosystem integrity	**3.5**	Forest habitat condition remains quite good, original semi-evergreen forest remains quite largely, with some medium and small species of fauna species are present, certainly declined today in quantity.
Ecosystem status	**M+**	Some interesting in further northeast from the plot, it has some pine community which would not principally provide high number of flora and fauna species.

- **Current threats and management**

Nothing, neither this sample plot is classified to be part of any conservation area in the country nor any management is in place. Hunters with guns were found in the forest.

Sample Point: 28 Nearest location: Ban Dak Sieng

Forest type/Ecosystem: Semi-evergreen forest ecosystem

Latitude (N)	Longitude (E)	Altitude	Date
1704747	731985	1,264 m a.s.l.	Dec 30, 2020

Initial Field Assessment:

Low **Moderate** High Exceptional
(Flora & Fauna)

Reason for initial assessment:

Upper semi-evergreen forests and as part of Dakcheung plateau which would support some important forest habitats for fauna species.

Habitat Description:

Upper semi-evergreen forest and some young fallow, the habitat condition remains quite good especially to the east. This plot of 500m radius is considered fairly good ecological status as original forest remains with some diversity of flora and fauna. Pine tree in the area is considered high but some small part of the forest was newly slashed for agricultural land.

Characteristic flora (composition):

Mainly semi-evergreen forest, with mostly medium trees (height 25m and DBH 40m). The forest structure has only 2 layers, the higher layer is highly dominant by Mai kor (*Quercus and and Lithocarpus)* and pines.

Flora species or interest (present or likely to be present):

Dominance: Mai kor ban, Mai Meuad and Mai Paek (see the list).

Key species: Mai Khaenhin (Hopea, EN)

Native species: None

Fauna species (present or highly likely to be present):

Species/signs of species recorded for:

Key species: None

Other species/native species: Asian Barred Owlet, and some number of small forest birds especially bulbuls, flycatchers and warblers (see the list).

Species of interest likely to be present:

Key species: None

Other species/native species: Silver pheasant (see the list).

Ecosystems Services comments
Watershed and NTFPs.

Striped-throated Bulbul

List of some flora species at the sample plot

No	Local Name	Scientific Name	Family Name	IUCN RedList	Remarks
1	Mai Paek	*Pinus kesiya*	PINACEAE		
2	Mai kham pom	*Phyllanthus emblica L*	PHYLLANTHACEAE		
3	Mai kor nok	*Lithocarpus polystachyus (Wall.) Rehd*	FAGACEAE		
4	Mai kor nam	*Castancea mollissima Blume*	FAGACEAE		
5	Mai meaud	*Aporosa tetrapleura Hance*	EUPHORBIACEAE		
6	Mai kor houm	*Quercus fabrei*	FAGACEAE		
7	Mai kor ban	*Lithocarpus corneus (Lour.) Rehder*	FAGACEAE		
8	Mai kor noy	*Morella cerifere (L.) small*	MYRICACEAE		
9	Mai hing luang	*Dacrydium elatum (Roxb.) Wall. ex.*	PODOCARPACEAE		
10	Mai Chuang	*Cinnamomum iners Reinw. ex Blume*	LAURACEAE		
11	Mai khaen hin	*Hopea pierrei Hance*	DIPTEROCARPCEAE		
12					
13					
14					
15					

List of some fauna species at the sample plot

No	Local Name	Common Name	Scientific Name	IUCN RedList	Remarks
1	Fan	Barking Deer	*Muntiacus muntjac*		L, suitability, report
2	Mu pa	Wild Pig	*Sus scrofa*		L, suitability, report
3	Ngen hang kan	Large Indian Civet	*Viverra zebetha*		L, suitability, report
4	Ngen Om	Common Palm Civet	*Para. hermaphroditus*		L, suitability, report
5	Ngen Khor	Binturong	*Arctictis binturong*	VU	L, suitability, report
6	Chon phon	Small Asian Mongoose	*Herpestes javanicus*		L, suitability, report
7	Seua meo	Leopard cat	*Prio. bengalensis*		L, suitability, report
8	Ngen	Civet sp.			L, suitability, report
9	Nok khao	Asian Barred Owlet	*Glaucidium cuculoides*		L, suitability, report
10	Nok ka thad seak	Stripe-throated Bulbul	*Pycnonotus finlaysoni*		L, suitability, report
11	Ka tae	Indo. ground squirrel	*Menetes berdmorei*		L, feeding site seen
12	Bang nai	Phayrei's Flying squirrel	*Hylopetes sp.*		L, feeding site seen
13	Nok Eing mong	Black collared Starling	*Gracupica nigricollis*		L, sighting
14	Kai pa	Red junglefowl	*Gallus gallus*		L, feeding site seen
15	Nok jib	Warbler sp.	*Phyloscopus sp.*		L, sighting
16	Nok ka thad deng	Red-whiskered Bulbul	*Pycnonotus jocosus*		L, sighting

17	Nok khiew	Common Iora	*Aegithina tiphia*		L, sighting
18	Nok ka thad dam	Black crested Bulbul	*Rubigula flaviventris*		L, sighting
19	Nok fai	Scarlet Mivinet	*Pericrocotus speciosus*		L, sighting
20					

- **Rating of the ecosystem integrity at location** (1 = Poor to 5 = excellent)

Key Parameter	Rating	Justification
Habitat/forest structure	**3.0**	Forest habitat condition remains good, but some parts of the sample plot, about 30% was a secondary forest. It has 2 layers of canopy, with some pine tree species.
Flora	**3.5**	Tree species remains as pretty original status but some parts were converted.
Fauna	**2.5**	Some few medium and small wildlife species are present in the area, probably hardly any globally threatened species.
Ecosystem integrity	**3.0**	Forest habitat condition remains quite good, original semi-evergreen forest remains quite largely, with some medium and small species of fauna species are present, it is quite close to Ban Dak Sieng, certainly declined today in quantity.
Ecosystem status	**M**	Some interesting, but not really since it has some pine community which would not provide principally high number of flora and fauna species.

- **Current threats and management**

Nothing, neither this sample plot is classified to be part of any conservation area in the country nor any management is in place.

Sample Point: 29 Nearest location: Ban Dak Bong

Forest type/Ecosystem: Shrubland/Semi-evergreen forest ecosystem

Latitude (N)	Longitude (E)	Altitude	Date
1708832	744106	1,215 m a.s.l.	Dec 27, 2020

Initial Field Assessment:

Low Moderate High Exceptional
(Flora & Fauna)

Reason for initial assessment:

Shrubland as part of Dakcheung plateau which would support some important forest habitats for fauna species.

Habitat Description:

Shrubland/fallows, originally from upper semi-evergreen forest. The habitat condition remains very poor. This plot of 500m radius is considered very poor ecological status as no original forest remains with very low biodiversity of flora and fauna species.

Characteristic flora (composition):

As shrubland/fallows with mostly medium trees (height 20m and DBH 40m. The forest structure has only 2 layers, the higher layer is highly dominant by Mai kor (Quercus and and Lithocarpus) and Mai meaud.

Flora species or interest (present or likely to be present):

Dominance: Mai Meuad, Mai kor and Mai Khampom (see the list).

Key species: None

Native species: None

Fauna species (present or highly likely to be present):

Species/signs of species recorded for:

Key species: None

Other species/native species: some small forest birds especially bulbul and warbler (see the list).

Species of interest likely to be present:

Key species: None

Other species/native species:

Phyllanthus

Ecosystems Services comments

Barely function anything of particular ecosystem service.

List of some flora species at the sample plot

No	Local Name	Scientific Name	Family Name	IUCN RedList	Remarks
1	Mai meaud	*Aporosa tetrapleura Hance*	EUPHORBIACEAE		
2	Mai kor nok	*Lithocarpus polystachyus (Wall.) Rehd*	FAGACEAE		
3	Mai kham pom	*Phyllanthus emblica L*	PHYLLANTHACEAE		
4	Mai kor houm	*Quercus fabrei*	FAGACEAE		
5	Mai kor nam	*Castancea mollissima Blume*	FAGACEAE		
6	Mai kor ban	*Lithocarpus corneus (Lour.) Rehder*	FAGACEAE		
7	Mai kor noy	*Morella cerifere (L.) small*	MYRICACEAE		
8	Mai meuad er	*Memecylon edule Roxb.*	MELASTOMATACEAE		
9	Mai meuad keo	*Aporosa planchoniana Baillon ex Müll-Arg.*	EUPHORBIACEAE		
10					
11					
12					
13					
14					
15					

List of some fauna species at the sample plot

No	Local Name	Common Name	Scientific Name	IUCN RedList	Remarks
1	Chon phon	Small Asian Mongoose	*Herpestes javanicus*		L, suitability, report
2	Nok khao	Asian Barred Owlet	*Glaucidium cuculoides*		L, suitability, report
3	Nok Eing mong	Black collared Starling	*Gracupica nigricollis*		L, sighting
4	Nok jib	Warbler sp.	*Phyloscopus sp.*		L, sighting
5	Nok ka thad deng	Red-whiskered Bulbul	*Pycnonotus jocosus*		L, sighting
6	Nok ka thad dam	Black crested Bulbul	*Rubigula flaviventris*		L, sighting
7					
8					
8					
10					
11					
12					
13					
14					
15					

- **Rating of the ecosystem integrity at location** (1 = Poor to 5 = excellent)

Key Parameter	Rating	Justification
Habitat/forest structure	**1.0**	Shrubland and some secondary forest was found in pattern, originally from semi-evergreen forest. One good forest block (6 ha) on east of the plot which would be a sacred or cemetery.
Flora	**1.5**	Some number of trees were found, mostly small and bush trees.
Fauna	**1.0**	Only a few small forest birds were present. This SP is just within the town.
Ecosystem integrity	**1.1**	Very poor
Ecosystem status	**L**	No any particular ecosystem value of this plot can be described.

- **Current threats and management**

Nothing, neither this sample plot is classified to be part of any conservation area in the country nor any management is in place. It is just in the urban area.

Annex 2. Percentage of detailed categories of land use type of the Monsoon Windfarm Power Project.

No	Land use type	Area (ha)	%
1	Annual Crop	364.11	0.52
2	Barren	939.32	1.33
3	Evergreen	28,518.64	40.39
4	Building	5.16	0.01
5	Coniferous Forest	2,336.08	3.31
6	Crop	681.78	0.97
7	Grass land	739.34	1.05
8	Orchard	229.97	0.33
9	Plantation	5,247.18	7.43
10	Rice paddy	161.59	0.23
10	Shifting cultivation	877.63	1.24
11	Shrubland	30,428.87	43.09
12	Water body	59.26	0.08
14	Other	26.51	0.04
	Grand Total	70,615.43	100.00

Annex 3. List of waypoints for Sample Plots

No. Plot	UTM		Decimal Degrees	
	East	North	Latitude	Longitude
1	727270	1697345	15.34273	107.116986
2	739117	1702633	15.389427	107.22779
3	736574	1704760	15.408873	107.204312
4	734181	1706786	15.427402	107.182213
5	734364	1700121	15.367171	107.18329
6	730495	1698537	15.353208	107.147118
7	747567	1713605	15.487736	107.307565
8	749978	1716544	15.512046	107.331694
9	751456	1718230	15.529139	107.344261
10	752442	1720013	15.545146	107.353637
11	728517	1691026	15.285527	107.128021
12	722722	1691660	15.291762	107.074138
13	724024	1688692	15.264831	107.085989
14	723622	1685728	15.238086	107.081985
15	741550	1705564	15.415671	107.250732
16	732667	1692737	15.300618	107.166806
17	733548	1695867	15.32881	107.175296
18	734510	1692456	15.29791	107.183932
19	730871	1688539	15.262852	107.1497
20	722583	1713727	15.491144	107.074818
21	725221	1706127	15.422253	107.098707
22	723518	1707135	15.431509	107.082932
23	726162	1713050	15.484717	107.108103
24	727867	1713321	15.487009	107.124011
25	731717	1714487	15.497198	107.159993
26	727211	1707366	15.43327	107.117355
27	731359	1707606	15.435067	107.156008
28	731985	1704747	15.409182	107.161572
29	744106	1708832	15.444957	107.274851

Annex 4. Summary of international environmental standards

As to ensure sustainable investment and development project there are several key international environmental standards for which the developer to consider as below:

- IFC Performance Standard 6
- ADB Environment and Social Safeguard (2009)
- World Bank Safeguard Policy

Under these environmental standards a project area must determine the presence of three habitat categories *Modified habitat, Natural habitat, Critical habitat.* These habitats may contain a large population of some or more fauna and flora as the habitat may support some critical ecosystem.

