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Natural Capital Valuation using primary data research methods in Baleh, Sarawak Heart of Borneo Project

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October 2018

Final Report on Natural Capital Valuation using primary data research methods in Baleh, Sarawak Heart of Borneo Project area

By

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Green Economy in the Heart of Borneo project

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On behalf of

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

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Background

This final report is for a consultancy research assignment for the economic valuation of natural capital in the Baleh watershed in Sarawak, Malaysia. The consultancy is initiated under the Green Economy in the Heart of Borneo project (a joint collaboration between WWF-Malaysia, WWF-Indonesia and WWF-Germany), which is designed to align with the Vision of a Green Economy laid down in the trilateral Heart of Borneo Declaration in 2007. For implementation, this vision needs a solid green economy management concept, which includes two components: a land-use plan and a green economy action plan. The management concept revolves around collaboration of government institutions, the private sector and local communities and indigenous groups, and it functions in an international context. It is driven by three inter-related priorities: greenhouse-gas emission reduction, sustainable economic growth and biodiversity conservation.

The Baleh River is a large tributary of the Rajang River with a catchment size of 12,433 square kilometres. The Baleh watershed area is populated with communities of local indigenous people. Much of the watershed is still under forest cover, however, about 88% of the Baleh watershed will be developed for the SCORE (Sarawak Corridor of Renewable Energy) hinterland development, which is planned under the Sarawak Economic Transformation Plan, to move Sarawak into a developed status by 2030. Agriculture, tourism, forestry, palm oil, rubber and biotechnology development for aquaculture, forestry, palm oil and rubber are the main economic development potentials being explored. Access roads linking to towns such as Tunoh in Baleh are also planned.

The existing major economic activity is logging. Licensed planted forests are also being planned to increase economic revenues from forestry. As a result of logging and shifting cultivation practices, the current wildlife habitat is a matrix of logged and secondary forest at different stages of regeneration. A large hydroelectric power (HEP) plant project has been approved for development on the Baleh river approximately 105 km upstream of Kapit Town at Pala Bayong. A case needs to be built to improve management of activities within the watershed for the protection of the ecosystem services it provides to nature, people and economy. This includes building the case for better development planning which will reduce negative impacts to the ecosystem services of the watershed.

The end goal is to put Baleh on a green economy pathway that maintains and enhances its natural capital as a critical economic asset and as a source of public benefits. Toward this end, it is imperative to undertake appropriate measures to value the natural capital of Baleh. WWF is advocating for integrated watershed management and the study will assist to provide vital information to support this.

Introduction

The purpose of this Final Report is to present the results and policy recommendations from study. It expands on the Interim Report, which provided a description of the policy and institutional context of the study with a view to developing policy recommendations; the development of alternative future land use scenarios that underlie the economic valuation of ecosystem services; the spatial modelling of ecosystem services; the implementation of primary data collection

through three surveys; and the preliminary results of those surveys. This Final Report builds on the Interim report to present the results of the bio-physical models of ecosystem service provision; the economic valuation results; and develops policy recommendations.

In order to produce a comprehensive assessment of the economic value of ecosystem services from the Baleh watershed, the area of interest is defined from the headwaters of the Baleh River at the Indonesia-Malaysia border to the main stem and mouth of the Rajang River – this is referred to in this report as the Baleh-Rajang study area. The assessment will examine ecosystem services produced by natural capital within the Baleh watershed and examine the values of those services to beneficiaries both within the Baleh watershed and in the downstream portion of the Rajang River (and further afield if relevant). The location of the Rajang basin and Baleh watershed is shown in Figure 1. For all ecosystem services, a description of the beneficiaries and their location will be provided. By adopting a wider perspective toward the location of beneficiaries, this study aims to adequately capture the full value of the natural capital of the Baleh watershed.

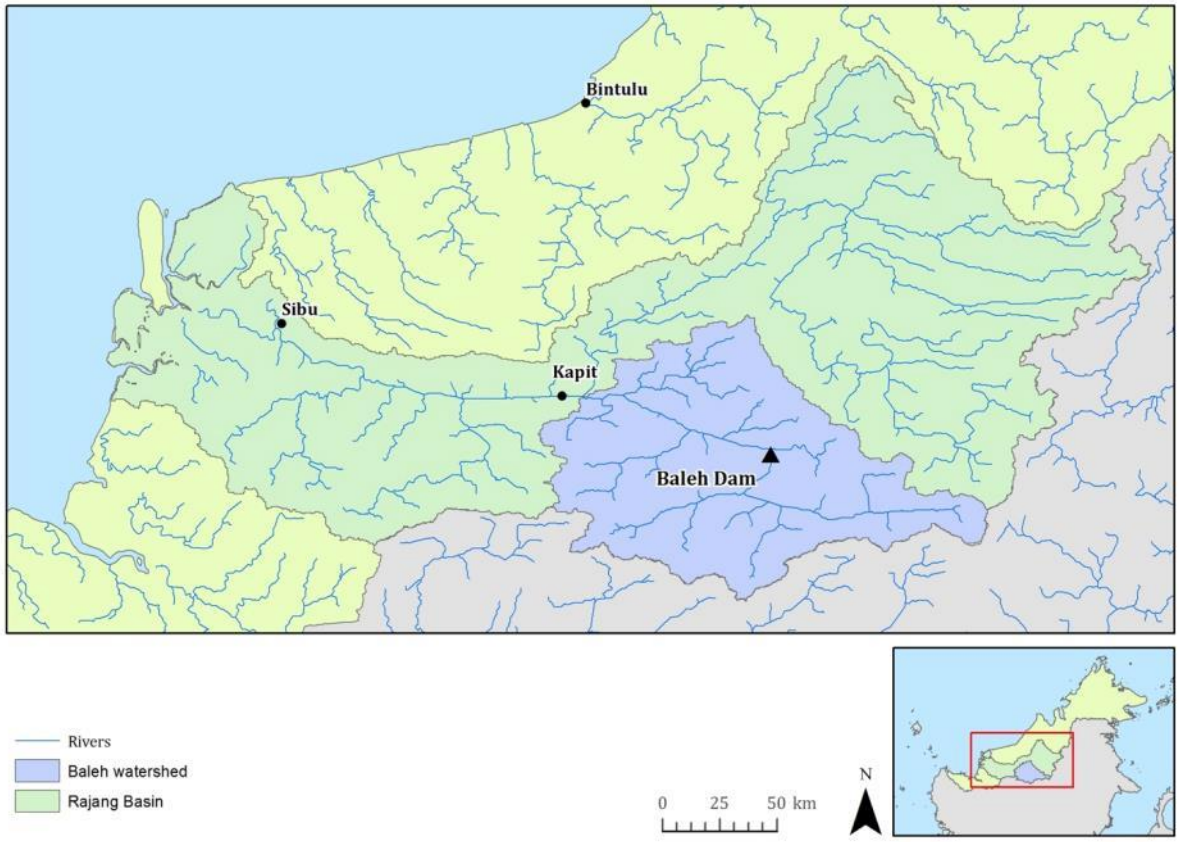

Figure 1. Location of the Rajang river basin (4.96 million hectares) and the Baleh watershed (1.24 million hectares).

Chapter 1. Ecological and hydrological context

The descriptions of the ecological and hydrological context are drawn mostly from the Environmental Impact Assessment produced for the Baleh Hydropower Dam development.

1.1 Ecological context

Data collection for the Baleh Hydropower Dam Environmental Impact Assessment (EIA) involved biological surveys of 54 sites in the Baleh catchment. The descriptions below are summarised from the EIA.

1.1.1 Terrestrial fauna

At least 16 species of mammals have been recorded in the Upper Baleh watershed. They include two species of bats, three species of rodents, two species of Viverids and one Mustelid, one species of mousedeer, two species of deer, two species of monkey, one species of ape, and wild pigs.

The reptiles and amphibians survey in the Upper Baleh includes 34 species of frog and 29 species of reptile. Some species are rated by IUCN: seven species are identified as Near Threatened, and one species of turtle is classified as Vulnerable. At a local level, three turtle species, two python species and two monitor lizard species are protected under Malaysia's Wildlife Protection Ordinance 1998. The watershed also contains five reptile species and eight frog species that are endemic to Borneo. All the frog species, including the endemic species, identified at EIA survey sites are in locations that will be inundated following dam construction and operation.

Avifauna recorded at the EIA sites included 152 species. The diversity of species ranged from 13 at one site, up to 38 at a site described as a small stream flowing through mixed secondary and logged dipterocarp forest. The most abundant bird species observed in the Upper Baleh, in decreasing order of abundance, are the Pacific Swallow, Dusky Munia and the Little Spiderhunter.

1.1.2 Aquatic fauna

Sixty species of fish were recorded in the Upper Baleh watershed, with 58 of those recorded in the watercourses that will be flooded, and 58 species were recorded in watercourses that won't be flooded. It is thought that fish movement is very localised. However, upon inundation, some fish species that prefer clear and fast flowing water devoid of sedimentation will be significantly impacted following the change in flow conditions from a free-flowing river to a still lake environment.

The Baleh Hydropower Dam EIA states that fishes upstream of the dam will be impacted by the inundation. Fishing is an important economic activity of some local villagers, and inundation could result in the loss of fish catches worth about RM 500,000 annually.

Seventy-four species of macroinvertebrate were recorded in the Upper Baleh; aquatic insects comprised 61 (82%) of the macroinvertebrate species. Four species of macroinvertebrate are endemic to Borneo.

1.1.3 Terrestrial flora

Surveys of the secondary forest in the Upper Baleh found 68 genera of plants, dominated by *Shorea* spp. and *Nephelium* spp. Secondary forest is forest that has

been logged or used for agricultural activity but has regrown. Four species identified by the IUCN Red List as endangered are *Dryobalanops lanceolata, Shorea platyclados, Shorea macroptera* and *Shorea myrionerva*.

1.2 Hydrological context

The Baleh watershed is about 1.24 million hectares, which is approximately one quarter of the entire Rajang watershed (4.96 million hectares). The area that will supply the hydropower dam is about 560,000 hectares, i.e. just under half of the Baleh watershed. The entire Baleh watershed falls within the Kapit gazetted water catchment. The major topographical feature of the upper Baleh is the Nieuwenhuis Mountains, which rise up to 1,900 m in elevation. Elevation at the lower north-western parts of the watershed ranges from 550-650 m above sea level.

The climate of the Baleh watershed is typical of an equatorial climate, which sees heavy rainfall, uniform temperatures and high humidity. There are two monsoonal seasons, the South-westerly Monsoon (May – September) and the North-easterly Monsoon (November – March). The average monthly precipitation ranges from around 200 mm in July to nearly 400m in December.

The watercourses in the upper Baleh are characterised as upland and montane rivers and streams. The two main tributaries upstream of the dam are the Upper Baleh River, flowing from east to west, and the Mengiong River, flowing from west to east. At their junction, they proceed to flow northwards for about 25km until the dam site. Estimated mean monthly flows (over the period 1967-2010) of the Baleh River at the dam site range from about 570 m3/s in July and August to about 870 m3/s from November to January. These are estimated from a hydrological station 12 km downstream of the dam site because no hydrological station is located within the river systems of the dam catchment.

Water quality samples taken for the environmental impact statement of the Baleh Hydropower Dam indicate that the larger streams have high total suspended solids, ammoniacal nitrogen and total coliform, with the overall quality rated as clean or slightly polluted.

Chapter 2. Cultural and economic context

This chapter provides a profile of the socio-cultural and economic activities dependent on the Baleh Watershed. A clear understanding of the socio-economic context is of high importance in identifying and valuing the ecosystem services provided by the watershed.

This chapter identifies the socio-cultural profile of the study area by looking at the latest available demographic data published by the Department of Statistics of Malaysia. It also evaluates the economic significance of the study area by identifying and measuring the following economic activities that are directly or indirectly dependent on the Rajang River and, by extension, on the Baleh River, which is one of its main tributaries:

- Water supply
- Commercial navigation and port services
- Shipbuilding
- Aquaculture
- Tourism
- Coal mining and sand mining

Much of the data used in this chapter is available and reported at the level of administrative districts within the study area (i.e. the Baleh watershed and downstream sections of the Rajang river). The eight administrative districts in Central Sarawak are Kapit, Song, Kanowit, Sibu, Meradong, Sarikei, Matu and Daro. It is noted that the boundaries of the administrative districts do not necessarily match the hydrological boundary of the study area. As such, the socio-economic data obtained by administrative district represents an area somewhat larger than the area defined by the hydrological boundary.

2.1 Population

In 2015, over half a million residents lived in the Baleh-Rajang study area, including 61,100 people in Kapit, 22,600 in Song, 31,700 in Kanowit, 270,600 in Sibu, 32,300 in Meradong, 63,000 in Sarikei, 19,500 in Matu and 34,700 in Daro (Figure 2). The population of the Baleh-Rajang study area constituted about 20 percent of the population in Sarawak.

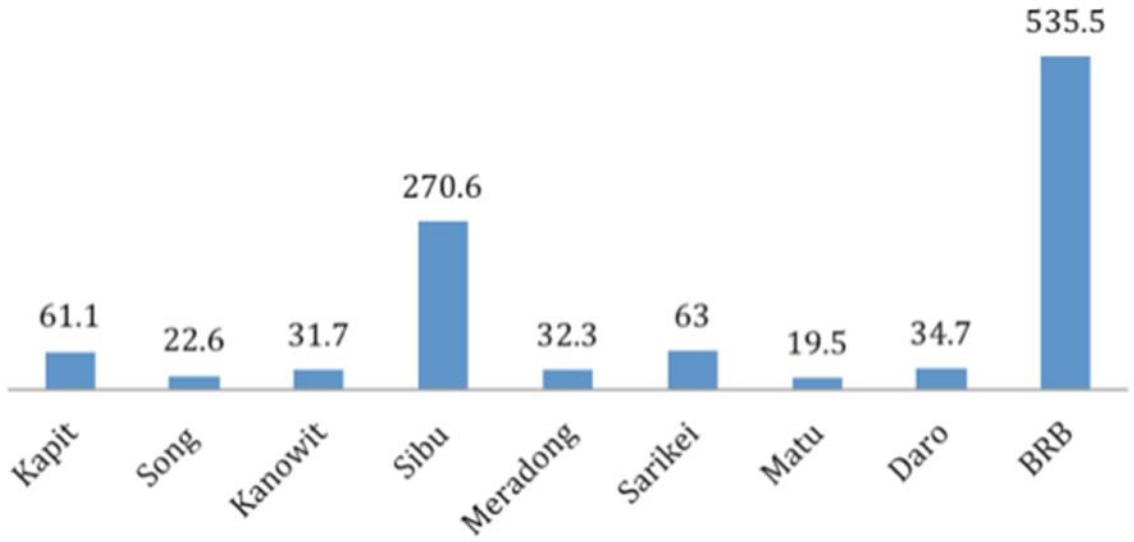

Figure 2. Population in Baleh-Rajang study area ('000s). Source: DOS, Malaysia (2017), Economic Census 2016, Establishment Statistics

The Baleh-Rajang study area experienced population growth between 2010 and 2015 at an average annual growth rate (AAGR) of 1.7 percent, on par with the growth rate registered at the state level. Two coastal districts, Daro and Matu, recorded the highest population growth rate at 2.3 percent and 2.1 percent respectively. Song's population growth rate was slightly above the state's average growth rate (Table 1).

It should be noted that population numbers do not necessarily reflect year-round residence, particularly in rural communities. Many longhouse families and members may spend part, or even the majority, of their time living elsewhere.

Table 1. Baleh-Rajang study area: Number of population ('000s), AAGR & % share.

	2010	2015	AAGR
Kapit	56.4	61.1	1.6
Song	20.7	22.6	1.8
Kanowit	29.1	31.7	1.7
Sibu	249.7	270.6	1.6
Meradong	29.6	32.3	1.7
Sarikei	58.4	63	1.5
Matu	17.6	19.5	2.1
Daro	31	34.7	2.3
Baleh-Rajang study area	492.5	535.5	1.7
Sarawak	2487.1	2709.7	1.7
Baleh-Rajang study area % share of total Sarawak population	19.8	19.8	

Source: DOS, Malaysia (2017), Economic Census 2016, Establishment Statistics

2.2 Cultural and social context

The Baleh-Rajang study area has a rich culture and heritage. It is the heartland of the Iban and Melanau people. There is a high concentration of Iban people in Song, Kanowit and Kapit, representing over 80 percent of the total population in the districts. The Melanau people are mostly concentrated in the downstream and coastal areas of the Basin, most notably in the Daro and Matu Districts. Around 70 percent of the total population in the two districts are Melanau. Sibu and Sarikei on the other hand have significant Chinese-Foochow population (Table 2).

Table 2. Population by ethnic group and administrative district, 2015(p), % Share.

	Malay	Iban	Bidayuh	Melanau	Other Bumiputera	Chinese	Indian & Others	Non-M'sian
Kapit	4.1	81.0	0.6	1.3	4.5	6.9	0.4	1.1
Song	3.8	88.3	0.5	0.9	0.9	4.7	0.5	0.5
Kanowit	4.3	83.9	0.3	1.0	1.0	8.6	0.3	1.0
Sibu	10.5	28.7	0.8	6.3	1.5	45.2	0.8	6.2
Meradong	15.9	44.9	0.7	5.0	1.0	27.9	0.7	4.0
Sarikei	16.6	33.4	0.8	6.6	1.2	38.3	0.8	2.0
Matu	3.4	19.5	0.5	68.8	2.4	3.4	0.5	2.0
Daro	6.4	13.1	0.3	71.2	1.3	2.1	0.0	5.4
Total	**9.6**	**40.1**	**0.7**	**12.7**	**1.7**	**30.3**	**0.6**	**4.2**

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2. Note: (p) preliminary

2.3 Education

The Baleh-Rajang study area supports 306 primary schools, 50 secondary schools and one college (Table 3). Altogether there are close to 100,000 students studying in these educational institutions (Table 4).

Table 3. Number of schools by administrative district, 2015.

	Total	Primary School	Secondary School	Tertiary
Sibu	121	92	28	1
Kanowit	38	35	3	-
Sarikei	50	44	6	-
Meradong	36	32	4	-
Kapit	49	45	4	-
Song	19	17	2	-
Daro	44	41	3	-
Total	**357**	**306**	**50**	**1**

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2

Table 4. Number of students by administrative district, 2015.

	Total	Primary School	Secondary School	Vocational college
Sibu	51,393	27,087	23,846	460
Kanowit	6,170	3,818	2,352	-
Sarikei	11,658	6,506	5,152	-
Meradong	6,668	3,280	3,388	-
Kapit	11,701	7,186	4,515	-
Song	3,251	1,945	1,306	-
Daro	8,528	5,642	2,886	-
Total	**99,369**	**55,464**	**43,445**	**460**

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2

2.4 Health care

There are five public hospitals in the Basin area. The Basin also features other types of health facilities such as health clinic, mobile clinic and school clinics (Table 5).

Table 5. Number of government hospitals and clinics by type and administrative district, Sarawak, 2015

	Hospital	General Outpatient Department	Health Clinic	MCH	1 Malaysia Clinic	MCHC	Mobile Clinic	Dental Specialist Clinic	Public Dental Clinic	School Clinic	Mobile Clinic	Mobile Dental Team
Sarikei	1	-	2	2	1	-	3	1	1	5	-	4
Meradong	-	-	1	-	-	-	-	-	1	4	-	2
Sibu	1	-	5	-	7	1	2	2	2	18	1	9
Kanowit	1	1	5	-	-	1	1	-	1	3	-	2
Matu	-	-	6	-	-	-	1	-	-	1	-	1
Daro	1	-	9	-	-	-	2	-	-	1	-	2
Kapit	1	-	11	-	-	-	10	-	1	3	-	3
Song	-	-	5	-	-	-	3	-	1	2	-	1
Total	**5**	**1**	**44**	**2**	**8**	**2**	**22**	**3**	**7**	**37**	**1**	**24**

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2

2.5 Economic activity

The Baleh-Rajang study area directly and indirectly supported 12,480 economic establishments in 2015, comprising 20.4 percent of the total economic establishments in Sarawak (Table 6). These establishments were entities registered with the Companies Commission of Malaysia, local authorities, other government agencies, and various business and trade associations located in the Basin. The sectors covered include services; manufacturing; construction; agriculture; mining and quarrying; water supply, sewerage, waste management and remediation activities; and electricity, gas, steam and air conditioning supply.

These sectors use the Baleh-Rajang study area's ecosystem in a number of ways. Many of the sectors directly utilize the waters of the river for purposes that include water supply, food, transport, irrigation, tourism, recreation, and waste disposal.

Table 6. Number of economic establishments by administrative district, 2015

	Economic establishments
Kapit	574
Song	115
Kanowit	265
Sibu	8,562
Meradong	549
Sarikei	1,607
Matu	266
Daro	542
Total Baleh-Rajang study area	**12,480**
Sarawak	**61,298**
% share of Sarawak	**20.4**

Source: DOS, Malaysia (2017), Economic Census 2016, Establishment Statistics

2.5.1 Water supply

The Baleh-Rajang study area is a valuable ecological and economic resource that supplies drinking water to over half a million of the population in Sarawak. The Sibu Water Board has its water intake points, pump stations, treatment plans and storage facilities along the Rajang River (Figure 3).

The Sibu Water Board produced over 41 million cubic metres of freshwater in 2011. The production volume increased steadily to reach 53 million cubic metres in 2016, accounting for 20 percent of the water production in Sarawak (Figure 4). In 2015, 42 percent of the water produced by the Sibu Water Board is meant for domestic consumption, 14 percent for industrial and commercial consumption, 8 percent for government consumption, 4 percent for other purposes, reflecting the important role of the Baleh-Rajang study area in sustaining the socio-economic well-being of the region (Table 7).