The international standards are concerned about the loss of critical habitats that could result in a reduction of a population of critically or endangered species. The IFC standard 6 recognizes that protecting and conserving biodiversity; maintaining ecosystem services and; sustainably managing living natural resources are fundamental to sustainable development.

Critical habitat are areas with High biodiversity value or High Conservation Value (HCV), including habitat required for the survival of critically endangered or endangered species according to IUCN Redlist 2013. It can be areas having special significance for endemic or restricted-range species; sites that are critical for the survival of migratory species; supporting globally significant concentrations, evolutionary processes or provide key ecosystem services; and areas having biodiversity of significance. Also, it is about those areas of international recognition such as Ramsar Site, World Natural Heritage including National Parks and National Protected Areas. Similarly, ADB and World Bank safeguards have to ensure environmental soundness and sustainability of projects and to support the integration of environmental considerations into the project decision-making process.

No project activities should be undertaken unless;

(i) there are no measurable adverse impacts such as critical habitat;
(ii) the project is not anticipated to lead to a reduction in the population of any recognized endangered or critically endangered species;
(iii) (iii) no mitigation measures are designed to achieve at least no net loss of biodiversity and;
(iv) any lesser impacts are mitigated.

If a project is located within a legally protected area, implement additional programs to promote and enhance the conservation aims of the protected area. In an area of natural habitats, there must be no significant conversion or degradation, unless;

(i) alternatives are not available;
(ii) (ii) the overall benefits from the project substantially outweigh the environmental costs, and
(iii) (iii) any conversion or degradation is appropriately mitigated. A combination of actions, such as post-project restoration of habitats, offset of losses through effective conservation action.

Annex 5. Data form for sample plot assessment

Sample Point: XXX   Nearest location: XXX

Forest type/Ecosystem: Upper Evergreen forest ecosystem

Latitude (N)	Longitude (E)	Altitude	Date

Initial Field Assessment:

Low   Moderate   High   Exceptional
(Flora & Fauna)

Reason for initial assessment:

Habitat Description:

Characteristic flora (composition):

Flora species or interest (present or likely to be present):

Dominance:

Key species:

Native species:

Fauna species (present or highly likely to be present):

Species/signs of species recorded for:

Key species:

Other species/native species:

Species of interest likely to be present:

Key species:

Other species/native species:

Ecosystems Services comments

List of flora species at the sample plot

No	Local Name	Scientific Name	Family Name	IUCN RedList	Remarks
1					
2					

3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

List of some fauna species at the sample plot

No	Local Name	Common Name	Scientific Name	IUCN RedList	Remarks
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

- **Rating of the ecosystem integrity at location** (1 = Poor to 5 = excellent)

Key Parameter	Rating	Justification
Habitat/forest structure		
Flora		
Fauna		
Ecosystem integrity		
Ecosystem status		

- **Current threats and management**

Annex 6. Distribution of Globally threatened species in the project area according IUCN/IBAT Database

No	Taxon	Common Name	Scientific Name	IUCN Status	REA/potential habitat for specie presence in the project area (NZ = northern zone)	Target species
I	**Amphibian**					
1			*Leptobrachium xanthops*	EN	No info	No
II	**Reptile**					
2		Siamese crocodile	*Crocodylus siamensis*	CR	No longer, no habitat potential	No
3		Keeled Box Turtle	*Cuora mouhotii*	EN	No info, maybe, both NZ and TL	Possible
4		Spitting Cobra	*Naja siamensis*	VU	Likely possible, both NZ and TL	Possible
5		King Cobra	*Ophiophagus hannah*	VU	Likely possible, both NZ and TL	Possible
6		Burmese Python	*Python bivittatus*	VU	Highly possible, both NZ and TL	Possible
7		Three Horned-scaled Pitviper	*Protobothrops sieversorum*	EN	Likely possible, both NZ and TL	Possible
III	**Bird**					
8		Masked Finfoot	*Heliopais personatus*	EN	No info, maybe, Upper Xekhaman, TL	Possible
9		Pale-capped Pigeon	*Columba punicea*	VU	Likely possible, both NZ and TL	Possible
10		Greater Spotted Eagle	*Clanga clanga*	VU	Likely possible, both NZ and TL	Possible
11		Yellow-breasted Bunting	*Emberiza aureola*	CR	Maybe, the IBA but its habitat already lost	No
12		Chestnut-eared Laughingthrush	*Garrulax konkakinhensis*	VU	Likely possible, both NZ and TL	Possible
13		Hill Myna	*Gracula robusta*	CR	Likely possible, both NZ and TL	Possible
14		White-rumped Vulture	*Gyps bengalensis*	CR	No info, very rare, maybe as just visiting	Possible
15		Slender-billed Vulture	*Gyps tenuirostris*	CR	No info, very rare, maybe as just visiting	Possible
16		Red-headed Vulture	*Sarcogyps calvus*	CR	No info, very rare, maybe as just visiting	Possible
17		Great Slaty Woodpecker	*Mulleripicus pulverulentus*	VU	Likely possible, both NZ and TL	Possible
18		Green Peafowl	*Pavo muticus*	EN	Likely possible, both NZ and TL	Possible
19		Black-bellied Tern	*Sterna acuticauda*	EN	May no longer, if any will be only Xekhaman	No
IV	**Mammal**					
20		Red-shanked Douc Langur	*Pygathrix nemaeus*	EN	Highly possible, both NZ and TL	Yes
21		Indochinese Lutung	*Trachypithecus germain*	EN	Likely possible, both NZ and TL	Yes
22		Buff-cheeked Gibbon	*Nomascus annamensis*	CR	Highly possible, both NZ and TL	Yes
23		Asian Small-clawed Otter	*Aonyx cinereus*	VU	Highly possible, both NZ and TL	Yes
24		Binturong	*Arctictis binturong*	VU	Highly possible, both NZ and TL	Yes
25		Greater Hog Badger	*Arctonyx collaris*	VU	Highly possible, both NZ and TL	Yes
26		Gaur	*Bos gaurus*	VU	No info, maybe	Possible
27		Owston's Civet	*Chrotogale owstoni*	EN	Highly possible, both NZ and TL	Yes
28		Asian Elephant	*Elephas maximus*	EN	No info, maybe no longer in the area	Possible
29		Smooth-coated Otter	*Lutrogale perspicillata*	VU	Highly possible, both NZ and TL	Yes
30		Stump-tailed Macaque	*Macaca arctoides*	VU	Highly possible, both NZ and TL	Yes
31		Northern Pig-tailed Macaque	*Macaca leonina*	VU	Highly possible, both NZ and TL	Yes
32		Sunda Pangolin	Manis javanica	CR	Possible, but rare	YES

33		Large-antlered Muntjac	*Muntiacus vuquangensis*	CR	Possible, but rare	YES
34		Clouded Leopard	*Neofelis nebulosa*	VU	Possible, but rare	YES
35		Bengal Slow Loris	*Nycticebus bengalensis*	VU	Highly possible, both NZ and TL	Yes
36		Pygmy Slow Loris	*Nycticebus pygmaeus*	VU	Highly possible, both NZ and TL	Yes
37		Tiger	*Panthera tigris*	EN	No info, maybe no longer in the area	Possible
38		Sambar	*Rusa unicolor*	VU	Confirmed for NZ and highly possible for TL	Yes
39		Asiatic Black Bear	*Ursus thibetanus*	VU	Confirmed for NZ and highly possible for TL	Yes
40		Southern Serow	*Capricornis s. sumatraensis*	VU	Confirmed for NZ and highly possible for TL	Yes
41		Large-spotted Civet	*Viverra megaspila*	EN	Possible, both NZ and TL	Yes
V	**Fish**					
42		Carp	*Bangana behri*	VU	No info, possible in Xekhaman, TL	No
43		Giant Carp	*Catlocarpio siamensis*	CR	No info, possible in Xekhaman, TL	Maybe
44		Small Scaled Mud Carp	*Cirrhinus microlepis*	VU	No info, possible in Xekhaman, TL	No
45		Tiger perch	*Datnioides undecimradiatus*	VU	No info, possible in Xekhaman, TL	Maybe
46		Red Fin Shark	*palzeorhynchos munense*	VU	No info, possible in Xekhaman, TL	No
47		Mekong Freshwater Stingray	*Hemitrygon laosensis*	EN	No info, possible in Xekhaman, TL	Maybe
48		Ray-finned carp	*Hypsibarbus lagleri*	VU	No info, possible in Xekhaman, TL	No
49		Ray-finned carp	*Labeo pierrei*	VU	No info, possible in Xekhaman, TL	No
50		Flying Minnow	*Laubuca caeruleostigmata*	EN	No info, possible in Xekhaman, TL	Maybe
51		Elephant Ear Gourami	*Osphronemus exodon*	VU	No info, possible in Xekhaman, TL	Maybe
52		Striped Catfish	*Pangasianodon hypophthalmus*	EN	No info, possible in Xekhaman, TL	Maybe
53		Chinese pangasid-catfish	*Pangasius krempfi*	VU	No info, possible in Xekhaman, TL	Maybe
54		Giant Pangasius	*Pangasius sanitwongsei*	CR	No info, possible in Xekhaman, TL	No
55		Cyprinid	*Poropuntius bolovenensis*	EN	No info, possible, in small and upstream, NZ	No
56		Cyprinid	*Poropuntius consternans*	EN	No info, possible, in small and upstream, NZ	No
57		Cyprinid	*Poropuntius lobocheiloides*	EN	No info, possible, in small and upstream, NZ	No
58		Cyprinid	*Poropuntius solitus*	EN	No info, possible, in small and upstream, NZ	No
59		Thick-lipped Barb	*Probarbus labeamajor*	EN	No info, possible, in small and upstream, NZ	No
60		Cyprinid	*Pseudohemiculter dispar*	VU	No info, possible, in small and upstream, NZ	No
61		Bandan sharp-mouth barb	*Scaphognathops bandanensis*	VU	No info, possible, in small and upstream, NZ	No
62		Ray-finned	*Schistura bolavenensis*	EN	No info, possible, in small and upstream, NZ	Maybe
63		Black-Lined Loach	*Yasuhikotakia nigrolineata*	VU	No info, possible in Xekhaman, TL	No

BASELINE BAT ASSESSMENT REPORT FOR DRY & WET SEASONS

Baseline
Bat Assessment
—2021 Dry & Wet Seasons—

for the

600 MW Monsoon Wind Power Station, Xekong & Attapu Provinces, Lao PDR

on behalf of

Impact Energy Asia Development Ltd.

Neil M. Furey &
Bounsavane Douangboubpha
September, 2021

Document History

Title: Baseline Bat Assessment—2021 Dry & Wet Seasons—600 MW Monsoon Wind Power Station, Xekong & Attapu Provinces, Lao PDR.

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1	23 August 2021	Revisions: Section 3.3, Text amended to clarify forest types present Table 6, Amended to clarify species collision risks Section 5.1, Reference to Rapid Ecological Assessment added Annex 2–3, Habitat details added Annex 4, Detailed maps of all sampling locations added
2	6 September 2021	Addition of acoustic data analysis for July '21, specifically to: Executive Summary, text Section 3.4, text and Table 5 Section 3.5, text and Fig 12 & Fig 13 Section 4.2, text and Table 6 Section 5.1, text

Executive Summary

This report details the results of a baseline bat assessment undertaken during the 2021 dry and wet seasons to determine if the project development area of the 600 MW Monsoon onshore wind power station in the Xekong and Attapu provinces of southern Lao PDR supports bat species and related habitats of elevated conservation significance.

The baseline assessment comprised a literature review and passive and active sampling for bats within the project area, including a portion of the proposed transmission line adjacent to the international border with Vietnam. Sampling methods included key informant interviews, roost surveys, live-sampling with harp traps and mist nets and acoustic sampling with ultrasound detectors, all of which were undertaken between elevations of 973–1,526 m within the Xekong portion of the project area during February–March and June–July 2021.

Literature review revealed that although 56 bat species have been recorded in southern Lao PDR (defined here as the Salavan, Champasak, Xekong & Attapu provinces) to date, only two were documented in Xekong Province (where >80% of the project development area is located) prior to the survey. Consistent with key informant interviews and observations throughout the survey, the review also revealed that limestone karst outcrops, significant cave bat roosts (>100 bats) and flying fox colonies are unlikely to occur in the Xekong portion of the project area.

Fifty-seven discrete locations across nine survey zones were sampled with live-traps during the survey, including 52 locations within the project area and five on the proposed transmission line. This resulted in the live-capture of 468 bats representing 29 species, all but two of which are currently considered Least Concern by the IUCN. Analysis of 571 detector-nights of acoustic sampling data detected 20 phonically-distinct bat taxa. Fourteen of these taxa were identifiable to species (all Least Concern or not evaluated), whereas the remainder cannot be reliably assigned as yet, due to the shortage of verified reference call data for Lao bat species.

Two bat species encountered during the assessment constitute the first country records for Lao PDR: *Rhinolophus francisi* and *Harpiola isodon*. The two species recorded which have yet to be evaluated by IUCN (*R. francisi* & *Kerivoula depressa*) are unlikely to be assigned to a globally-threatened category due to their relatively broad distributions in SE Asia. Taken together, literature review and survey data indicate at least 39 bat species occur in the Monsoon project region. They also suggest that while additional bat taxa are likely present, the project area is unlikely to support significant populations of any of the globally-threatened or nationally-endemic bat species currently documented in Lao PDR.

Data generated by the assessment further indicates that avoidance of mature and/or old-growth forest stands in the layout of wind turbines, transmission lines and other infrastructure will be critical to minimizing impacts on bats during the project's construction phase. They also suggest that fatalities arising from bat-turbine collisions during project operations may be skewed towards ten high-risk species, whereas 11 other taxa would experience a medium risk. As such, the report concludes with a summary of recommendations to minimise impacts on bats, including considerations for project layout, stationary infrastructure and wind turbine operations.

Contents

1. Context

1.1 Bat Biodiversity in SE Asia & Lao PDR

Bats are divided into two suborders: the Yinpterochiroptera (Rhinolophoid bats and Old-World fruit bats) and Yangochiroptera (all other bats), whose ability to perceive their surroundings using echolocation, together with powered flight, has allowed them to master the night skies and exploit a wide range of niches worldwide (Schnitzler et al. 2001, Jones & Teeling 2006). Over 1,400 bat species are currently recognized (Simmons & Cirranello 2021), and this figure grows each year with the discovery of new species, particularly in SE Asia (Tsang et al. 2016).

Bats form a critical component of the SE Asia's mammal fauna, as the group constitutes ca. 30% of the region's mammal species and can comprise as many as half of all mammal species in tropical rainforests (Kingston et al. 2006). Southeast Asia is also pivotal area for global bat conservation as it supports over 25% of the world's bat fauna and as >197 of 342 species known from the region are endemic to it (Kingston 2010).

Despite the economic and conservation importance of bats (Kunz et al. 2011), the natural history of bats in Lao PDR is relatively poorly known. With ≈100 bat species now recorded (Thomas et al. 2013, N. Furey, unpublished data) however, knowledge regarding its composition has increased dramatically in recent years. As elsewhere in SE Asia, the group is seriously threatened by habitat loss, hunting —particularly of cave-dwelling bats— and other human disturbance (Francis 1999, Thomas et al. 2013, Furey & Douangboubpha 2015, 2017).

Of the ≈100 species known in Lao PDR, nine are fruit bats belonging to the Pteropodidae, whereas the remainder are mostly insectivores arranged in seven families. Though discovery of additional species is likely, just one bat species is presently recognized as nationally endemic to the country (*Hipposideros rotalis*) whereas 13 species are currently listed in categories other than Least Concern by IUCN (2021).

1.2 Project & Survey Objectives

Impact Energy Asia Development Ltd (hereafter 'IEAD') currently holds the development rights granted by the government of Lao PDR for the proposed 600 MW Monsoon onshore wind power station along with all related support facilities and associated infrastructure in the Xekong and Attapu provinces of southern Lao PDR (hereafter 'Monsoon Project').

As part of developing the Monsoon Project, IEAD is undertaking an Environmental & Social Impact Assessment (ESIA) with assistance from Environment Resources Management Co. Ltd (ERM) and commissioned the authors to conduct a baseline assessment of bats for the project. The geographical remit for the baseline assessment comprised the project area and a portion of an associated power transmission line adjacent to the international border with Vietnam (Fig. 1).

The baseline assessment for bats was completed over the course of three dry season surveys in February–March 2021 and two wet season surveys in June–July 2021 (Table 1). The purpose of the assessment was to determine if the Monsoon Project area supports bat species and associated habitats of elevated conservation significance.

Fig. 1: Location of Monsoon Project & bat survey zones in the 2021 dry and wet seasons, Xekong & Attapu provinces, Lao PDR

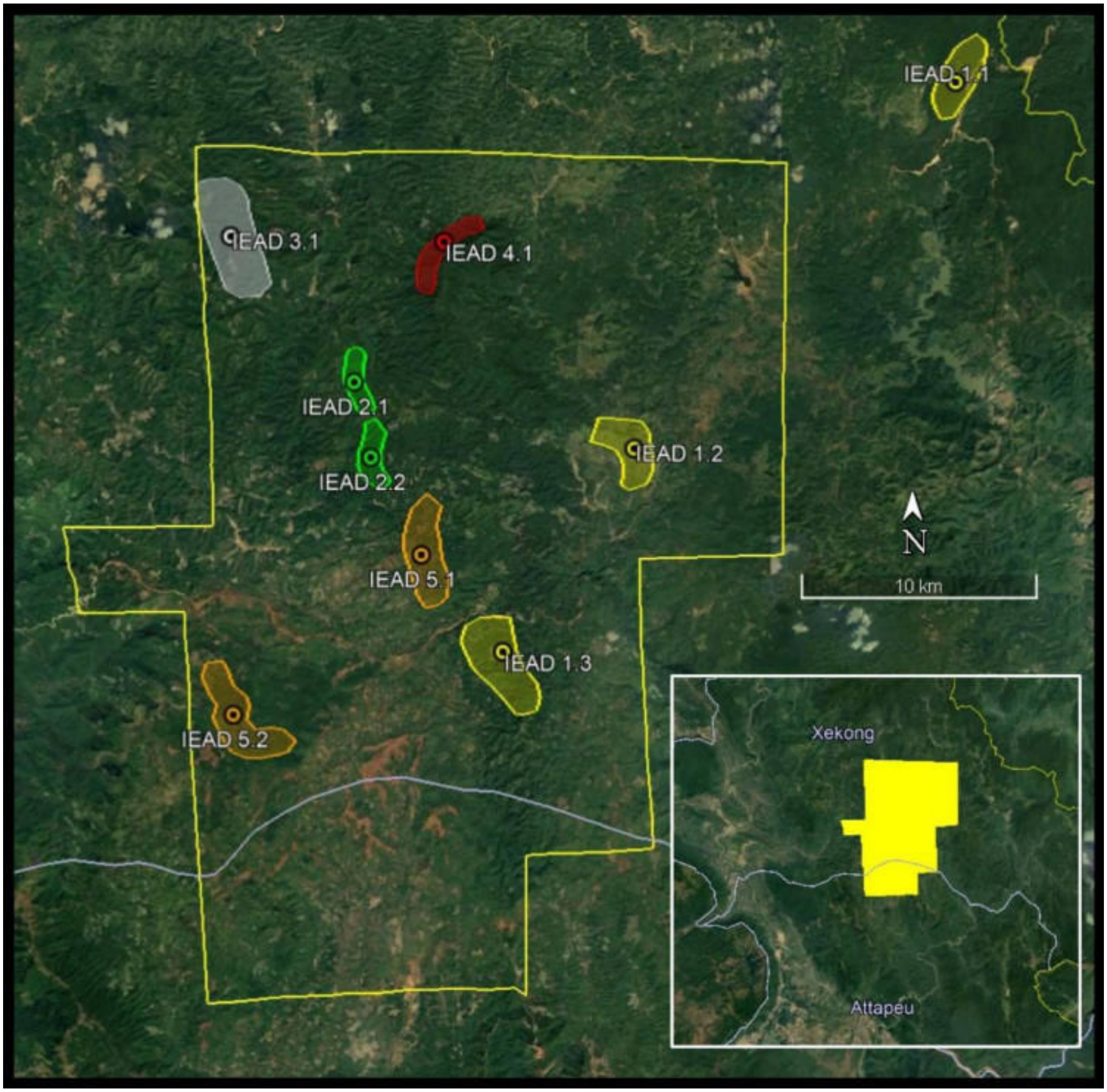


Table 1: Itinerary for bat baseline assessment in 2021 dry & wet seasons

#	Survey Period	Sampling Nights	Survey Zone
1	3–7 February 2021	4	IEAD 1.1
	7–11 February 2021	4	IEAD 1.2
	11–15 February 2021	4	IEAD 1.3
2	23 February – 1 March 2021	6	IEAD 2.1
	1–7 March 2021	6	IEAD 2.2

#	Survey Period	Sampling Nights	Survey Zone
3	16–28 March 2021	12	IEAD 3.1
4	17–29 June 2021	12	IEAD 4.1
5	14–20 July 2021	6	IEAD 5.1
	20–26 July 2021	6	IEAD 5.2

2. Survey Methods

Alongside literature review, the field survey focused on passive and active sampling for bats within the project area, including a portion of the proposed transmission line adjacent to the international border (Fig. 1). All sampling occurred in Xekong province (where >80% of the project development area is located). Sampling methods comprised live-trapping with harp traps and mist nets, acoustic surveys with ultrasound detectors, and key informant interviews undertaken during the dry (February–March, 2021) and wet (June–July, 2021) seasons. Meteorological data were also incorporated into the assessment.

2.1 Data Collection

2.1.1 Literature Review

A desk review of published and unpublished records of bats from southern Lao PDR (defined here as Salavan, Xekong, Champasak & Attapu provinces) was undertaken prior to the field survey. This included review of specimens from these provinces held in the collection of the Faculty of Environmental Sciences, National University of Laos in Vientiane (collection prefix: FESC).

2.1.2 Roost Surveys

In addition to direct searches, key informant interviews were undertaken with residents living in the vicinity of sampling sites to determine if significant bat colonies (e.g., > 100 individuals) occurred within or nearby the project area, with a specific focus on cave roosts and flying fox (*Pteropus* spp.) colonies. Because flying fox colonies—which roost in the open on tall trees—are highly conspicuous and thus invariably well-known where they occur, determining whether these existed in the vicinity of the project site was straightforward.

2.1.3 Live Sampling

Outside of cave roosts, the success of live-sampling efforts in any bat survey are largely determined by the extent to which the habitat and terrain concentrate commuting bats into discreet flyways. Selection of sampling locations consequently focused on perceived flyways within the widest range of characteristic vegetation types in-situ, including ecotones and the interior (e.g., trails, watercourses and natural linear breaks) and edge of each (plus any water stationary features). Geo-coordinates, descriptive habitat data and photo-documentation were recorded at all study sites.