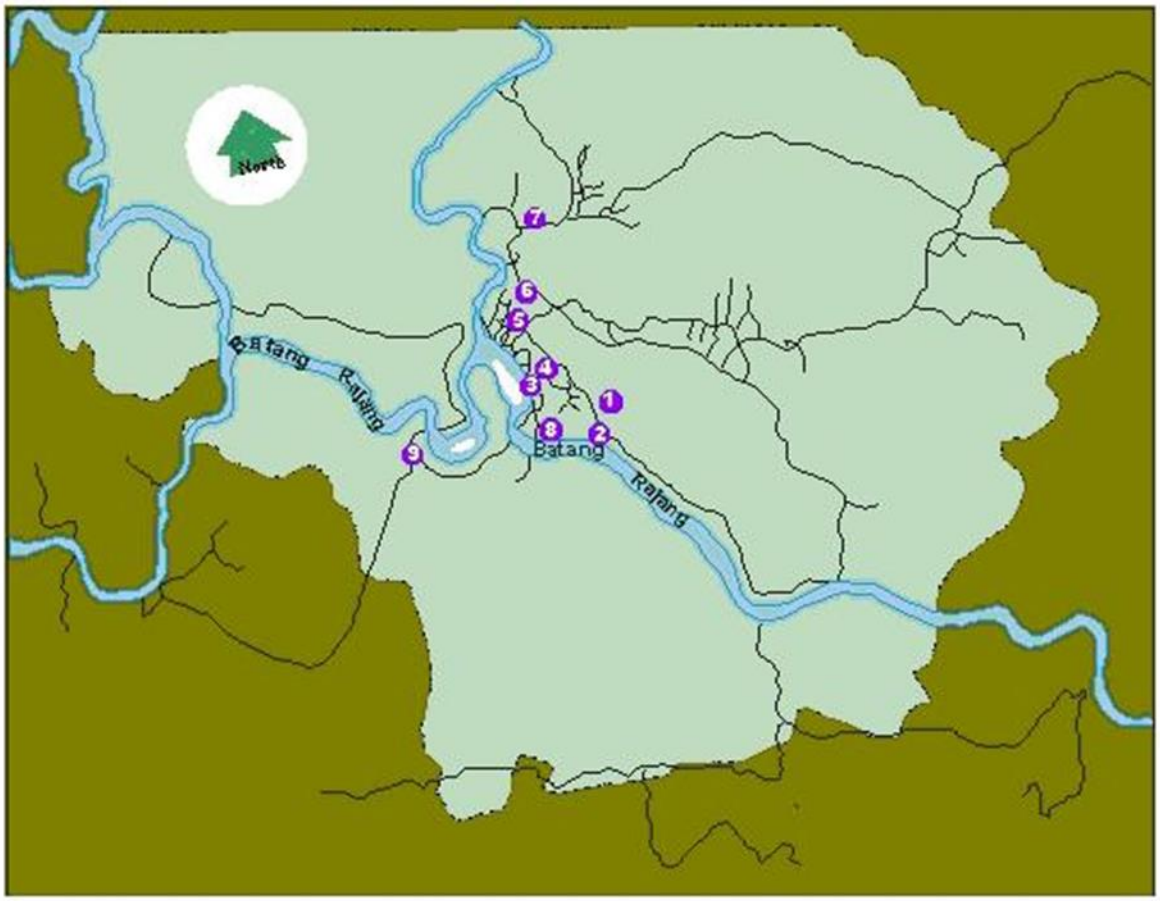

Figure 3. Sibu Water Board, locations of water intake points & other facilities. Source: Sibu Water Board (http://www.swb.gov.my/). Note: 1. Sibu Water Board Depot Admin; 2. Salim Intake; 3. Bukit Lima Intake; 4. Bukit Lima Treatment Plant; 5. Olive High Level Tank; 6. Deshon Road Booster Pump Station; 7. Teku Road Booster Pump Station; 8. Upper Lanang High Level Tank; and 9. Pradom High Level Tank

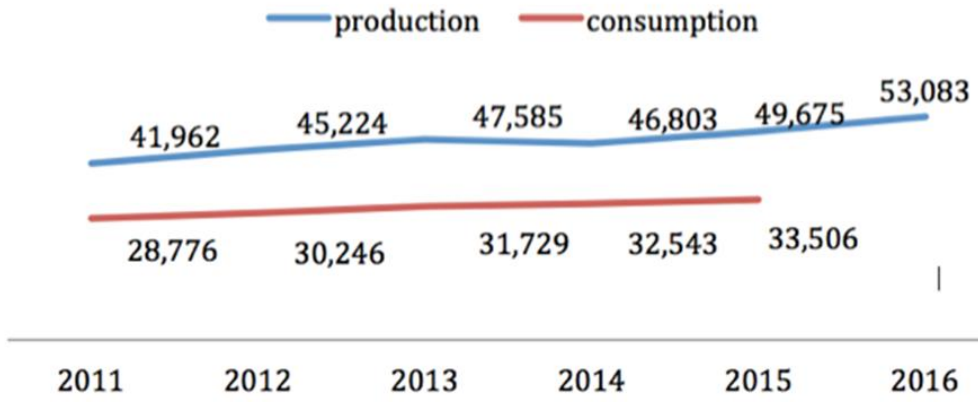

Figure 4. Production and consumption of water as recorded by Sibu Water Board, 2011-15. Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2 and Sibu Water Board

Besides the Sibu Water Board, the Sarawak Rural Water Supply Department also plays a critical role in improving accessibility to supply water in the Baleh-Rajang study area, especially in the Kapit District.

Table 7. Production and consumption of water, Sarawak ('000 Cu. Metres)

Year	Production	Consumption				
	Total production	Total consumption	Domestic	Industrial & commercial	Government	Others
Sarawak (total)						
2011	197,654	130,617	79,428	20,918	28,147	2,124
2012	204,545	135,964	82,104	15,236	36,165	2,459
2013	211,678	139,523	85,044	15,028	36,913	2,538
2014	218,305	142,525	86,492	16,177	37,526	2,330
2015	229,315	151,683	89,443	17,250	41,830	3,160
Sibu Water Board						
2011	**41,962**	**28,776**	18,575	6,701	2,899	601
2012	**45,224**	**30,246**	18,978	7,384	3,037	847
2013	**47,585**	**31,729**	19,921	7,455	3,225	1,128
2014	**46,803**	**32,543**	20,438	7,667	3,353	1,085
2015	**49,471**	**33,506**	20,781	7,067	3,762	1,896
Sibu's share of the total (%)						
			% share of total production by Sibu Water Board			
2011	**21**	**22**	44	16	7	1
2012	**22**	**22**	42	16	7	2
2013	**22**	**23**	42	16	7	2
2014	**21**	**23**	44	16	7	2
2015	**22**	**22**	42	14	8	4

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2

2.5.2 Commercial navigation and port services

The commercial navigation and port services sector is highly dependent on the river. The Rajang River has significant instream navigation use value. It is navigable for 130 km to Sibu by oceangoing vessels and for another 160 km by shallow-draft craft; small canoes can penetrate even farther into the upper part of the Baleh River.[1] The Rajang River provides cost-effective means for transporting large volume of cargo and passengers.

Given the difficult terrain and relatively poor road connectivity across many areas in central Sarawak, inland waterway transport is the leading mode of transport in the Basin.

There are five river ports located along the Rajang River, namely, Tanjung Manis, Sarikei, Bintangor, Sibu and Sungai Merah (Figure 5). The Tanjung Manis Port is operated by the Tanjung Manis Integrated Port Sdn. Bhd., a wholly owned subsidiary of Sarawak Timber Development Corporation (STIDC). It is under the administration of the Tanjung Manis Port Authority.[2] The other four ports are under the administration of the Rajang Port Authority. Sibu Port is the principal port serving the central region of Sarawak. It provides the vital link of the feeder route to the major ports in Malaysia as well as a port of call for ships from various parts of the world.[3]

Figure 5. Ports along the Rajang Rivers. Source: Rajang Port Authority

[1] https://www.britannica.com/place/Rajang-River
[2] Tanjung Manis Integrated Port Sdn Bhd (http://www.tmport.com.my/profile.php)
[3] Rajang Port Authority (http://www.rajangport.gov.my/)

The Rajang Port has three sub-ports, namely Sibu, Sarikei and Tajung Manis Ports. It handled 1,720 vessels (arrivals and departures) in 2015, accounting for 14.5 percent of the total number of vessels handled by all ports in Sarawak. On average, about 30 percent of the vessels handled by these ports are ocean-going vessels and 70 percent are riverine boats. The large percentage share of riverine boats signifies a high degree of dependency by local communities on the river for mobility (Tables 8 to 11).

Table 8. Arrivals and departures of vessels by sea port, Sarawak

Ports	Year	Arrivals		Departures	
		Number	'000 N.R.T.	Number	'000 N.R.T.
Kuching	2011	3528	4641	3528	4641
	2012	3726	5012	3726	5012
	2013	4199	5310	4198	5308
	2014	3871	5160	3871	5160
	2015	3945	4567	3945	4567
Rajang	2011	2661	4048	2661	4048
	2012	2788	4659	2788	4659
	2013	2477	4380	2477	4380
	2014	2259	3928	2259	3928
	2015	1720	3014	1720	3014
Bintulu	2011	4364	20264	4364	20264
	2012	4631	18535	4631	18535
	2013	3491	20282	3491	20282
	2014	3315	18547	3315	18547
	2015	3261	19033	3261	19033
Miri	2011	2576	3344	2578	3344
	2012	2314	3124	2314	3124
	2013	1436	2359	1413	2248
	2014	2388	2642	2376	2629
	2015	2191	3047	2191	3047
Others	2011	738	197	736	197
	2012	494	133	498	138
	2013	541	276	535	274
	2014	752	190	733	185
	2015	732	250	736	250
Total	2011	13867	32494	13867	32494
	2012	13953	31463	13957	31468
	2013	12144	32607	12114	32492
	2014	12585	30467	12554	30449
	2015	11849	29911	11853	29911

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2
Note: Rajang include ports at Sibu, Sarikei and Tanjung Manis.

Table 9. Arrivals and departures of vessels by ports, Sarawak, % share

Ports	Year	Arrivals		Departures	
		Number	'000 N.R.T.	Number	'000 N.R.T.
Kuching	2011	25.4	14.3	25.4	14.3
	2012	26.7	15.9	26.7	15.9
	2013	34.6	16.3	34.7	16.3
	2014	30.8	16.9	30.8	16.9
	2015	33.3	15.3	33.3	15.3
Rajang	2011	19.2	12.5	19.2	12.5
	2012	20.0	14.8	20.0	14.8
	2013	20.4	13.4	20.4	13.5
	2014	17.9	12.9	18.0	12.9
	2015	14.5	10.1	14.5	10.1
Bintulu	2011	31.5	62.4	31.5	62.4
	2012	33.2	58.9	33.2	58.9
	2013	28.7	62.2	28.8	62.4
	2014	26.3	60.9	26.4	60.9
	2015	27.5	63.6	27.5	63.6
Miri	2011	18.6	10.3	18.6	10.3
	2012	16.6	9.9	16.6	9.9
	2013	11.8	7.2	11.7	6.9
	2014	19.0	8.7	18.9	8.6
	2015	18.5	10.2	18.5	10.2
Others	2011	5.3	0.6	5.3	0.6
	2012	3.5	0.4	3.6	0.4
	2013	4.5	0.8	4.4	0.8
	2014	6.0	0.6	5.8	0.6
	2015	6.2	0.8	6.2	0.8
Total	2011	100.0	100.0	100.0	100.0
	2012	100.0	100.0	100.0	100.0
	2013	100.0	100.0	100.0	100.0
	2014	100.0	100.0	100.0	100.0
	2015	100.0	100.0	100.0	100.0

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2
Note: Rajang include ports at Sibu, Sarikei and Tanjung Manis

Table 10. Rajang Port, number of river and ocean-going vessels

	Arrivals		Departures	
Year	river	ocean-going	river	ocean-going
2011	1783	878	1893	768
2012	1899	889	2034	754
2013	1662	815	1819	658
2014	1632	627	1696	563
2015	1149	571	1279	441

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2
Note: Rajang include ports at Sibu, Sarikei and Tanjung Manis