Because bat species vary in their relative susceptibility to capture with mist nets and harp traps (Francis 1989, Berry et al. 2004) and the aim was to maximize inventory completeness, both capture devices were employed. Mist nets measuring 9x3.6m (32.4 m^2) and two four-bank harp traps were employed, each with a capture surface of 2.9 m^2 (Fig. 2). To standardize units of sampling effort between these traps per Furey et al. (2010), sampling effort for mist nets was calculated as m^2 of net multiplied by the hours for which they were set (m^2mnh), while harp trap effort was similarly calculated as m^2 multiplied by the hours of use (m^2hth).

Fig. 2: Four-bank harp trap (left) and mist net (right)

Mist nets and harp traps were employed from ≈1730–0630 hrs each night, except where heavy rain prohibited live trapping. These were checked for captures every 30 minutes between 1800–2100 hrs and again the following morning. Live-sampling was avoided on consecutive nights at the same location to avoid trap familiarity, and following processing, bats captured were released during the same session. Field guides were interviewed to elicit information on roosts or specific foraging sites (e.g., water features) at the onset of fieldwork.

All bats captured during live-sampling were measured, photographed and identified in the field using the appropriate field guides/monographs e.g., Kruskop (2013) & Francis (2019), and released at their capture site the same night. Reference echolocation calls were recorded from each released individual using the appropriate species-specific methods to facilitate identification of unseen bats registered in the acoustic sampling.

Where required to verify species identifications, non-reproductively active adult bats were retained as voucher specimens in 80% ethanol (in practice, this usually means 1–2 specimens for species which are taxonomically complex). Where required, skulls and bacula (where taxonomically diagnostic) of selected voucher specimens were extracted for measurement and comparative examination of craniodental features and other character states.

2.1.4 Acoustic Sampling

Acoustic sampling with ultrasound detectors is extensively used in temperate regions and is an essential complement to conventional capture methods (e.g., mist nets and harp traps) for bat species inventories in the tropics (MacSwiney et al. 2008, Furey et al. 2009). This is particularly true for insectivorous species that habitually fly in open areas and at higher altitudes outside the range of ground-based live-traps. Bat detectors are highly effective for detecting such species because they emit high intensity calls (Fenton 1990, Furey et al. 2009).

The purpose of acoustic sampling was to maximize the inventory completeness of the bat survey and determine spatial and temporal (nightly) variations in species presence/absence and activity in representative locations within the project area. These data were used to identify areas, habitats and features that may pose a high risk of bat fatalities and thereby aid decision-making.

Fixed-point recordings were made each sampling night with 1–2 Song Meter 4 full spectrum (SM4) bat detectors (Wildlife Acoustics, USA: Fig. 3) and 10 AudioMoth full spectrum (AM) bat detectors (Open Acoustic Devices, UK: Fig. 3). The SM4 detectors changed location each night during the survey, whereas the AM detectors were deployed in static locations to maximize coverage of representative habitats in each survey zone (Fig. 1) for the duration of its sampling. All detectors were set to record from ≥30 minutes before sunset until ≥30 minutes after sunrise each night. Local sunrise and sunset times during the dry season were 05:51–06:21 hrs and 17:51–18:04 hrs, and 05:23–05:35 hrs and 18:22–18:23 hrs during the wet season. Similar to the live-sampling sites, GPS coordinates, descriptive habitat data and photo-documentation were recorded for all acoustic sampling sites.

Phonically distinct bat species were identified through visual inspection of the recordings (via call frequencies, structure and duration) in Adobe Audition (Adobe Systems, USA) and Batsound (Pettersson Elecktronic, Sweden) and 19 parameters were measured per call for each phonic type using SCAN'R software (Binary Acoustic Technology, USA). Identifications were made to the lowest possible taxonomic level possible based on discriminant function analysis employing A) reference call data generated by the survey for identified species (this study), and B) datasets of verified recordings for known bat species from Lao PDR (e.g., Furey & Douangboubpha 2015, 2017) and neighbouring countries held by the lead author (e.g., Furey et al. 2009, Phauk et al. 2013). These reference data were subsequently employed to determine the presence/absence of species and phonic types in each sampling location using a filtering pipeline in SZAPP software (Armstrong & Aplin 2014, Armstrong et al. 2016).

Fig. 3: SM4 (left) & AM (right) detectors in Monsoon project area

Analysis of temporal variations in bat activity were confined to recordings generated by the SM4 detectors as these directly reflect actual activity in being triggered by bat calls and other sounds (as opposed to recordings provided by AM devices which operate on fixed schedules and recording cycles). SCAN'R software was initially employed to remove a large proportion of the recordings comprising non-bat sounds, after which the remainder were manually validated. Because bat detectors cannot distinguish between different individuals (and so a single circling bat can be acoustically equivalent to many bats passing just once), an index of activity was employed for analysis based on the number of bat passes. Following international standards, a bat pass was defined as a sequence of >2 echolocation calls, with each sequence, or pass, separated by >1 second (Kunz et al. 2007). Temporal variations in bat activity were quantified using proprietary code in the R program environment (R Core Team, Austria).

2.1.5 Abiotic Sampling

Hourly temperature and relative humidity were recorded during the survey at ground level using EL-USB-2 (Lascar Electronics, UK) and Tinytag data loggers (Gemini Data Loggers, UK). Daily rainfall conditions were also noted.

2.2 Analysis

2.2.1 Conservation Significance

The conservation significance of all bat species recorded was evaluated using IUCN (2021) and refined where necessary with reference to existing literature and unpublished data held by the consultant for Lao PDR and mainland SE Asia. Taxonomy and nomenclature follow Simmons & Cirranello (2021), with the exception of some rhinolophids (per Burgin, 2019).

2.2.2 Ecological Traits & Collision Risks

Ecological trait data for each bat species were obtained from Francis (2019), Kruskop (2013), Furey et al. (2010, 2011), Furey & Racey (2016), IUCN (2021) and data held by the lead author.

All bat species were assigned to one or more of three categories regarding their roosting preferences. These categories comprised: 1) *Caves*, defined here as including other subterranean sites such as mines and rock voids, 2) *Foliage*, inclusive here of tree cavities and hollows, and 3) *Artificial* roosts, recognized here as including all man-made structures above ground. Where the roosting preferences of species were poorly documented, these were inferred from the preferences of related taxa and land cover of known localities for each species.

The wing morphology of bats determines their mobility and directly influences their foraging preferences, home range areas and dispersal abilities, including capacity for migration (Norberg & Rayner 1987). Because the classification of McKenzie et al. (1995) reflects the differential risks of collision at wind farms and propensities for migration of bat species, all species registered during the survey were assigned to one of the following categories on the basis of their known or inferred traits (specifically wing morphology, echolocation call design, diet, roosting & foraging preferences):

- Strategy I: Insectivorous species that forage in the highly cluttered airspace within the forest interior (or forest interior specialists);
- Strategy II: Insectivorous species that forage in partially cluttered spaces such as clearings, streams or other tunnels within the forest or just above the canopy (edge and gap foragers);
- Strategy III: Insectivorous bats that forage in unobstructed airspaces found in large clearings or high above the forest canopy (open-space foragers);
- Strategy IV: Fruit and nectar-eating bats that fly into the partially cluttered air-spaces between tree canopies, roost in small numbers and forage locally;
- Strategy V: Fruit and nectar-eating bats that fly in unobstructed airspaces, roost in large colonies and forage over large areas.

As absolute data on flight height ranges do not exist for most bat species in Southeast Asia, all bat species not effectively confined to the complex airspaces of the forest interior (e.g., Strategy II–V spp.) were assumed to be capable of flying within the ranges of turbine blades.

In decreasing order, the risk of collision at wind farms and propensity for migration associated with the five categories is typically: strategy III > strategy V > strategy IV > strategy II > strategy I[1]. This is supported by studies of bat mortality at wind farms in Vietnam (Furey 2018)

[1] It should be noted that differential risk of turbine collisions for bat species is influenced by the nature of habitats present at a given site. For instance, because fruit plantations and extensive orchards attract large numbers of strategy IV and V species (frugivores and nectarivores), their presence significantly elevates the risk for such taxa.

and the five categories translate into the following classifications: *High risk* = strategy III and V species, *Medium risk* = strategy II and IV species, *Low risk* = strategy I species.

3. Results

3.1 Literature Review

Review of published and unpublished literature for Lao PDR indicates that 56 bat species have previously been documented in the southern portion of the country (defined here as the Salavan, Xekong, Champasak & Attapu provinces) (Table 2). All but six of these species are currently recognised as Least Concern by the IUCN (2021), the exceptions being *Rhinolophus chaseni*, *Myotis ancricola*, *Kerivoula depressa* and *K. dongduongana* (Not Evaluated) and *Hypsugo dolichodon* and *Murina walstoni* (Data Deficient).

While the review revealed that almost no data exist for bats in Xekong province (with just two species documented, both Least Concern: Table 2), the checklist for neighbouring provinces provides a reasonable (although certainly incomplete) indication of bat species likely to occur there. It also suggests that limestone karst is unlikely occur in the project region. While some carbonate rocks extend into the western part of Xekong from Salavan province to the north, the extensive reviews of Kiernan (2009) and Laumanns & Price (2016) did not reveal any karst in the area occupied by the Monsoon Project.

The review also indicated that flying foxes are rather unlikely to occur in the project area. The sole record of any flying fox species in Lao PDR is of a captive animal which was photographed in a remote village in Bolikhamxai in 1998 (Francis et al. 1999). It is unclear whether this bat was a trade animal from elsewhere or a natural vagrant captured locally, but no *Pteropus* is now likely to be resident in Lao PDR given these species' relative conspicuousness coupled with the lack of reports from villagers in the central and southern regions (Francis et al. 1999).

Table 2: Bat species previously recorded in southern Lao PDR (Salavan, Xekong, Champasak & Attapu provinces)

Provinces: At=Attapu, Ch=Champasak, Sa=Salavan, Xe=Xekong.
IUCN Status: DD=Data Deficient, LC=Least Concern, NE=Not evaluated.

#	Family / Species	Province	IUCN Status	Source
I	**Pteropodidae**			
1	*Rousettus amplexicaudatus*	At,Ch	LC	Robinson 1998, Thomas et al. 2013
2	*Rousettus leschenaultii*	Ch	LC	Robinson 1998
3	*Cynopterus brachyotis*	Ch	LC	Thomas et al. 2013
4	*Cynopterus sphinx*	At,Ch	LC	Thomas et al. 2013
5	*Megaerops niphanae*	At,Ch	LC	Robinson 1998, Thomas et al. 2013
6	*Eonycteris spelaea*	At,Ch	LC	Robinson 1998, Thomas et al. 2013
II	**Emballonuridae**			
7	*Taphozous theobaldi*	Ch	LC	Robinson 1998
8	*Taphozous melanopogon*	At	LC	Thomas et al. 2013
9	*Taphozous longimanus*	Ch	LC	Douangboubpha et al. 2014
III	**Megadermatidae**			
10	*Lyroderma lyra*	Ch	LC	Robinson 1998

#	Family / Species	Province	IUCN Status	Source
11	*Megaderma spasma*	At,Ch	LC	Robinson 1998, Thomas et al. 2013, FESC
IV	**Rhinolophidae**			
12	*Rhinolophus perniger*	At,Ch	LC	Thomas et al. 2013
13	*Rhinolophus shameli*	At,Ch	LC	Thomas et al. 2013, FESC
14	*Rhinolophus acuminatus*	At,Ch	LC	Thomas et al. 2013
15	*Rhinolophus pusillus*	At,Ch,Xe	LC	Thomas et al. 2013, FESC
16	*Rhinolophus affinis*	At,Ch	LC	Thomas et al. 2013
17	*Rhinolophus microglobosus*	At	LC	Thomas et al. 2013
18	*Rhinolophus malayanus*	At,Ch,Xe	LC	Thomas et al. 2013, FESC
19	*Rhinolophus chaseni*	At,Ch	NE	Thomas et al. 2013
20	*Rhinolophus thomasi*	At,Ch	LC	Thomas et al. 2013
21	*Rhinolophus pearsonii*	Ch	LC	Thomas et al. 2013
V	**Hipposideridae**			
22	*Hipposideros gentilis*	At, Ch	LC	Thomas et al. 2013
23	*Hipposideros cineraceus*	At, Ch	LC	Thomas et al. 2013
24	*Hipposideros galeritus*	At, Ch	LC	Thomas et al. 2013
25	*Hipposideros* cf. *larvatus*	At, Ch	LC	Thomas et al. 2013, FESC
26	*Hipposideros diadema*	At, Ch	LC	Thomas et al. 2013
27	*Hipposideros armiger*	At, Ch	LC	Thomas et al. 2013
VI	**Vespertilionidae**			
28	*Myotis rufoniger*	At	LC	Thomas et al. 2013
29	*Myotis annectans*	At	LC	Thomas et al. 2013
30	*Myotis rosseti*	At	LC	Thomas et al. 2013
31	*Myotis horsfieldii*	At,Ch	LC	Thomas et al. 2013
32	*Myotis alticraniatus*	Ch	LC	Thomas et al. 2013
33	*Myotis ancriola*	At	NE	Kruskop et al. 2018
34	*Pipistrellus javanicus*	Ch	LC	Thomas et al. 2013
35	*Pipistrellus paterculus*	Ch	LC	Thomas et al. 2013
36	*Pipistrellus coromandra*	At	LC	Thomas et al. 2013
37	*Pipistrellus tenuis*	At,Ch	LC	Robinson 1998, Thomas et al. 2013
38	*Hypsugo cadornae*	At	LC	Thomas et al. 2013
39	*Hypsugo dolichodon*	At	DD	Gorfol et al. 2018
40	*Hesperoptenus blanfordi*	At,Ch	LC	Robinson 1998, Thomas et al. 2013
41	*Hesperoptenus tickelli*	Ch	LC	Robinson 1998, Thomas et al. 2013
42	*Scotophilus heathii*	At,Ch	LC	Thomas et al. 2013
43	*Tylonycteris malayana*	At,Ch	LC	Thomas et al. 2013
44	*Tylonycteris fulvida*	At	LC	Thomas et al. 2013
45	*Murina cyclotis*	At,Ch	LC	Thomas et al. 2013
46	*Murina feae*	At	LC	Francis & Eger 2012
47	*Murina walstoni*	At,Ch	DD	Francis & Eger 2012
48	*Kerivoula papillosa*	At	LC	Thomas et al. 2013
49	*Kerivoula kachinensis*	Ch	LC	Thomas et al. 2013
50	*Kerivoula hardwickii*	Ch	LC	Vuong et al. 2018
51	*Kerivoula depressa*	At,Ch	NE	Vuong et al. 2018
52	*Kerivoula dongduongana*	Ch	NE	Vuong et al. 2018
53	*Kerivoula titania*	At	LC	Thomas et al. 2013
54	*Phoniscus jagorii*	Ch	LC	Thomas et al. 2013
VII	**Miniopteridae**			

#	Family / Species	Province	IUCN Status	Source
55	*Miniopterus magnater*	Ch	LC	Thomas et al. 2013
56	*Miniopterus pusillus*	Ch	LC	Thomas et al. 2013

3.2 Roost Surveys

Alongside discussions with local authorities and field guides, 22 residents with a combined total of 625 years of local experience (mean 30 years) were interviewed during the field survey (Annex 1). Consistent with the literature review, these unanimously suggested that karst and caves do not occur within the Xekong portion of the project area and neither were detected during the survey. The same was true of flying fox colonies and no sightings of foraging animals were reported. Because flying foxes are unlikely to now reside in Lao PDR and their colonies are conspicuous and well-known where they occur, it is reasonable to conclude these do not occur in the Monsoon project area.

Direct observations throughout the survey did not reveal any significant (e.g., >100 individuals) natural or anthropogenic roosting sites for bats, although two local residents from Dak Chieng A village reported that ≈100 bats occupied a rock crevice near Houay Vee and one resident from Xieng Louang village reported that a cave roost with ≈10,000 bats existed ten years previously in the Sanxay District of Attapu Province (Annex 1). The continued existence of this roost could not be confirmed however and given the apparent lack of karst, caves and anthropogenic roost sites within the Xekong portion of the project it is reasonable to assume significant bat colonies do not exist within the area. As a result, roosting colonies will be smaller and much more evenly distributed (relative to sites with karst caves) throughout existing forests within the project area.

3.3 Sampling Effort & Survey Conditions

Over the course of the survey, 56 nights of live-sampling were undertaken with harp traps and mist nets at 57 discrete locations (Table 3). As a consequence, a total of 112 harp-trap-nights (= 3,870.7 m^2hth) and 167 mist-net-nights (=64,929.6 m^2mnh) of trapping effort were achieved. Thirty-four of the 56 sampling nights occurred during the dry season, whereas 22 were undertaken during the wet season. Geocoordinates and maps of these sites are provided in Annex 2 and 4.

Table 3: Live-sampling effort in project area, February–March & June–July 2021

Survey Zone	Site Codes	Survey Dates	Sampling Nights	Harp Traps		Mist Mets	
				Harp Nights	m^2hth	Net Nights	m^2mnh
Dry Season (February–March)							
1.1	LT01–LT05	3–7/2	4	8	276.5	12	4,665.6
1.2	LT06–LT09	7–11/2	4	8	276.5	12	4,665.6
1.3	LT10–LT13	11–15/2	4	8	276.5	12	4,665.6
2.1	LT14–LT18	24/2–1/3	5	10	345.6	15	5,832.0
2.2	LT19–LT23	2–7/3	5	10	345.6	15	5,832.0
3.1	LT24–LT35	16–28/3	12	24	829.4	36	13,996.8
Wet Season (June-July)							

Survey Zone	Site Codes	Survey Dates	Sampling Nights	Harp Traps		Mist Mets	
				Harp Nights	m^2hth	Net Nights	m^2mnh
4.1	LT36–LT47	17–29/6	12	24	829.4	35	13,608.0
5.1	LT48–LT53	14–20/7	6	12	414.7	18	6,998.4
5.2	LT54–LT57	20–24/7	4	8	276.5	12	4,665.6
TOTAL			**56**	**112**	**3,870.7**	**167**	**64,929.6**

Over the course of the survey, a total of 571 detector-nights of acoustic sampling were achieved with AudioMoth (AM) and Song Meter 4 (SM4) devices. Of these, 288 detector-nights were undertaken during the dry season and 283 during the wet season (Table 4). Geocoordinates and maps of the acoustic sampling sites are provided in Annex 2–4.

Table 4: Acoustic sampling effort in project area, February–March & June–July 2021

Survey Zone	Survey Dates	Sampling Nights	AM-Device Nights	SM4-Device Nights	Total Detector-Nights
Dry Season (February–March)					
1.1 [1]	3–7/2	4	0	8	8
1.2 [1]	7–11/2	4	0	8	8
1.3 [1]	11–15/2	4	0	8	8
2.1	23/2–1/3	6	60	7	67
2.2	1–7/3	6	60	6	66
3.1	16–28/3	12	120	11	131
Wet Season (June-July)					
4.1	17–29/6	12	118	24	142
5.1	14–20/7	6	60	12	72
5.2	20–26/7	6	57	12	69
TOTAL			**475**	**96**	**571**

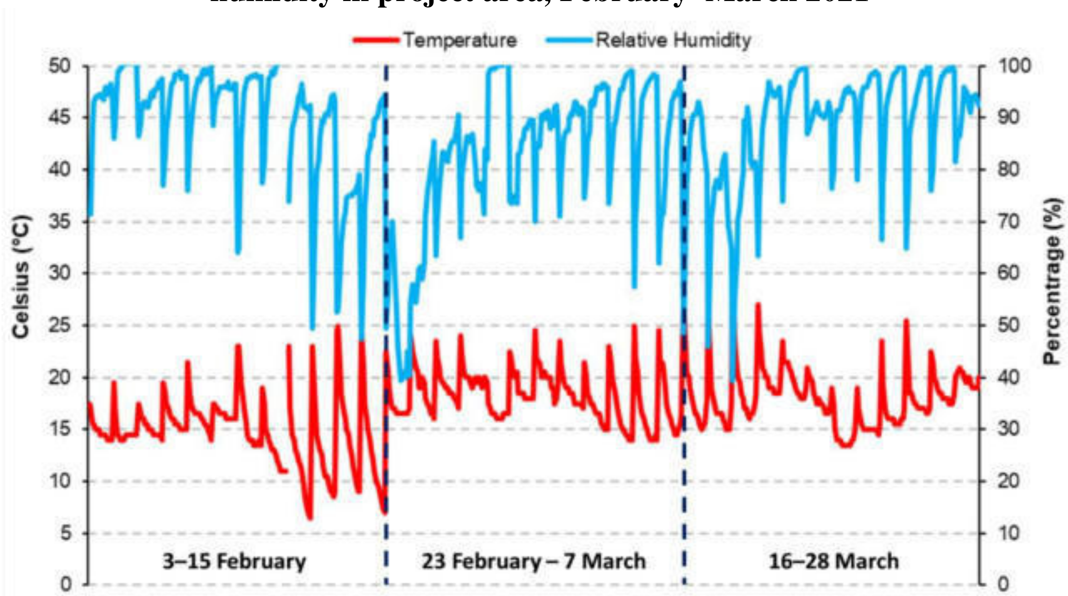
[1] AudioMoth sampling was not possible in zones 1.1–1.3 due to delays importing the devices to Lao PDR.

Light rain was experienced on five nights during the dry season sampling (February–March), although heavy rain fell for approximately one hour before the trapping on 26 March. Overnight temperatures during the season averaged 17.0 °C (range 6.5–29.0 °C), whereas relative humidity averaged 87.2% (range 39–100 %) (Fig. 4). Nightly variation was significant with notably lower minimum temperatures in the latter portion of the first sampling period (early to mid-February).

During the wet season (June–July), rain was experienced on four nights during the sampling in survey zone 4.1 (June). Rain also occurred on most days during sampling in zones 5.1 and 5.2 (July) and prohibited live-trapping on 24 and 25 July. Overnight temperatures during the season averaged 20.0 °C (range 18.0–25.5 °C), whereas relative humidity averaged 96.6% (range 76.5–100.0 %) (Fig. 5). As in the dry season, hourly temperatures naturally declined overnight whereas the reverse was true for relative humidity.