Table 11. Rajang Port, % share of river and ocean-going vessels

	Arrivals		Departures	
Year	river	ocean-going	river	ocean-going
2011	67	33	71.1	28.9
2012	68	32	73.0	27.0
2013	67	33	73.4	26.6
2014	72	28	75.1	24.9
2015	67	33	74.4	25.6

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2
Note: Rajang include ports at Sibu, Sarikei and Tanjung Manis

In the year 2015, the Rajang Port Authority recorded a total revenue of RM 32.1 million. In fact it has been staying profitable over the past many years (Figure 6). However, in recent years, the ports in Rajang appear to be losing their competitiveness due to sedimentation[4] which also causes frequent flooding in Sibu Town in which dredging is said to be an ineffective method to overcoming the problem.[5]

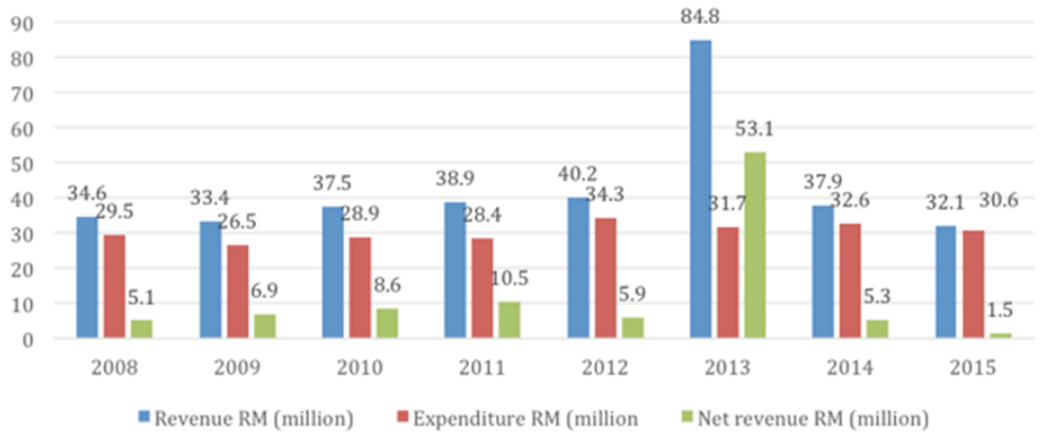

Figure 6. Rajang Port Authority revenue and expenditure. Source: Rajang Port Authority

[4] http://www.thestar.com.my/metro/community/2015/10/03/chamber-rajang-port-not-closing-down/#1FeBWFw6IPxJLIwV.99
[5] http://www.theborneopost.com/2014/07/11/nature-hits-back-with-vengeance/

Inland waterway transport has traditionally been the mode of choice for movement of people and goods in and out of Baleh. However, its dominance is on a decline due mainly to better road connectivity and higher car ownership. The construction of the 73km access road to the Baleh Dam, from Nanga Mujung in Kapit is expected to be completed by the end of 2019.[6] This shall further erode the use of inland waterway as the main mode of transport.

2.5.3 Shipbuilding

The Baleh-Rajang study area supports a premier ship building industry in Malaysia. Sibu, in particular, is the heartland of Malaysia's shipbuilding industry. In 2014, there were 120 shipyards in Malaysia, 70 of which were in Sarawak. Of the total, 50 were found in Sibu Town[7]. The industry has been around for almost 100 years. Shipyards in the Baleh-Rajang study area produce a wide range of vessels including tugboat, barge, landing craft, cargo ship, offshore supply vessel, passenger boat, ferry and fast crew boat for the domestic and international markets.[8] Seventeen of the biggest Sibu-based shipyards are located in Rantau Panjang by the Rajang River, an area designated by the Sarawak state government in 2003 as a cluster for the industry. The shipyard houses key industry players such as Yong Chui Kui, Far East, Tuong Aik, Gim Hwak, Fulsail, Eastern Marine, Vitawani and SL Shipbuilding.[9]

2.5.4 Aquaculture

There is a significant aquaculture industry in the floodplain and coastal regions of the Baleh-Rajang study area, particularly in the brackish water areas in the Sarikei Division (Table 12). Freshwater ponds, cages and concrete tanks/canvas are also found within the basin boundary (Table 13).

Table 12. Estimated area and number of brackish water ponds and cages by division, Sarawak, 2015[p]

	Fish pond		Cage		Sea prawn pond	
Division	Number	Hectare	Number	Area (m2)	Number	Area (m2)
Sarikei	-	-	192	1728	40	28.8
Sibu	-	-	-	-	-	-
Kapit	-	-	-	-	-	-
Total	0	0	192	1728	40	28.8

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2
Note: (p) preliminary

6 The Borneo Post, 30 Apr 2016
7 http://www.thestar.com.my/news/community/2014/02/17/still-not-a-smooth-sailing-for-shipbuilders-says-association/
8 http://www.theborneopost.com/2016/03/02/sibu-shipbuilders-urged-to-remain-united/
9 http://www.amim.org.my/AMIM/in-the-heartland-of-malaysias-shipbuilding-ship-repairing-industry/

Table 13. Estimated area and number of freshwater ponds, cages and concrete tanks/canvas by division, Sarawak, 2015[p]

Division	Pond		Cage		Concrete tanks/ Canvas	
	Number	Hectare (ha)	Number	Area (m2)	Number	Area (m2)
Sarikei	1108	91.9	20	180	-	-
Sibu	717	74.8	18	162	-	-
Kapit	128	18.8	-	-	20	550.7
Total	1953	185.5	38	342	20	550.7

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2
Note: [(p)] preliminary

2.5.5 Tourism

The records of the Immigration Department of Sarawak have shown that the Baleh-Rajang study area draws approximately 300,000 to 376,000 visitors every year (Table 14). The points of entry are Sibu and Sarikei. These figures, however, are likely a gross underestimate given that both domestic and international visitors travelling from other domestic points within Sarawak (e.g., from Kuching) to the Baleh-Rajang study area are not required to go through the immigration processes in the points of entry in Sibu and Sarikei (in this case, the immigration clearance for international visitors is done at Kuching International Airport).

Table 14. Number of arrivals by point of entry, Sarawak

Point of entry	2013	2014	2015
Sibu	364,190	363,265	289,635
Sarikei	12,718	12,736	10,959
Baleh-Rajang study area	376,908	376,001	300,594

Source: Immigration Department, Sarawak

Table 15. Aircraft movements at principal airports, Sarawak (number of landings and takeoffs)

Airports	2011	2012	2013	2014	2015
Kuching	51,763	46,252	53,095	50,917	52,807
Miri	43,760	45,666	47,774	48,602	47,384
Sibu	18,211	17,150	19,613	21,776	19,452
Bintulu	13,609	11,493	12,466	12,698	12,635
Others (a)	15,590	15,092	15,188	11,168	18,968
Total	142,933	135,653	148,136	145,161	151,246

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2
Note: (a) Figures refer to returns from Mukah, Limbang, Lawas, Marudi, Mulu, Bario, Ba'kalalan, Long Banga, Long Lellang, Long Seridan and Long Akah airports.

Table 16. Aircraft movements at principal airports, Sarawak (% share)

Airports	2011	2012	2013	2014	2015
Kuching	36	34	36	35	35
Miri	31	34	32	33	31
Sibu	13	13	13	15	13
Bintulu	10	8	8	9	8
Others (a)	11	11	10	8	13
Total	100	100	100	100	100

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2
Note: (a) Figures refer to returns from Mukah, Limbang, Lawas, Marudi, Mulu, Bario, Ba'kalalan, Long Banga, Long Lellang, Long Seridan and Long Akah airports.

2.5.6 Coal mining and sand mining

Coal is found in Peninsular Malaysia, Sarawak and Sabah. But Sarawak has the most widespread and abundant occurrences of coal in Malaysia[10]. Sarawak produced close to 2.6 million tonnes of coal in 2015[11]. A bulk of the production occurs in the Merit Pila coalfield which is located 75 km upstream of Kapit on the Rajang river[12]. Coal deposits with substantial reserves are also known in Hose Mountains[13], which is part of the Baleh watershed. However, there is no report suggesting that the coal reserves in the area have been mined. Sand mining activities are found in the study area. Sand mining companies are required to obtain EIA approval prior to their operation[14]. However, illegal sand mining activities are not uncommon in the area[15].

2.6 Revenue of municipal and district councils

Local governments in Sarawak have the mandate to raise certain revenues from taxes, levies and fees. The main sources of revenue are from collection of assessment rates, vehicle parking fees, fines, business licensing fees, rental, tender fees, among others. The municipal and district councils in the Baleh-Rajang study area received an annual revenue of between RM95 million to RM111 million for the period 2013-2015, accounting for 13 to 15 percent of the revenue generated by all the municipal and district councils in Sarawak (Table 17).

[10] Chen S.P. (1986). Coal Potential and Exploration in Sarawak, GEOSEA V Proceedings Vol. II, Geological Society of Malaysia, Bulletin 20, Aug
[11] Department of Statistics Malaysia (2016). Statistics Yearbook Sarawak, 2015 version 2.0
[12] Baruya P. (2010). Prospects for coal and clean coal technologies in Malaysia, International Energy Agency Clean Coal Centre
[13] Chen S.P. (1992). Coal as an energy resource in Malaysia, Geological Society of Malaysia-Circum-Pacific Council for Energy and Mineral Resources Tectonic Framework and Energy Resources of the Western Margin of the Pacific Basin 27 Nov – 2 Dec
[14] http://www.theborneopost.com/2010/11/03/%E2%80%98dept-ordered-to-intensify-monitoring-on-sand-mining%E2%80%99/
[15] http://www.theborneopost.com/2018/04/06/businessman-held-for-illegal-dredging-rm1m-worth-of-sand-seized/

Table 17. Revenue [(a)] of municipal and district Councils, Sarawak (RM; '000s)

Municipal/ District Council	2013	2014	2015
Sibu Municipal	59,964	65,666	58,644
Sibu Rural	12,683	13,486	7,891
Sarikei	17,016	18,045	10,145
Meradong/ Julau	4,167	4,552	4,498
Kanowit	3,817	4,747	3,413
Kapit	6,596	8,071	6,771
Matu/ Daro	6,595	7,187	4,270
Baleh-Rajang study area	110,838	121,754	95,632
Total Sarawak	852,645	803,138	630,125
% share	13	15	15

Source: DOS, Malaysia (December 2016), Sarawak Year Book 2015 v.2
Note: (a) Includes development revenue.

Chapter 3. Policy and institutional context

To build a solid case for better development planning of Baleh Watershed will require careful consideration of the policies and institutional frameworks affecting the area. Additionally, to provide relevant policy input to put Baleh on a green economy pathway, some of the recent policy pronouncements made by the State Government (such as on forestry and oil palm production) should be examined. The section below summarises key policies and institutional frameworks relevant to the Baleh Watershed.

3.1 Sarawak Corridor of Renewable Energy

Sarawak aims to become a developed state by 2030. To achieve high-income status, Sarawak needs to increase its current annual GDP growth rate from about four per cent to six per cent over the next 13 years.

One of the major programmes adopted by the State to generate economic growth is the Sarawak Corridor of Renewable Energy (SCORE). SCORE covers a land area of 7 million ha in central Sarawak, home to a population of 600,000.

Since it was launched in February 2008, SCORE has attracted over RM104 billion of private and public sector investment. Energy intensive activities such as manufacturing of polycrystalline silicon, aluminum ingots and billets, manganese and ferroalloys are being actively promoted by the Government and are mainstays of SCORE.