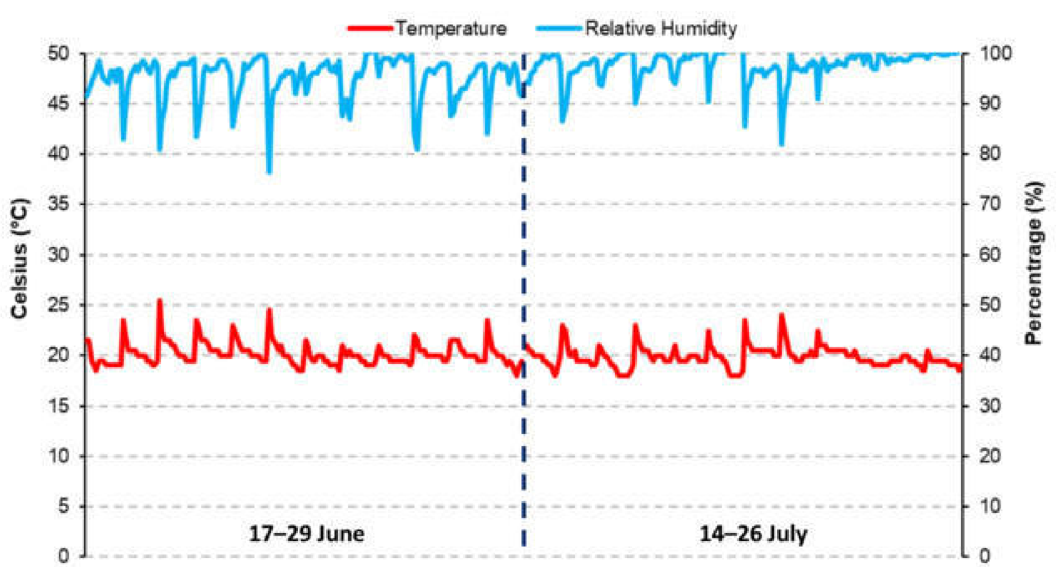
Elevations sampled (live-trapping and acoustically) during the field surveys ranged from 973–1,526 m and averaged 1,183 m in survey zones 1.1–1.3 (973–1,361 m), 1,243 m in zones 2.1–2.2 (1,176–1,320 m), 1,340 m in zone 3.1 (1,145–1,471 m), 1,417 m in zone 4.1 (1,236–1,564 m) and 1,190 in zones 5.1–5.2 (1,122–1,279 m) (Annex 2–4). As such, the natural vegetation of the project area is hill evergreen (broadleaf) forest which is intermixed with stands of coniferous (pine) forest and frequently includes groves of bamboo and wild banana in disturbed areas (selective timber logging has occurred in many areas). These form a mosaic of variably disturbed forest stands with more accessible areas cleared for arable cultivation (wet rice, coffee and pineapple plantations) and grazing for livestock. Indicative images of habitats at selected sampling locations are provided in Fig. 6–7.

Fig. 4: Overnight (1700–0700 hrs) temperatures & relative humidity in project area, February–March 2021



Note: Peaks for temperature and troughs for relative humidity represent daily values at 17:00 hrs.

Fig. 5: Overnight (1700–0700 hrs) temperatures & relative humidity in project area, June–July 2021



Note: Peaks for temperature and troughs for humidity represent daily values at 17:00 hrs.

Fig. 6: Indicative images of habitats sampled in project area, February–March 2021

Fig. 7: Indicative images of habitats sampled in project area, June–July 2021

3.4 Bat Species Composition

During the field survey, 468 bats representing 29 species arranged in five families were captured in live traps (Table 5, Fig. 8–10). Frugivorous bats (Pteropodidae) accounted for most captures (40.4 %, 189 individuals) with seven species, followed by horseshoe bats (Rhinolophidae, 31.6%, 148 bats) also with seven species, whereas evening bats (Vespertilionidae) comprised 26.7% of captures (125 bats) with 13 species. The remainder comprised leaf-nosed bats (Hipposideridae, 1.1%, five bats) and bent-winged bats (Miniopteridae, 0.2%, one bat) with a single species apiece.

With the exception of *Rhinolophus pusillus* which was previously documented in Xekong by Thomas et al. (2013) (Table 2), the remaining 28 species constitute first records for the province, whereas at least ten represent the first records for southern Lao PDR (Table 5). The latter also include two species which constitute the first records for the country: *R. francisi* and *Harpiola isodon*. Aside from *R. francisi* and *Kerivoula depressa* which have yet to be evaluated by IUCN (2021), all of species recorded are currently considered Least Concern.

In representing the first records for Lao PDR, *R. francisi* and *H. isodon* are notable from a national perspective. *Rhinolophus francisi* was first described in 2015 and until now, was solely known from western Thailand, Borneo and one locality in an adjacent area of Vietnam (Francis, 2019). *Harpiola isodon* is hitherto known only from Taiwan (where it is apparently common) and two localities in mainland Southeast Asia, one in northwest Vietnam and the other adjacent to the Monsoon Project area, also in Vietnam (Kuo & Huang, 2020).

Twenty phonically distinct bat taxa were detected in the acoustic sampling. Presence/absence data for these are provided in Table 5 and exemplar calls are shown in Fig. 11. Literature review and reference data from the survey permitted specific assignment of 14 phonic types, all of which are Least Concern aside from *R. francisi* (not evaluated). The remaining six types cannot be assigned with confidence due to a lack of verified reference calls for Lao bat species, although all six are evidently aerial insectivores within the Vespertilionidae, Miniopteridae and/or Molossidae. Phonic types 4–6 could potentially represent certain species captured in live-traps during the survey and so are excluded from the combined species totals in Table 5.

Table 5: Bat species recorded in project area, February–March & June–July 2021

#	**Family /** Species	**Survey Zones** (per Fig. 1, Annex 4)									**IUCN**
		1.1	**1.2**	**1.3**	**2.1**	**2.2**	**3.1**	**4.1**	**5.1**	**5.2**	
I	**Pteropodidae**										
1	*Megaerops niphanae*			4	13	2	71	1	4	6	LC
2	*Cynopterus horsfieldii* [1]		2	4			4				LC
3	*Cynopterus sphinx*		1	3			17				LC
4	*Sphaerias blanfordi* [1]	1	23	7	2	5	9	1	1		LC
5	*Macroglossus sobrinus* [1]	1	1	1			3				LC
6	*Rousettus amplexicaudatus*						1				LC
7	*Rousettus leschenaultii*						1				LC
II	**Rhinolophidae**										
8	*Rhinolophus affinis*	3[A]		6[A]	12[A]	9[A]	[A]	35[A]	10[A]	1[A]	LC

#	**Family /** Species	**Survey Zones** (per Fig. 1, Annex 4)									IUCN
		1.1	**1.2**	**1.3**	**2.1**	**2.2**	**3.1**	**4.1**	**5.1**	**5.2**	
9	*Rhinolophus microglobosus*			^{A}	^{A}	^{A}	13^{A}	8^{A}	2^{A}	3^{A}	LC
10	*Rhinolophus francisi* [1,2]				2^{A}	^{A}	^{A}	^{A}			NE
11	*Rhinolophus perniger*	^{A}	^{A}		^{A}	^{A}	^{A}	^{A}	^{A}	1^{A}	LC
12	*Rhinolophus pusillus*	1^{A}	^{A}	2^{A}	6^{A}	6^{A}	7^{A}	11^{A}	4^{A}	1^{A}	LC
13	[*Rhinolophus lepidus*]				^{A}			^{A}	^{A}	^{A}	LC
14	*Rhinolophus siamensis* [1,3]				^{A}	^{A}	^{A}	1	^{A}	^{A}	LC
15	*Rhinolophus shameli* [3]				^{A}	^{A}	^{A}		^{A}	4^{A}	LC
III	**Hipposideridae**										
16	*Hipposideros gentilis*				1	2^{A}			1	1	LC
17	[*Hipposideros galeritus*]	^{A}									LC
18	[*Hipposideros armiger*]									^{A}	LC
19	[*Hipposideros* cf. *larvatus*]									^{A}	LC
IV	**Vespertilionidae**										
20	*Myotis muricola* [1]	1^{A}	^{A}	2^{A}	^{A}	1^{A}	^{A}	1^{A}	2^{A}	^{A}	LC
21	*Pipistrellus* cf. *paterculus*				1	1	2				LC
22	*Hypsugo cadornae*								4		LC
23	*Murina cyclotis*	2	1	4			8	1	4	1	LC
24	*Murina eleryi* [1]		1	1		4	3	3	8		LC
25	*Murina feae*			1		2	1	1	1		LC
26	*Murina fionae* [1]				1	1	2	1			LC
27	*Harpiola isodon* [1,2]						1				LC
28	*Harpiocephalus harpia* [1]			2		1		1			LC
29	*Kerivoula depressa*	1	2	3	1	10	12	1	7	1	NE
30	*Kerivoula titania*					7	5		1		LC
31	*Phoniscus jagorii*					1					LC
32	*Tyloncyteris fulvida*			1							LC
33	[*Scotophilus heathii*]	^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	LC
34	[*Scotophilus kuhlii*]	^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	LC
V	**Miniopteridae**										
35	*Miniopterus pusillus*					1					LC
Unidentified Phonic Types											
36	Phonic type 1 (15–18 kHz)		^{A}		^{A}	^{A}	^{A}		^{A}	^{A}	-
37	Phonic type 2 (22–26 kHz)	^{A}	^{A}	^{A}	^{A}		^{A}	^{A}	^{A}	^{A}	-
38	Phonic type 3 (27–34 kHz)		^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	^{A}	-
-	Phonic type 4 (49–51 kHz)		^{A}			^{A}	^{A}	^{A}	^{A}	^{A}	-
-	Phonic type 5 (66–67 kHz)	^{A}						^{A}	^{A}		-
-	Phonic type 6 (80–90 kHz)	^{A}	^{A}	^{A}			^{A}	^{A}			-
	Individuals captured	**10**	**31**	**41**	**39**	**53**	**160**	**66**	**49**	**19**	
	Species captured	**7**	**7**	**14**	**9**	**15**	**17**	**13**	**13**	**9**	
	Combined species total [4]	**12**	**15**	**19**	**19**	**23**	**27**	**23**	**21**	**18**	

Notes: ^{A} = Acoustic Record. [ ] = Identification solely based on verified reference calls and/or literature data from other sites in Laos and Indochina. Status: LC=Least Concern, NE=Not evaluated. [1] First record for southern Lao PDR,

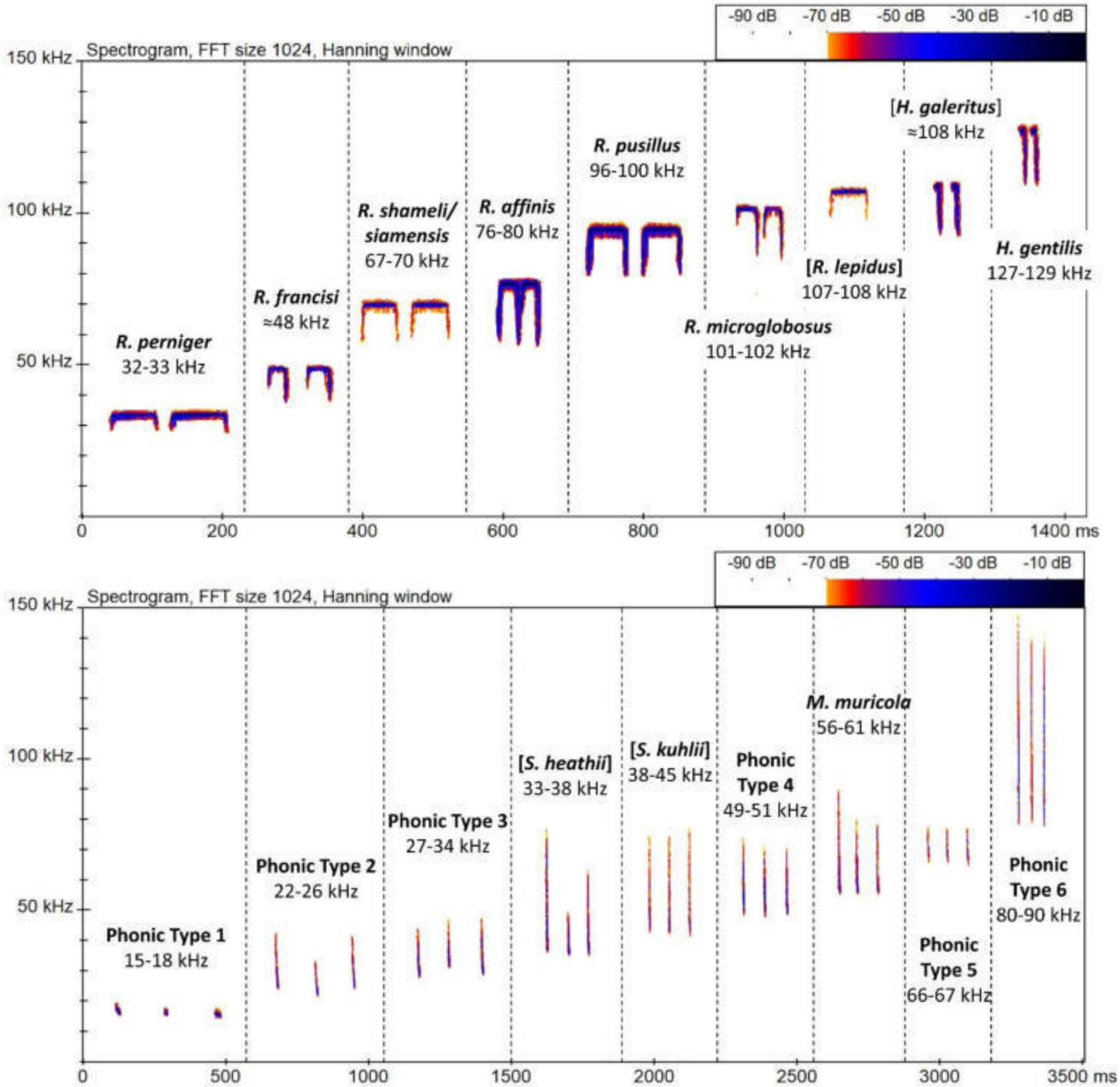
[2] First country record for Lao PDR, [3] These two species overlap in frequency in southern Lao PDR so cannot be reliably separated acoustically (and are counted as a single taxon in the combined species totals), [4] Combined totals exclude phonic types 4–6 which could represent taxa captured such as *Tyloncyteris*, *Miniopterus, Pipistrellus* and *Murina* spp.