The success of SCORE is therefore heavily dependent on how well the State Government manages its main sources of energy, i.e., the 2,400MW Bakun hydroelectricity power (HEP) dam, 944MW Murum HEP dam and 1,285 MW Baleh HEP dam. Presently, Sarawak's power generation mix is 75% renewable hydro and 25% gas and coal resources.

3.2 Protected Area

The National Parks and Nature Reserves Ordinance (1998) of Sarawak is an ordinance for the constitution and management of National Parks and Nature Reserves in the state. The Wild Life Protection Ordinance (1998) of Sarawak stipulates that a State land may be constituted as Wild Life Sanctuary for the conservation of wildlife and habitat. Forest Department Sarawak is the agency that executes and enforces the ordinances.

As of July 2017, Sarawak had gazetted 903,769 ha of areas as Totally Protected Areas (TPAs) that consisted of 35 national parks (694,770 ha), 14 nature reserves (2,539 ha) and six wildlife sanctuaries (206,460 ha).

A National Parks and Wildlife Department is expected to be established in 2018 to focus on wildlife protection and accelerate the gazettement of TPAs in the state[16]. The

[16] The gazetting process would sometimes take a long time to be implemented. For example, the gazetting process of Santubong National Park in Sarawak took not less than 20 years

management of national parks and wildlife in the state is expected to be more systematic and effective under the new department.

3.3 Master Plan for Wildlife in Sarawak

"A Master Plan for Wildlife in Sarawak" was prepared by Forest Department Sarawak and Wildlife Conservation Society in 1996. Driven by the Forest Department Sarawak and Sarawak Forestry Corporation, the Master Plan provides a comprehensive, cross-sectoral wildlife strategy for Sarawak that aims at enabling Sarawak to manage and conserve its native wildlife populations in perpetuity.

While progress has been made in the implementation of the master plan, a full revision is timely, considering the extent of land use changes that have happened since this document was prepared[17].

3.4 Forestry

The Forests Ordinance 2015 provides regulations and guidelines in the management of the forest of Sarawak and controls for the harvesting of forest resources in both Permanent Forest Estate and State-land Forests.

In recent years, the State Government has made it mandatory for all timber companies to obtain Sustainable Forest Management (SFM) certification by 2022. This is in recognition of the importance of SFM to address the issues of forest degradation and deforestation, ensure sustainability in production, improve governance of the forestry sector as well as to meet the demand of high value overseas markets. The policy was announced in November 2017. Before this, the requirement had only been implemented on a select few with relatively slow progress[18]. The Programme for the Endorsement of Forest Certification (PEFC) Council-endorsed Malaysian Timber Certification Scheme (MTCS) is the dominant certification scheme in Sarawak.

The state has set a target that by 2020, only timber and timber products that have been certified with Sarawak Timber Licence Verification System (STLVS) could be exported. This is to ensure that timber and timber products from Sarawak meet the stringent measures set by the international markets, especially on the issue of 'chain of custody'.

The STLVS includes procedures to regulate the forest and timber industry and standard for independent verification of compliance to Sarawak regulatory requirements. The STLVS acts as the process of due diligence for the forest and timber industry of Sarawak to meet international trade regulations. The Ministry of Urban Development & Natural Resources of Sarawak expects that all forest and mill operations in Sarawak shall meet the requirements as defined in this standard.

As of March 2018, 16 timber companies have adopted the new system since its introduction in 2017. The Sarawak Forest Department is targeting another 20 timber

[17] Hon J. and Shibata S. (2003). Borneo Journal of Resource Science and Technology (2013) 3(2): 22-35

[18] As of June 2016, there was only one licensed area – Anap Muput Forest Management Unit owned by Shin Yang Group covering 83,535 ha, which has obtained certification through its subsidiary Zee Tee Sdn. Bhd. (source: The Borneo Post, 10 Jun 2016)

companies to adopt the new system by December 2018[19]. However, the system has been implemented with limited public consultations.

Due to declining timber stock from natural forests, the State Government has also embarked on Industrial Tree Planting (ITP) with a target of one million hectares of fast growing tree species. The ITP timber will be an alternative source of timber and should be established on degraded land to encourage soil rehabilitation and amelioration. The government had issued 42 licences for planted forest (LPF), with a gross area of 2.57 million ha. However, the progress on the ground has been slow going with only approximately 383,244 ha of the area planted as of early 2017[20]. The Government is contemplating whether sections of the LPF area that are not plantable due to rugged terrain can be gazetted as TPA.

3.5 Oil palm

Sarawak has the nation's second largest oil palm planted area – covering 1.56 million ha, producing 4.1 million tonnes of crude palm oil and involving 34,590 smallholders.

To meet the growing external demand for certified sustainable palm oil, the State Government, following decisions taken by the Federal Government, agreed in May 2017 to implement the Malaysian Sustainable Palm Oil (MSPO) certification on mandatory basis beginning December 2019. All industry players, including smallholding farmers, have been given about 2.5 years to adjust and also to obtain certification. The MSPO is operated by the Malaysian Palm Oil Certification Council.

The certification scheme is said to give the Malaysian authorities the means to enforce certification standards since it ties in with existing instruments, for example, the official licences required for anyone operating in the palm oil business and issued by the Malaysian Palm Oil Board.

To date, there are 518,000 ha of MSPO-certified plantations in Malaysia, of which 30% are in Sarawak, and 15 out of 50 MSPO-certified palm oil mills are also in the state.

3.6 Water

The legislations regulating the water sector/industry in Sarawak are Water Ordinance, 1994 (Cap. 13); and Water Supply Regulations, 1995. Under the Sarawak Water Ordinance 1994, the Water Resources Council of Sarawak identifies, gazettes and protects important water catchments.

The Sarawak Integrated Water Resources Management initiative of the State Planning Unit, on the other hand, undertakes integration and sustainable management of water resources.

Under the regulation, there should be no human activities within the 8km radius from the water intake. This is to:

[19] There are at least 200 timber companies operating in Sarawak

[20] Forest Landscape restoration Forum, March 2017, Kuching, from presentation made by Forest Department Sarawak

- Provide a buffer zone around the raw water intake to provide some level of protection against pollution;
- Provide dilution of contaminant before it reaches the intake point;
- Allow time of about half an hour or so depending on river flow velocity for water treatment plant operators to take action to prevent the contaminant from entering the water supply system, e.g. by shutting down the operation of the raw water intake.

However, there is no evidence suggesting that this regulation has been adequately adhered to.

The goal of the State Government is to achieve 100% coverage in terms of water supply by 2025. The State Planning Unit is preparing a long-term strategy to provide water to the urban and rural areas throughout Sarawak. The state cabinet has decided to allocate RM1 billion for a water supply system called State Water Grid to supply villages and longhouses across the state with regular treated water. For the first phase, a water grid from Batang Ai dam to Tanjong Manis is underway with facilities to supply treated water to the villages affected by water supply issues along the grid. The State Water Grid is meant not just for human consumption, but also the development of the agriculture industry.

The State Planning Unit is also drawing up long-term plans to source water from Baleh, Murum and Bakun dams for the surrounding areas. The government plans to establish a 'Lake Authority' to regulate the usage of lakes created by dams.

3.7 Heart of Borneo Initiative

The Heart of Borneo (HoB) Declaration was signed by the governments of Brunei, Indonesia and Malaysia in February 2007. The declaration commits the governments to a single conservation vision to ensure the effective management of resources and conservation of a network of protected areas, productive forests and other sustainable land uses. Besides the national governments, state/provincial governments are the major partners of the initiative.

About 11% (2.7 million ha) of the total area of the HoB falls within the boundary of Sarawak. Most of the HoB areas in Sarawak are the highlands, which are important watersheds that contains the headwaters of the Baleh, Murum and Bakun dams. For the sustainable management of the watershed, all timber licenses within the HoB are required to practice sustainable forest management and obtain certification.

The HoB Initiative encourages investment in nature for a Green Economy. It also focuses on securing and restoring landscape connectivity in the Heart of Borneo by linking protected areas through sustainable and traditional land use, and sustainable forest management across Borneo.

The HoB Initiative has five programs, namely Transboundary Management, Protected Areas Management, Sustainable Natural Resource Management, Ecotourism Development, and Capacity Building. Within each of these programs are a number of strategic actions, with a total of 21 actions across the HoB Initiative.

Our study contributes to the Protected Areas Management and the Sustainable Natural Resource Management programs by revealing the value of the natural capital and ecosystem service flows. This information is needed to support robust

management of natural resources and expansion and better management of protected areas. The concept of a Green Economy is central to the HoB goal of attracting sustainable finance and investment in conservation through, for example, payment for ecosystem services (PES). Our study estimates the value of natural capital to support a PES program.

Chapter 4. Key ecosystem services valued in the study

This chapter outlines the selection of ecosystem services that are valued in the study. The identification of relevant ecosystem services is based on a review of HoB reports; documents and visit reports provided by WWF Malaysia; and consultations conducted during the scoping visit (see Final Scoping Report). The TEEB ecosystem services typology (see Table 18) is used in order to enable direct comparisons and potential scaling up of valuation results to other policy sites within the Heart of Borneo. This will complement and be consistent with other TEEB studies at the national and regional levels.[21]

Table 19 provides an overview of which ecosystem services are valued in this study including information on the valuation method used and data inputs.

Table 18. TEEB classification of ecosystem services (TEEB 2010)

Ecosystem service	Definition
Provisioning services	
Food	Ecosystems provide the conditions for growing food. Food comes principally from managed agro-ecosystems but marine and freshwater systems or forests also provide food for human consumption.
Raw materials	Ecosystems provide a great diversity of materials for construction and fuel including wood, biofuels and plant oils that are directly derived from wild and cultivated plant species.
Fresh water	Ecosystems play a vital role in the global hydrological cycle, as they regulate the flow and purification of water. Vegetation and forests influence the quantity and quality of water available locally.
Medicinal resources	Ecosystems and biodiversity provide many plants used as traditional medicines as well as providing the raw materials for the pharmaceutical industry.
Regulating services	
Local climate and air quality	Trees provide shade whilst forests influence rainfall and water availability both locally and regionally. Trees or other plants also play an important role in regulating air quality by removing pollutants from the atmosphere.
Carbon sequestration and storage	Ecosystems regulate the global climate by storing and sequestering greenhouse gases. As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues.
Moderation of extreme events	Extreme weather events or natural hazards include floods, storms, tsunamis, avalanches and landslides. Ecosystems and living organisms create buffers against natural disasters, thereby preventing possible damage.

[21] To facilitate comparisons with studies that use alternative classification systems, a table showing the corresponding ecosystem service groups in the Millennium Ecosystem Assessment (MA) and Common International Classification for Ecosystem Services (CICES) is included in Appendix 1.