Fig. 8: Bat species captured in Monsoon project area, 2021 (not to scale)

Fig. 9: Bat species captured in Monsoon project area, 2021 (not to scale)

Fig. 10: Bat species captured in Monsoon project area, 2021 (not to scale)

Fig. 11: Search-phase echolocation calls of selected bat species in project area



Notes: Square brackets indicate bat species not captured during survey and therefore identified on the basis of verified reference calls and/or descriptions from other sites in Lao PDR and Indochina. Values in kHz indicate the typical ranges of characteristic frequencies (Fc) for each species/phonic type.

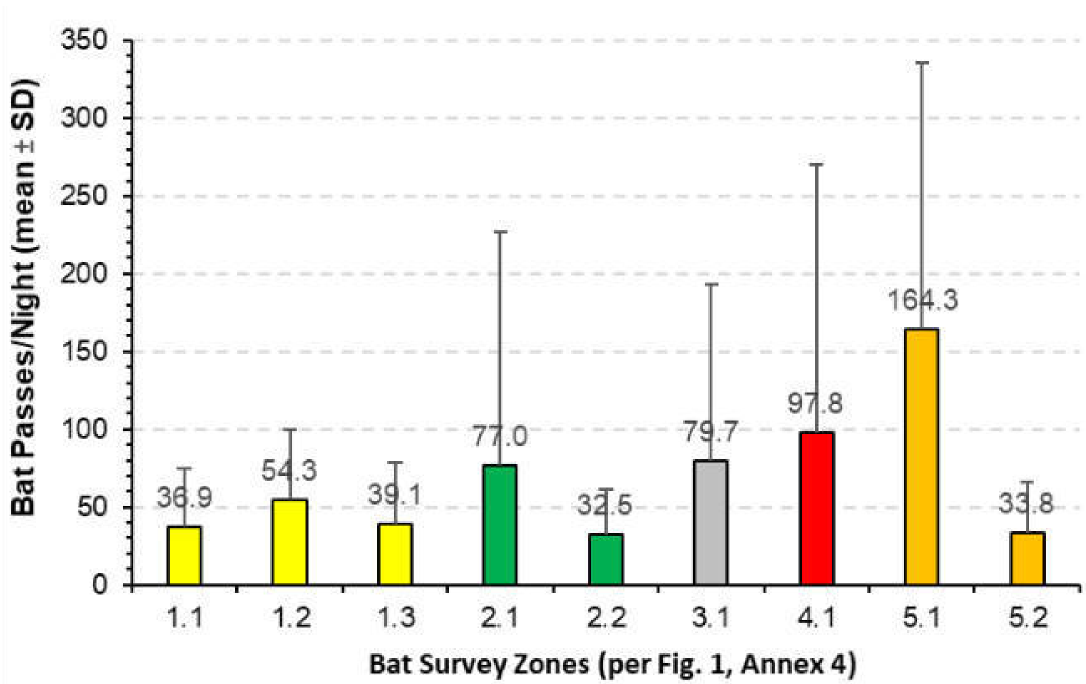
As anticipated in the interim survey report (Furey & Douangboubpha, 2021), the inclusion of acoustic sampling data markedly increased the number of bat species documented in each survey zone (Table 5). Across the nine survey zones for which live-trapping and acoustic data are available (Fig. 1, Annex 4), survey zone 3.1 supported the greatest number of bat species with 27 species, followed by survey zones 4.1 and 2.2 with 23 species apiece. Survey zones 1.3, 2.1, 5.1 and 5.2 exhibited intermediate species richness with 18–21 species apiece, whereas zones 1.2 and 1.1 supported lower species richness with 15 and 12 taxa respectively. However, firm conclusions should not be drawn from the latter figures as much less survey effort was achieved in these zones due to delays in importing AudioMoth sampling devices into Lao PDR (Table 4).

3.5 Echolocating Bat Activity

Over the course of the survey in both seasons (February–March & June–July '21 = 96 detector-nights: Table 4), 334.31 GB of recordings were registered by the SM4 detectors. Following the removal of all recordings with <3 bat signals, these represented 29.1 GB of echolocating bat activity comprising 7,376 discrete bat passes.

Variations in average nightly bat activity between sampling zones are depicted in Fig. 12. Median figures for nightly bat activity in each survey zone were as follows: zone 1.1=28.5 bat-passes/detector-night (*n*=8), zone 1.2=55.0 (*n*=8), zone 1.3=26.0 (*n*=8), zone 2.1=26.0 (*n*=7), zone 2.2=34.0 (*n*=6), zone 3.1=22.0 (*n*=11), zone 4.1=27.5 (*n*=24), zone 5.1=88.5 (*n*=12) and zone 5.2=18.5 (*n*=12). Mean nightly activity during the dry season (February–March) was 55.3 bat passes/detector-night (SD=82.7, *n*=48), whereas this was 98.4 bat passes/detector-night (SD=154.3, *n*=48) during the wet season (June–July). The respective median figures were 26.5 and 36.5 bat passes/detector-night.

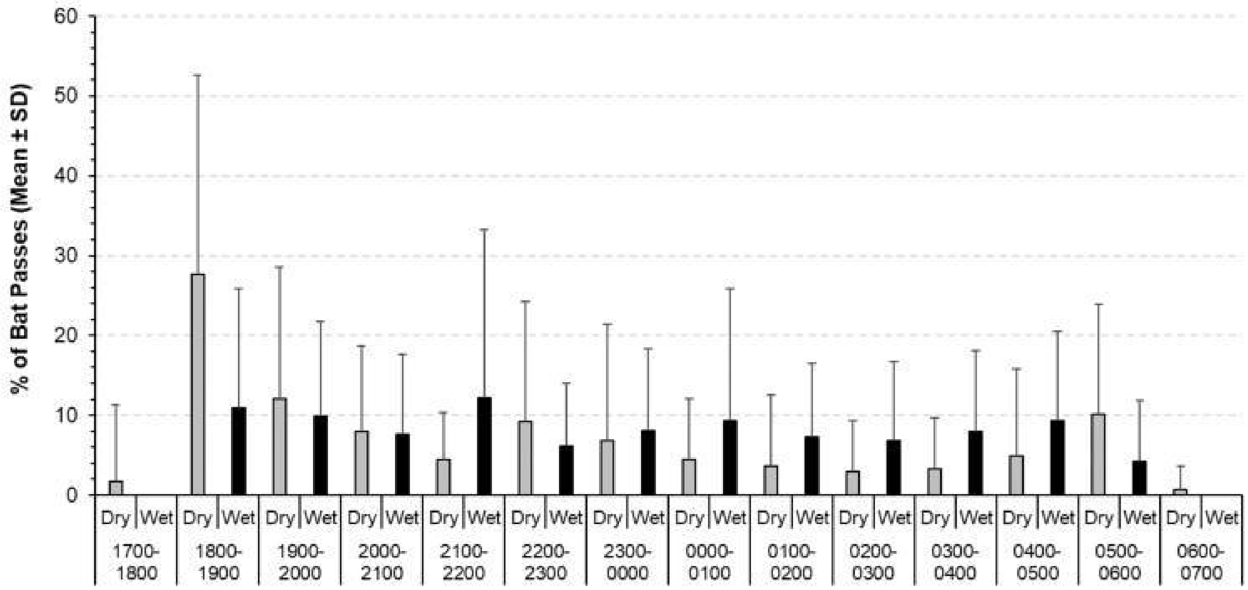
Fig. 12: Relative bat activity across survey zones in Monsoon project area



During the dry season (February–March), bat activity peaked between 1800–1900 hrs with 27.6% of mean hourly activity occurring during this period, although nightly variation was significant (SD=24.9, Fig. 13). Activity then declined from a mean value of 12.1% between 1900–2000 hrs to relatively stable rates of <10% per hour until 0500 hrs and finally increased before dawn with 10.1% of mean hourly activity occurring between 0500–0600 hrs (although nightly variation was again significant: SD=13.8).

A similar although much less pronounced pattern was observed during the wet season (June–July), with 11.0% of mean hourly activity (SD=14.8) occurring between 1800–1900 hrs and, excepting 2100–2200 hrs with a mean hourly value of 12.1% (SD=21.1), hourly values subsequently remaining below 10% between 1900–0500 hrs. Nightly variations were again significant.

Fig. 13: Hourly variation in bat activity during dry and wet seasons



4. Analysis

4.1 Conservation Significance

With the exception of *Rhinolophus francisi* and *Kerivoula depressa* which have yet to be evaluated by the IUCN (2021), all bat species recorded during the survey (and previously in southern Lao PDR: Table 2) are currently regarded as Least Concern (Table 5). Additionally, neither *R. francisi* or *K. depressa* are likely to be listed in a globally threatened category due to their relatively broad distributions (Soisook et al. 2015, Vuong et al. 2018).

It should be noted that additional bat species undoubtedly occur in the project area, as indicated by literature review (which indicates 56 bat species occur in neighbouring provinces: Table 2) and the absence of many commonplace taxa from the current species list for the site e.g., emballonurids, megadermatids, hipposiderids and Myotinae. It is also plausible these include poorly known taxa such as *Myotis ancriola* and *Hypsugo dolichodon* (Table 2).

Notwithstanding this, on the basis of current information, the Monsoon project area appears unlikely to support significant populations of any of the globally-threatened (Vulnerable, Endangered, Critically Endangered) or nationally-endemic bat species currently known in Lao PDR e.g., *Hipposideros khaokhouayensis*, *H. scutinares*, *Myotis pilosus* (all Vulnerable), *H. rotalis* (nationally-endemic), *Tadarida latouchei* (Endangered).

4.2 Bat-Turbine Collision Risks

The foraging strategies adopted by bats reflect their differential risks of collision with wind turbines. In decreasing order of risk, these typically rank as follows: Strategy III > Strategy V > Strategy IV > Strategy II > Strategy I (see section 2.2.1 for definitions). Although published data are extremely scarce for Southeast Asia, this is supported by unpublished studies of bat mortality at a wind farm in southern Vietnam (Furey 2018) and the five categories translate into the following classifications: High Risk = strategy III and V species, Medium Risk = strategy IV and II species, Low Risk = strategy I species.