Ecosystem service	Definition
Waste-water treatment	Ecosystems filter both human and animal waste and act as a natural buffer to the surrounding environment. Through the biological activity of microorganisms in the soil, most waste is broken down. Thereby pathogens (disease causing microbes) are eliminated, and the level of nutrients and pollution is reduced.
Erosion prevention and maintenance of soil fertility	Vegetation cover prevents soil erosion. Well functioning ecosystems supply the soil with nutrients required to support plant growth.
Pollination and seed dispersal	Insects (and some birds and bats) pollinate plants and trees, which is essential for the development of fruits, vegetables and seeds.
Biological control	Ecosystems regulate pests and diseases through the activities of predators and parasites. Birds, bats, flies, wasps, frogs and fungi all act as natural controls of pests.
Habitat and supporting services	
Habitats for species	Habitats provide everything that an individual plant or animal needs to survive: food; water; and shelter. Each ecosystem provides different habitats that can be essential for a species' lifecycle. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their movements.
Maintenance of genetic diversity	Genetic diversity is the variety of genes between and within species populations. Genetic diversity distinguishes different breeds or races from each other thus providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock.
Cultural services	
Recreation and mental and physical health	Recreating in green space is a good form of physical exercise and also lets people relax. Green space plays a role in maintaining mental and physical health.
Tourism	Ecosystems and biodiversity play an important role for many kinds of tourism, which in turn provides considerable economic benefits and is a major source of income for many countries.
Aesthetic appreciation and inspiration for culture, art and design	Language, knowledge and the natural environment have been intimately related throughout human history. Biodiversity, ecosystems and natural landscapes have been the source of inspiration for much of our art, culture and increasingly for science.
Spiritual experience and sense of place	In many parts of the world natural features such as specific forests, caves or mountains are considered sacred or have a religious meaning. Nature is a common element of all major religions and traditional knowledge, and associated customs are important for creating a sense of belonging.

Table 19. Ecosystem services, valuation methods and data needs

Ecosystem service	Included in study	Description	Valuation method	Data needs
Provisioning services				
Food	Yes	Wildlife (both legally and illegally harvested), fish, gingers, bamboo shoots, petai (stink beans), olives, edible palms and ferns harvested from forest and rivers. Cultivated crops grown in forest (e.g. rice, fruits). Downstream fisheries.	Net-factor income (revenue equivalent minus costs)	Data on household harvests, use, harvest cost and prices to be collected through a household survey. Questions on the illegal harvesting and sale of bushmeat are carefully phrased.
Raw materials	Yes	Rattan, beads, fuelwood, timber (used for building houses and boats)	Net-factor income (revenue equivalent minus costs)	Data on household harvests, use, harvest cost and prices to be collected through a household survey.
Fresh water	Yes	Provision of clean water for household use. The beneficiaries of clean water include households within the watershed.	Choice experiment	Household willingness to pay for change in fresh water availability is used to compute a value per litre of water.
Medicinal resources	No	The use of medicinal plants in the study area is minimal.		

Ecosystem service	Included in study	Description	Valuation method	Data needs
Regulating services[22]				
Local climate and air quality	No	Air quality is not an issue in the study area		
Carbon sequestration and storage	Yes	Quantity of carbon stored in forest. Note: the Malaysian federal government are looking into the potential of REDD+	Avoided damage costs of climate change; Net revenue from carbon credits	Data on change in physical quantity of carbon stored under alternative scenarios; and data on the economic value of emissions (the avoided climate change damage costs. Spatial variation in carbon sequestration/storage rates by land use class is modelled using available biophysical models.
Moderation of extreme events	Yes	Regulation of frequency and/or severity of flooding (regulation by forest only; not the HEP dam). Damage from landslides appears to be minimal.	Avoided damage costs; Choice experiment	Data on flood frequency and damage costs to longhouses collected through household surveys. Willingness to pay for changes in flood frequency estimated for downstream residents and tourists. Variation in flood frequency due to changes in forest cover is linked to modelled changes in base flow.
Waste-water treatment	No	Ecosystems do not appear to play a significant role in treating waste water in the study area		
Erosion prevention and maintenance of soil fertility	Yes	Regulation of sediment loads in Rajang river by forest outside of Baleh HEP dam catchment.	Choice experiment	Willingness to pay of downstream residents and tourists for clearer rivers. Variation in sediment load due to changes in land cover is modelled using available bio-physical models.
Pollination and seed dispersal	No	Although wild pigs and other fauna are important for seed		Need quantitative understanding of the bio-physical impacts on forest condition due to a

[22] The regulation of river flow as an input to river transportation (including transportation of logs) is not included in the assessment. Based on discussions during the scoping visit, this service was not deemed to be significantly affected by changes in land use within the Baleh watershed.

Ecosystem service	Included in study	Description	Valuation method	Data needs
		dispersal, sufficient data on the role of pollinators and seed dispersers could not be obtained.		reduction in seed dispersal.
Biological control of pests	No	This service was not identified in the study area		
Habitat and supporting services				
Habitats for species	No	The economic value of habitats for species is captured through the valuation of wildlife and plants for food, tourism and sense of place. This "intermediate service" is not valued separately to avoid double counting.		
Maintenance of genetic diversity	No	Genetic diversity is an input into several production processes. Inland fisheries department (IFD) are collecting fish from all over Sarawak for a breeding programme to maintain genetic diversity. Sarawak Biodiversity Centre (SBC) is collecting knowledge on traditional medicinal plants around Sarawak.	The first-best method would be a production function approach but data is not available.	
Cultural services				
Recreation and mental and physical health	Yes	Use of the watershed for recreation by local people and external parties is limited but there may be some (and increasing) recreational hunting.	Choice experiment	Willingness to pay by local communities for continued availability of recreational hunting opportunities.

Ecosystem service	Included in study	Description	Valuation method	Data needs
Tourism	Yes	Forests and wildlife in the Baleh watershed as an attraction for tourists. Tourist visits are currently low but may increase with accessibility and the designation of Baleh national park.	Net factor income to estimate producer surplus from providing tourism services; Contingent valuation to estimate tourists' willingness to pay for visit.	Tourist numbers and activities. Tourism related revenues and costs from relevant services providers (e.g. hotels, tour operators, transportation etc.). Survey of tourists regarding their expenditure, activities, and preferences for nature conservation and willingness to pay to access nature areas.
Aesthetic appreciation and inspiration for culture, art and design	Yes	Role of forests in local customs and identity for longhouse communities	Choice experiment	Preferences of longhouse communities for the aesthetic quality of their surroundings.
Spiritual experience and sense of place	Yes	Importance of preserving habitats and biodiversity to all residents and tourists to Sarawak ("non-use" values).	Choice experiment	Preferences of all Sarawak residents and tourists on the importance of conserving forests and wildlife in the Baleh watershed. Collected through a public survey of Sarawak residents in Kuching, Sibu and Kapit and tourists to Sarawak.

Chapter 5. Spatial modelling of ecosystem services

Land use is a major determinant of the magnitude of flow of ecosystem services (Crossman et al., 2013). Intensive land uses such as cropping agriculture and agroforestry supply mostly food and timber resources, and depending on the level of sustainability of the land management practices, may provide few other ecosystem services. Other land uses, such as protected areas, provide many other ecosystem services (such as erosion control, flood risk mitigation, recreation and tourism, habitat for biodiversity), but may provide very little food, depending on the level of protection. Land use changes in a landscape will change the flow of ecosystem services. It is therefore very important to map current land uses and plausible future land uses and apply ecosystem service models to each land use map to estimate the different flow of ecosystem services under different futures.

This chapter provides the methods and data used to model the flow of ecosystem services under current land use in the study area and under plausible alternative future land uses in the year 2030.

5.1 Methods and data

5.1.1 Land Use scenarios

This section describes the components of four spatially explicit land cover-land use scenarios developed for the study:

i) baseline of current land cover and use;
ii) 2030 economic development scenario;
iii) 2030 green economy scenario, and;
iv) 2030 conservation scenario.

These four scenarios were developed in close consultation with WWF Malaysia who advised on the major data inputs into each of the 2030 scenarios and provided the relevant spatial data.

Baseline - current land use

This scenario represents the current land cover and land use using latest available land cover and land use mapping data.

The extent of the baseline land use is the Rajang River Basin. The baseline map was extracted from the European Space Agency Climate Change Initiative Land Cover dataset (ESA CCI-LC) v. 2.0.7, released in April 2017[23]. The CCI-LC dataset consists of consistent global LC maps at 300m spatial resolution on an annual basis from 1992 to 2015 inclusive, based on moderate resolution satellite data (NOAA-AVHRR HRPT, ENVISAT MERIS, ENVISAT-ASAR, SPOT VGT and PROBA-V). We used only the 2015 land cover layer. The land cover for the study area (Rajang River Basin) was extracted from the global dataset. The CCI-LC maps' legend was defined using the Land Cover Classification Systems developed by the Food and Agriculture

[23] Available from https://www.esa-landcover-cci.org

Organization of the United Nations (FAO) and counts 22 classes at 'level 1' for the entire world and 14 additional classes at "level 2" based on more accurate and regional information, where available.

The land cover was merged with three important land use layers to produce a layer describing current major land uses in the study area. The land use layers integrated were: i) Forest Department Sarawak current protected areas; ii) the 2016 CIFOR mapped Oil Palm and Industrial Timber Plantations[24], and; iii) WWF mapped Oil Palm and Industrial Timber Plantations. The three layers, originally acquired as shapefiles, were converted to rasters using the spatial extent and resolution of the ESA land cover extracted to the Rajang River Basin. The baseline (current) land use layer for the Rajang River Basin is shown in Figure 7.

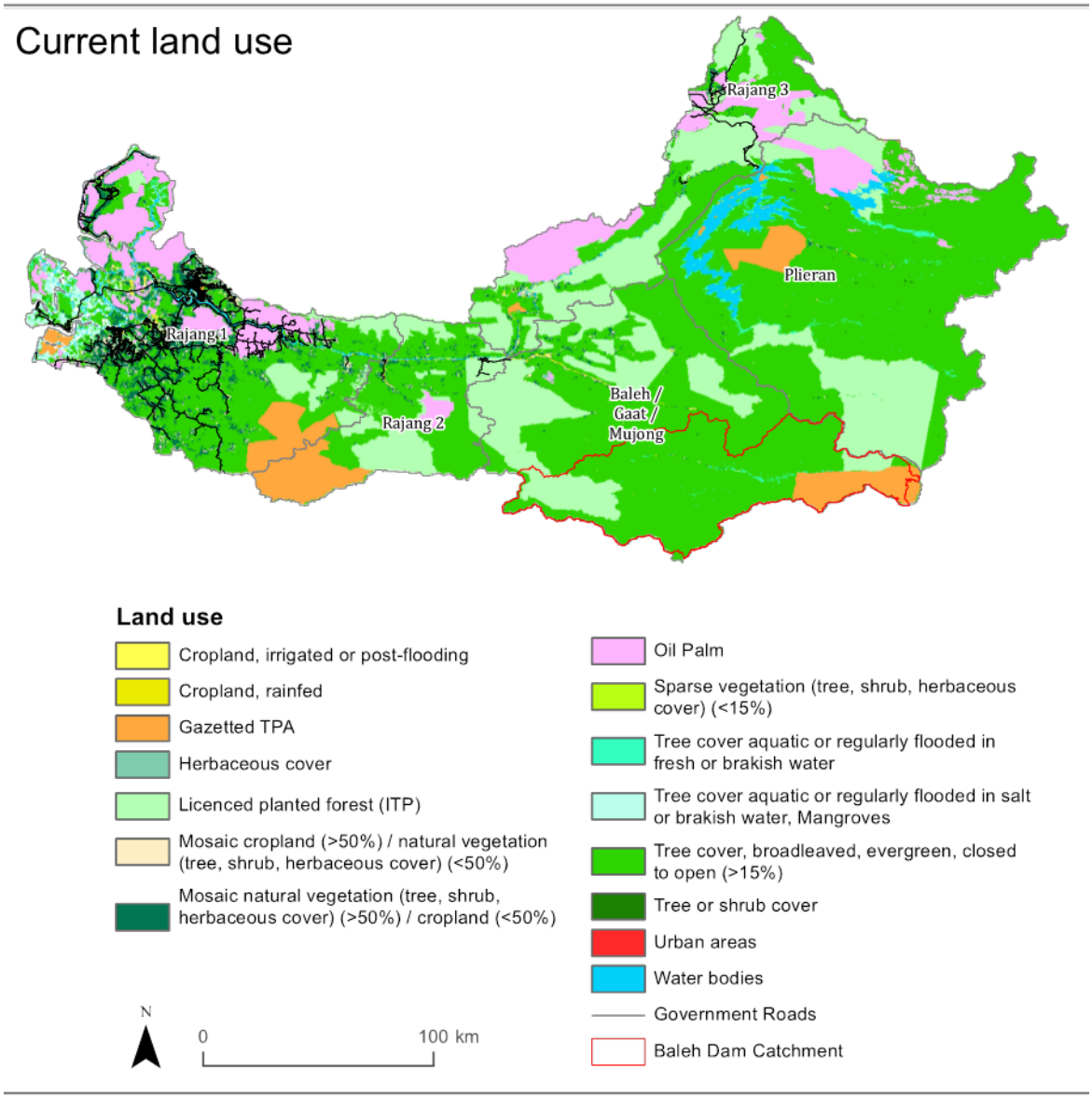

Figure 7. Current land use in the Rajang River Basin

[24] Available from https://www.cifor.org/map/atlas/

2030 Economic Development scenario

This scenario represents future economic development land uses. This scenario uses the baseline scenario (i.e. current land use) but adds new land uses based on spatially-explicit descriptions of future economic development for the upper Rajang and Baleh watersheds. The new spatial data for this layer was produced by scanning and the digitizing the 'Sustainable Green SCORE Hinterland' 2030 – proposed land use developments to 2030[25], including proposed protected areas. The new/expanded land uses are oil palm, licensed timber plantations, and the Baleh dam inundation. The 2030 Economic Development scenario land use layer for the Rajang River Basin is shown in Figure 9.

2030 Green Economy scenario

This scenario represent future economic development land uses but with more sustainable land and water resource management through widespread implementation of sustainable palm oil and sustainable timber harvesting standards. The spatial extents of land uses are identical to the 2030 economic development scenario. Therefore, the land uses include the 'Sustainable Green SCORE Hinterland' 2030 – proposed land use developments to 2030'. The difference between the two scenarios is how the land is managed as described by the adoption of the Malaysian Sustainable Palm Oil (MSPO) certification standards and the Malaysian Timber Certification Scheme (MTCS)[26] sustainability standards.

The MSPO certification standards and the MTCS sustainability standards for natural forest and for planted forests were assessed for specific actions relevant to land management and conservation and which could be implemented in ecosystem service models. Table 20 lists the principles and criteria from the MSPO and the MTCS which potentially influence ecosystem service model parameters and could be implemented in the ecosystem service models. However, the criteria in the MSPO and the MTCS standards (Table 20) are qualitative and therefore not able to be directly applied in the quantitative models. The criteria instead provide context for adjustment to various parameters in the ecosystem models described below. Visually the 2030 Green Economy scenario is identical to the 2030 Economic Development scenario in Figure 9.

2030 Conservation scenario

This scenario prioritises future biodiversity conservation and Integrated Water Resource Management (IWRM)[27] land uses. This scenario uses the 2030 Green Economy scenario but adds future conservation and IWRM land uses and incorporates spatial priorities from the Systematic Conservation Planning (SCP) exercise undertaken by the Technical Working Group for SCP Sarawak (WWF-Malaysia and Sheppard 2016). Any current/proposed oil palm and licensed planted forest (LPF) are removed from the proposed protected areas (giving the protected

[25] SCORE Draft Master Plan, Vol 2, p117

[26] MTCS was used in this analysis because it is the more popular certification scheme compared to FSC. Furthermore, there is no national interpretation for FSC, with no FSC sites in Sarawak, and issues related to post 94 rules and Policy of Association make FSC less popular. For practical reasons, this report considers MTCS as it is the certification scheme most likely to be adopted in the near future.

[27] Also known as Integrated River Basin Management. IWRM is used more commonly worldwide.

areas full protection) and high priority locations identified in the SCP prioritisation work, with the assumption these locations undergo ecological restoration. The entire catchment upstream of the Baleh dam is given full protection.

The extent of current and future total protected areas were taken from the Forest Department Sarawak TPA database. For the IWRM land uses, locations of water offtake points and gravity feed dams were buffered by 8km radius, as per the Sarawak IWRM plan[28]. Locations of micro-hydro points were buffered by 20m radius as per the Sarawak IWRM plan. The location data of the water offtake points, gravity feed dams and micro-hydro points was provided by WWF Malaysia. The 2030 Conservation scenario land use layer for the Rajang River Basin is shown in Figure 9.

[28] Available from http://www.siwrs.com.my/modules/iwrm/page.php?id=32&menu_id=12&sub_id=36

Table 20. Principles and criteria from the MSPO and MTCS certification standards for sustainable production of palm oil and timber, respectively. Where possible the best management practices for these principles and criteria will be incorporated into ecosystem services models.

Criteria/indicator	Relevant page #	Ecosystem service model application
Malaysian Sustainable Palm Oil (MSPO) Standards Part 3: General principles for oil palm plantations and organised smallholders		
4.5.5.1 Indicator 1: The management shall establish a water management plan to maintain the quality and availability of natural water resources (surface and ground water). The water management plan may include: a) Assessment of water usage and sources of supply. b) Monitoring of outgoing water which may have negative impacts into the natural waterways at a frequency that reflects the estate's current activities. c) Ways to optimize water and nutrient usage to reduce wastage (e.g. having in place systems for re-use, night application, maintenance of equipment to reduce leakage, collection of rainwater, etc.). d) Protection of water courses and wetlands, including maintaining and restoring appropriate riparian buffer zones at or before planting or replanting, along all natural waterways within the estate. e) Where natural vegetation in riparian areas has been removed, a plan with a timetable for restoration shall be established and implemented. f) Where bore well is being use for water supply, the level of the ground water table should be measured at least annually.	10	Only used in qualitative context – not used specifically in models
4.5.6.2 Indicator 2: If rare, threatened or endangered species, or high biodiversity value, are present, appropriate measures for management planning and operations should include: a) Ensuring that any legal requirements relating to the protection of the species are met. b) Discouraging any illegal or inappropriate hunting, fishing or collecting activities and developing responsible measures to resolve human-wildlife conflicts.	11	Provides context for factors in **biodiversity and habtat** model
4.7 Principle 7: Development of new plantings **4.7.1 Criterion 1: High biodiversity value** **4.7.1.1 Indicator 1**: Oil palm shall not be planted on land with high biodiversity value unless it is carried out in compliance with the National and/or State Biodiversity Legislation. **4.7.1.2 Indicator 2**: No conversion of Environmentally Sensitive Areas (ESAs) to oil palm as required under Peninsular Malaysia's National Physical Plan (NPP) and the Sabah Forest Management Unit under the Sabah Forest Management License Agreement. For Sabah and	13-14	Only used in qualitative context – not used specifically in models

Criteria/indicator	Relevant page #	Ecosystem service model application
Sarawak, new planting or replanting of an area 500ha or more requires an EIA. For areas below 500ha but above 100ha, a Proposal for Mitigation Measures (PMM) is required.		
4.7.2 Criterion 2: Peat land **4.7.2.1 Indicator 1**: New planting and replanting may be developed and implemented on peat land as per MPOB guidelines on peat land development or industry best practice.	13-14	Only used in qualitative context – not used specifically in models
4.7.4 Criterion 4: Soil and topographic information **4.7.4.1 Indicator 1**: Information on soil types shall be adequate to establish the long-term suitability of the land for oil palm cultivation. **4.7.4.2 Indicator 2**: Topographic information shall be adequate to guide the planning of planting programmes, drainage and irrigation systems, roads and other infrastructure.	13-14	Provides context for RUSLE model factors (C factor) in **sediment delivery ratio** model
4.7.5 Criterion 5: Planting on steep terrain, marginal and fragile soils **4.7.5.1 Indicator 1**: Extensive planting on steep terrain, marginal and fragile soils shall be avoided unless permitted by local, state and national laws. **4.7.5.2 Indicator 2**: Where planting on fragile and marginal soils is proposed, plans shall be developed and implemented to protect them and to minimize adverse impacts (e.g. hydrological) or significantly increased risks (e.g. fire risk) in areas outside the plantation. **4.7.5.3 Indicator 3**: Marginal and fragile soils, including excessive gradients and peat soils, shall be identified prior to conversion.	13-14	Provides context for RUSLE model factors (C factor) in **sediment delivery ratio** model
Malaysian Timber Certification Scheme: Malaysian Criteria and Indicators for Forest Management Certification (Natural Forest), 13 January 2012		
Principle 6: Environmental Impact Forest management shall conserve biological diversity and its associated values, water resources, soils and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and the integrity of the forest.	29	Only used in qualitative context – not used specifically in models
Indicator 6.2.2 Availability and implementation of management guidelines to establish representative conservation and protection areas, in accordance with existing forest ecosystems, appropriate to the scale and intensity of forest management.	32	Only used in qualitative context – not used specifically in models
Indicator 6.3.3 Harvesting is designed taking into consideration the need for the conservation of biological corridors and buffer zones for features of special biological interest for wildlife.	35	Provides context for factors in **biodiversity and habtat** model
Criterion 6.4 Representative samples of existing ecosystems within the landscape shall be protected in their natural state and recorded on maps, appropriate to the uniqueness of the affected resources and the scale and intensity of operations.	36	Provides context for factors in **biodiversity and habtat** model

Criteria/indicator	Relevant page #	Ecosystem service model application
Criterion 6.5 Guidelines shall be prepared and implemented to:- control erosion; minimise forest damage during harvesting, road construction, and all other mechanical disturbances; and protect water resources.	36	Provides context for RUSLE model factors (C factor) in **sediment delivery ratio** model
Criterion 6.10 Forest conversion to plantations or non-forest land uses shall not occur, except in circumstances where conversion: a) entails a very limited portion of the forest management unit; and b) does not occur on high conservation value forest areas; and c) will enable clear, substantial, additional, secure, long-term conservation, economic and social benefits across the forest management unit.	39	Provides context for factors in **biodiversity and habtat** model
Principle 9: Maintenance of High Conservation Value Forests Management activities in high conservation value forests shall maintain or enhance the attributes which define such forests. Decisions regarding high conservation value forests shall always be considered in the context of a precautionary approach.	45	Provides context for factors in **biodiversity and habtat** model
Malaysian Criteria and Indicators (MC&I) for Forest Plantation Management Certification (Version 2)		
Criterion 3.3 Sites of special cultural, ecological, economic or religious significance to indigenous peoples shall be clearly identified in cooperation with such peoples, and recognised and protected by forest plantation managers. **Indicator 3.3.1** Availability of appropriate procedures within current administrative processes for identifying and protecting such sites and provisions for rights of access to these sites by indigenous peoples within relevant federal and state legal frameworks or by mutual agreement.	13	Provides context for factors in **biodiversity and habtat** model
Criterion 5.5 Forest plantation management operations shall recognise, maintain, and, where appropriate, enhance the value of forest services and resources such as watersheds and fisheries. **Indicator 5.5.1** Availability and implementation of guidelines and/or procedures to identify and demarcate sensitive areas for the protection of soil and water, watercourses and wetlands in forest plantation areas. **Verifier** Sensitive areas in the forest plantation management unit identified, classified, mapped and protected	20	Provides contect for factors in **seasonal water yield** model
Criterion 6.2 • Safeguards shall exist which protect rare, threatened and endangered species and their habitats (e.g. nesting, salt licks and feeding areas). • Conservation zones and protection areas shall be established, appropriate to the scale and	22	Provides context for factors in **biodiversity and habtat** model