Of the 39 bat species currently documented in Xekong Province, 18 belong to Strategy I, six to Strategy II, eight to strategy III, five to Strategy IV and two to Strategy V (Table 6). On current information therefore, fatalities arising from bat-turbine collisions during the operational phase of the Monsoon Project would be skewed towards ten high-risk bat species, whereas 11 additional taxa would experience a medium risk.

Table 6: Ecological traits & status of bat species recorded in Xekong province

Typical Roosts: A=Artificial (anthropogenic) roosts, C=Caves, F=Foliage.
Foraging Strategy: See section 2.2.1. IUCN (2021): LC=Least Concern, NE=Not Evaluated.

#	**Family /** Species	**Typical Roosts**	**Foraging Strategy**	**IUCN (2021)**	**Predicted Risk**
I	**Pteropodidae**				
1	*Megaerops niphanae*	F	IV	LC	Medium
2	*Cynopterus horsfieldii*	F	IV	LC	Medium
3	*Cynopterus sphinx*	F	IV	LC	Medium
4	*Sphaerias blanfordi*	F	IV	LC	Medium
5	*Macroglossus sobrinus*	F	IV	LC	Medium
6	*Rousettus amplexicaudatus*	C	V	LC	High
7	*Rousettus leschenaulti*	C	V	LC	High
II	**Rhinolophidae**				
8	*Rhinolophus affinis*	C, F	II	LC	Medium
9	*Rhinolophus malayanus*	C	I	LC	Low
10	*Rhinolophus microglobosus*	C, F	I	LC	Low
11	*Rhinolophus francisi*	F	II	NE	Medium
12	*Rhinolophus perniger*	C, F	II	LC	Medium
13	*Rhinolophus pusillus*	C, F	I	LC	Low
14	[*Rhinolophus lepidus*]	A, C	I	LC	Low
15	*Rhinolophus siamensis*	F?	I	LC	Low
16	*Rhinolophus shameli*	C	I	LC	Low
III	**Hipposideridae**				
17	*Hipposideros gentilis*	C, F	I	LC	Low
18	[*Hipposideros galeritus*]	C	I	LC	Low
19	[*Hipposideros armiger*]	C, F	II	LC	Medium
20	[*Hipposideros* cf. *larvatus*]	C, F	II	LC	Medium
IV	**Vespertilionidae**				

#	**Family /** Species	Typical Roosts	Foraging Strategy	IUCN (2021)	Predicted Risk
21	*Myotis muricola*	F	II	LC	Medium
22	*Pipistrellus* cf. *paterculus*	A, F	III	LC	High
23	*Hypsugo cadornae*	F?	III	LC	High
24	*Murina cyclotis*	F	I	LC	Low
25	*Murina eleryi*	F	I	LC	Low
26	*Murina feae*	F	I	LC	Low
27	*Murina fionae*	F	I	LC	Low
28	*Harpiola isodon*	F	I	LC	Low
29	*Harpiocephalus harpia*	F	I	LC	Low
30	*Kerivoula depressa*	F	I	NE	Low
31	*Kerivoula titania*	F	I	LC	Low
32	*Phoniscus jagorii*	F	I	LC	Low
33	*Tyloncyteris fulvida*	F	I	LC	Low
34	[*Scotophilus heathii*]	F	III	LC	High
35	[*Scotophilus kuhlii*]	F	III	LC	High
V	**Miniopteridae**				
36	*Miniopterus pusillus*	C	III	LC	High
Unidentified Phonic Types					
37	Phonic type 1 (15–18 kHz)	-	III	-	High
38	Phonic type 2 (22–26 kHz)	-	III	-	High
39	Phonic type 3 (27–34 kHz)	-	III	-	High

Notes: [ ] = Provisional record as identification solely based on verified reference calls and/or literature data from other sites in Laos and Indochina.

It is important to note that the value of pre-construction assessments lies primarily in identifying the presence of bat species that have high risks of turbine collision or are of conservation concern. Because bat activity can change after construction, pre-construction studies have consistently proven to be poor predictors of the scale of bat fatalities (Hein et al. 2013, Lintott et al. 2016). As a consequence, post-construction studies are required to determine this and the appropriate mitigation options.

5. Synthesis & Recommendations

Because the spatial layout of turbines and other project infrastructure has yet to be finalized at the time of writing, recommendations given below include considerations that warrant attention in the project planning stage.

5.1 Project Design & Layout

The baseline assessment indicates that limestone karst outcrops, significant cave bat roosts (>100 individuals) and flying fox (*Pteropus* spp.) colonies are unlikely to exist in the Xekong portion of the Monsoon Project area. As a result, roosts employed by local bat populations will largely be confined to forest areas. Because forest roosts typically support small colonies and are rarely limited in abundance (Kunz & Lumsden 2003, Fletcher 2006), these will occur throughout the forests of the entire project area.

Baseline data also indicate that survey zone 3.1 (far northwest of project area) may support the greatest number of bat species with 27 taxa recorded, followed by zone 4.1 (far north of project area) and 2.2 (central northwest) with 23 species apiece, zone 5.1 (central area) with 21 species and zone 1.3 (central south) and 2.1 (central northwest) with 19 species apiece (Fig. 1, Annex 4, Table 5). Additionally, field observations suggest the condition or quality of forest habitats may rank in decreasing order (i.e. highest to lowest) as follows: zone 4.1 > zone 3.1 > zone 1.1 > zone 5.2 > zone 2.2 > zone 2.1 > zone 1.3 > zone 5.1 > zone 1.2. These observations may be verified through the Rapid Ecological Assessment and follow-up surveys undertaken as part of the ESIA.

In this context, studies in Vietnam and Thailand have demonstrated dramatic declines in bat abundance between areas with natural and mature forest cover compared to areas with disturbed formations or plantations (Furey et al. 2010, Phommexay et al. 2011). The loss of older, larger trees presents a particular concern as these typically provide more cavities, hollows and crevices for foliage-roosting species. Allied to this, close to half of the bat species currently documented in Xekong province (currently 18 of 39 species: Table 6) comprise forest-interior specialists which are poorly adapted to foraging in open areas (Furey & Racey 2016).

As a consequence, avoidance of mature and/or old-growth forest stands in the layout of wind turbines, transmission lines and other infrastructure will be critical to minimizing impacts on bats and all other forest dependent wildlife during the project's construction phase. To the extent practicable, priority should also be given to maintaining forest connectivity, because increased fragmentation and isolation of forest stands will erode the foraging effectiveness of forest-interior specialists and therefore increase their local extinction risks.

5.2 Stationary Infrastructure

Overhead power transmission cables, towers at substations, distribution poles or pylons rise high enough in space to pose collision risks to flying animals. The only published literature on bat collisions with human-made objects pertains to wind turbines, although only the moving parts of these structures (turbine blades) have been implicated in bat fatalities. In contrast, no peer-reviewed/published literature exists regarding bat fatalities from collisions with power lines, such that for example, Orbach & Fenton (2010) only cited 'anecdotal reports' of bats colliding with other stationary objects, including television towers.

While the perception and avoidance capabilities of bats vary considerably between species (Jones & Teeling 2006, Orbach & Fenton 2010, Furey & Racey 2016), this is unlikely to present a major risk to echolocating bat species in the project area, whereas any risk to non-echolocating species (Pteropodidae: frugivorous bats) could be potentially be reduced by marking vertical structures and power lines with flight deflectors[2].

Fatalities can also result from electrocution when an animal touches two phase conductors or one conductor and an earthed device simultaneously (Bevanger, 1998). As this primarily only occurs

[2] It should be noted that although wire-marking devices are known to benefit birds, their benefits for bats will remain speculative until research is conducted on the etiology of bat-wire collisions (Manville 2016).

to flying foxes[3] which are very unlikely to occur in the project area however, a minimum spacing of one metre between overhead power cables should suffice to safeguard all known bat species at the site from potential electrocution risks (in significantly exceeding the largest wingspans).

5.3 Wind Turbine Operations

Although widely considered a clean energy source, wind energy is not environmentally neutral. Rather, widespread and often extensive fatalities have increased concern regarding the impacts of wind energy development on bats and other wildlife such as birds (Kunz et al. 2007). Indeed, wind power is now recognised as the leading cause of mortality for bats worldwide (O'Shea et al. 2016, Tuttle 2017) because by 2012, more than 600,000 bats were being killed annually in the US alone, with numbers growing each year (Hayes 2013).

Aside from one study reporting bat fatalities at windfarms in Taiwan between 2007–2011 (Cheng-Han et al. 2017), recent reviews have failed to find data on bat fatalities caused by windfarms in mainland Asia (Arnett et al. 2016). However, these indicate that bats most at risk from collisions with turbines comprise species that routinely forage in open spaces (Arnett et al. 2008, Rydell et al. 2010, Thaxter et al. 2017). This is borne out by unpublished studies of bat mortality at windfarms in southern Viet Nam (Furey 2018) and turbine collisions also do not appear to be chance events. Bats are attracted to turbines either directly, as these may resemble roosts, or indirectly, because turbines attract insects on which the bats feed (Arnett et al. 2016).

Irrespective of the causal mechanisms, bat fatalities at windfarms raise serious concerns about population-level impacts (e.g., Frick et al. 2017). This is because bats are long-lived and have exceptionally low reproductive rates. As a consequence, their population growth is relatively slow, which limits their ability to recover from declines caused by human activities and maintain sustainable populations (Barclay & Harder 2003, Furey et al. 2011).

In studies worldwide, higher bat activity and fatalities at windfarms are consistently related to low wind speeds, higher temperatures and weather conditions typical of the passage of storm fronts (Arnett et al. 2013). Because bats significantly reduce their flight activity during rain, low temperatures and stronger winds, they are at less risk of colliding with wind turbines under these conditions. As a result, studies have consistently found that increasing normal turbine cut-in speed (wind speed at which turbines begin producing electricity into the power grid) up to at least 5 m/s during high risk periods for bat-turbine collisions reduces bat fatalities by at least 50% (Arnett & Baerwald 2013). On this basis, the following are recommended:

- Studies to determine the environmental conditions (rainfall, windspeed, temperature and humidity) defining high vs. low risk conditions for bat-turbine collisions.

- Incorporating the findings of the above, establishment of operational curtailment program which

  - Alters turbine operations to eliminate blade movement during high-risk periods for bat-turbine collisions by feathering blades (blades pitched 90° and parallel to the wind) at and

[3] Because flying foxes possess the largest wingspans (e.g., 1–1.5 m) among bats and thus are most capable of bridging overhead power lines with their wings (e.g., Molur et al. 2007, Rajeshkumar et al. 2013).

below manufacturer cut-in speeds when turbines are not producing electricity into the power grid; and

- Increases normal turbine cut-in speed (wind speed at which turbines begin producing electricity into the power grid) by 1.5–3.0 m/s above the manufacturer's cut-in speed (or up to at least 5 m/s overall) during high risk periods for bat-turbine collisions.

Justification: Few studies have disclosed the actual power loss and economic costs of the above kinds of operational mitigation to date, but those that have suggest that <1% of total annual output may be lost if operational mitigation is employed during high-risk periods for bat fatalities. This is borne out by multiple studies (e.g., Baerwald et al. 2009, Arnett et al. 2010, Arnett et al. 2013, Arnett and Baerwald 2013, Martin et al. 2017). Further, many vendors claim to have commercial systems (acoustic deterrents) that can detect or deter bat (and bird) species or that are in different stages of development. However, many of these systems have not undergone independent validation and their effectiveness and durability is still being evaluated (PNWWRM-XI 2017, AWWI 2018). Currently, only operational mitigation or curtailment programs during high-risk periods when bats are most active have demonstrated effective reductions in fatalities (Arnett 2017). Notwithstanding this, the option exists to trial acoustic deterrents at the site and adopt these for mitigation purposes if found to be effective.

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