Criteria/indicator	Relevant page #	Ecosystem service model application
intensity of forest plantation management and the uniqueness of the affected resources. • Hunting, fishing, trapping and collecting shall be controlled in accordance with applicable statutes and customary laws.		
Criterion 6.3 Ecological functions and values shall be maintained intact, enhanced, or restored, including: a) Forest regeneration and succession. b) Genetic, species and ecosystem diversity. c) Natural cycles that affect the productivity of the forest ecosystem. (This Criterion shall apply only to areas/sites within the forest plantation management unit which are allocated for conservation or natural forest management, in accordance with Principle 9 and Criterion 10.5)	23	Provides context for factors in **biodiversity and habtat** model
Criterion 6.4 Representative samples of existing ecosystems within the landscape shall be protected in their natural state and recorded on maps, appropriate to the scale and intensity of operations and the uniqueness of the affected resources.	24	Provides context for factors in **biodiversity and habtat** model
Criterion 6.5 Guidelines shall be prepared and implemented to: control erosion; minimise forest damage during plantation establishment and harvesting, road construction, and all other mechanical disturbances; and protect water resources.	24	Provides context for RUSLE model factors (C factor) in **sediment delivery ratio** model
Criterion 6.10 Forest conversion to plantations or non-forest land uses shall not occur, except in circumstances where conversion: a) does not occur on high conservation value areas; b) does not occur in ecological corridors and environmentally sensitive areas identified by the relevant authorities; and c) will enable clear, substantial, additional, secure, long-term benefits across the forest plantation management unit.	26	Provides context for factors in **biodiversity and habtat** model
Principal 9 Maintenance of High Conservation Value (HCV) Management activities in high conservation value areas shall maintain or enhance the attributes which define such areas. Decisions regarding high conservation value areas shall always be considered in the context of a precautionary approach.	31	Provides context for factors in **biodiversity and habtat** model
Criterion 10.2 The design and layout of plantation shall promote the protection, restoration and conservation of natural forests, and not increase pressures on natural forests. Wildlife corridors, streamside zones and a mosaic of stands of different ages and rotation periods, shall be used in the layout of the plantation, consistent with the scale of the operation.	33	Provides context for factors in **biodiversity and habtat** model

Criteria/indicator	Relevant page #	Ecosystem service model application
The scale and layout of plantation blocks shall be consistent with the patterns of forest stands found within the natural landscape.		
Criterion 10.5 A proportion of the overall forest plantation management area, appropriate to the scale of the plantation, shall be managed so as to restore the site to a natural forest cover.	34	Provides context for factors in **biodiversity and habtat** model
Criterion 10.6 Measures shall be taken to maintain or improve soil structure, fertility, and biological activity. The techniques and rate of harvesting, road and trail construction and maintenance, and the choice of species shall not result in long term soil degradation or adverse impacts on water quality, quantity or substantial deviation from stream course drainage patterns.	35	Provides context for RUSLE model factors (C factor) in **sediment delivery ratio** model

5.1.2 Ecosystem services

Three ecosystem service models from the InVEST toolbox were built and applied to all four land use scenarios (current, 2030 Economic Development, 2030 Green Economy and 2030 Conservation). InVEST is widely used to assess impacts on ecosystem services under alternative scenarios of land management and land use (Hamel et al. 2015, Kennedy et al. 2016). The InVEST toolbox contains several models and functions to assess change in user selected ecosystem services given changes in land use and land cover. We used the Sediment Delivery Ratio (SDR) model, the Seasonal Water Yield (SWY) model, and the Carbon Sequestration (CS) model (Sharp et al. 2016), all of which are based on published independent models. A fourth model was built to describe the importance of biodiversity and habitat – counts of IUCN Red List species ranges. This section describes each model and its input data and model parameters. The widely available spatial data used in the InVEST models are listed in Table 23. All spatial data in Table 23 are global datasets – these were extracted for the Rajang River Basin and resampled to the same extent and spatial resolution as the land use data. The models also require a set of non-spatial biophysical parameters which are provided in Appendix 5.

Seasonal Water Yield

The InVEST seasonal water yield model computes spatial indices that quantify the relative contribution of a parcel of land to the generation of both baseflow (occurring during dry weather) and quickflow (occurring during or shortly after rain events), and a quantitative estimate of quickflow. The non-spatial parameters for the Seasonal Water Yield model are hydrologic soil group curve number (CN) values and monthly crop factors (Kc) values for each land use type. We used CN and Kc values that are typical for each main land use type, as presented in NRCS-USDA (2007) and Allen et al., (1998), respectively (Appendix 5. This model also requires total rainy days per month, which we sourced from online weather and climate information for Kuching[29]

Sediment Delivery Ratio

The Sediment Delivery Ratio model calculates the amount of sediment that leaves the unit of analysis (e.g., raster cell or watershed) and reaches the main stream annually. The model uses the popular, simple, robust and inclusive Revised Universal Soil Loss Equation (RUSLE) model for soil erosion (Department of Irigation and Drainage 2010; Estrada-Carmona et al. 2017). Different land uses, land covers and land management practices have a bearing on the 'cover management' (C) and 'support practice' (P) factors of the RUSLE. The C factor is the ratio of soil loss from land under the specific land cover and management type to the corresponding soil loss from continuously fallow and tilled land. The C factor can be used to determine the relative effectiveness of soil and crop management systems in preventing soil loss. Permanent forest cover will have a very low C factor (e.g., 0.003) because the protective vegetative cover reduces rainfall drop intensity and the root biomass keeps the soil in place. Bare land will have a high C factor because there are no soil protection measures.

[29] See https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Kuching,Malaysia

The P factor is the ratio of soil loss by an improved management practice that reduces the amount and rate of water runoff to that of straight-row farming up and down the slope that does not mitigate runoff. The P factor estimates the effectiveness of land management practices that reduce runoff such as contouring and terracing. A low P factor (e.g. 0.1) would be applicable to natural forest cover, while recently cleared land may have a P factor of 0.7 and bare lands and urban areas a P factor of 1.0 (Kamaludin et al., 2013)

We applied C factors and P factors to each land use type in each scenario, using parameters from an application of the RUSLE model to the Pahang River Basin in Peninsula Malaysia (Kamaludin et al., 2013), an area of comparable topographic, land use and climatic conditions to the Rajang. Following adoption of the MSPO certification standards and the MTCS sustainability standards for palm oil and licensed planted forest, respectively, which place an emphasis on reducing soil erosion (Table 20), the C factor would be expected to be closer to the values of a permanent natural forest within a protected area. Therefore, we adjusted the C factor to be closer to forest, but not identical given erosion would still occur from extraction processes and access roads – the C factor were decreased by 50% to capture adoption of the MSPO certification standards and the MTCS sustainability standards in the 2030 Green Development and 2030 Conservation scenarios. The C factor and P factor for each land use type are listed in Appendix 5.

Carbon sequestration

The InVEST carbon sequestration model uses spatial data of land use and carbon stocks in four carbon pools (aboveground biomass, belowground biomass, soil, dead organic matter) per land use to estimate the amount of carbon currently stored in a landscape or the amount of carbon sequestered over time. Aboveground biomass comprises all living plant material above the soil (e.g., bark, trunks, branches, leaves). Belowground biomass encompasses the living root systems of aboveground biomass. Soil organic matter is the organic component of soil, and represents the largest terrestrial carbon pool. Dead organic matter includes litter as well as lying and standing dead wood.

For aboveground carbon stocks we used remotely sensed (MODIS) and modelled estimates of aboveground live woody biomass density in the tropics produced by Baccini et al. (2017)[30], a 30m resolution dataset for the year 2000. This was converted to carbon stock by multiplying biomass density by 0.5, and the mean aboveground biomass carbon stock was calculated for each land use type. To verify the Rajang River Basin carbon densities, we compared values to a study that mapped aboveground carbon stocks in Sabah (Asner et al. 2018). For soil carbon stocks we used estimates of soil organic carbon stocks produced by UNCCD to support country-level reporting on progress toward the UN Sustainable Development Goal 15 on land degradation. Using variables from the ISRIC Global Soil Database, the UNCCD estimated soil organic carbon stocks for 2015. We extracted the data for the Rajang River Basin and calculated the mean soil organic carbon stocks under each land use type. We did not estimate carbon pools for belowground biomass and dead organic

[30] Available from Global Forest Watch: http://data.globalforestwatch.org/datasets/8f93a6f94a414f9588ce4657a39c59ff_1

matter due to absence of data. The mean values of the aboveground biomass and the soil carbon pools for each land use type are listed in Appendix 5.

Biodiversity and habitat

To estimate spatial extent of biodiversity in the Rajang River Basin under different land use types, we produced a simple model of the richness of conservation-rated species. We used the global ranges of IUCN Red List species – terrestrial mammals, amphibians and reptiles – and extracted them to the Rajang River Basin. The range of each species, originally in a polygon format, was converted to a raster, and all rasters were overlaid and counted to produce a count of species in every location in the study area. Different land uses will provide different levels of habitat suitability for species. For example, intensive land uses will be unsuitable for many species, while totally protected areas will be suitable for all species. To capture the differences in land uses and associated species habitat suitability, we applied to each land use a factor between 0 – 1 according to land use intensity. Its now well known that oil palm plantations in tropical Asia support much fewer species than do forests and often also fewer than other tree crops (Meijaard and Sheil, 2007; Fitzherbert et al., 2008; Wilcove and Koh, 2010; Jennings et al., 2015). Therefore, we assigned totally protected areas a factor of 1, licensed planted forests a factor of 0.5, oil palm a factor of 0.2, and cropland a factor of 0.1. This can be interpreted as protected areas being suitable for 100% of conservation-rated species, licensed planted forests suitable for 50% of rated species, oil palm suitable for 20% of rated species and cropland for 10% of rated species. Although these proportions are subjective they are in general agreement with the scientific literature (e.g. see Fitzherbert et al., 2008).

The biodiversity land use factor remained constant for each land use type across the four land use datasets (current and the three 2030 scenarios) except for palm oil and licensed planted forest, whereby the factors were increased given the adoption of the MSPO certification standards and the MTCS sustainability standards in the 2030 Green Development and 2030 Conservation scenarios. The adoption of the certification standards assumes that conservation-rated species will be managed and protected (Table 20), but it's unrealistic to expect species diversity in oil palm and planted forest to match that of natural forest in protected areas, with species diversity being higher in protected areas. Therefore, we assigned a factor of 0.66 to these land uses in the 2030 scenarios where MSPO and MTCS standards were adopted. The land use intensity habitat suitability factors are listed in Appendix 5 for each land use.

Table 21. Spatial data used for application of the InVEST toolbox in the Rajang River Basin

Data	Seasoal Water Yield model	Sediment Delivery Ratio model	Carbon sequestration	Biodiversity	Data sources
Land use (Current and 2030 scenarios)	•	•	•	•	European Space Agency Climate Change Initiative Land Cover dataset (ESA CCI-LC) v. 2.0.7
Digital Elevation model	•	•	•		Shuttle Radar Data Topography Mission (SRTM), 90m resolution
Monthly mean precipitation, 1970-2000	•				WorldClim 1km Global Climate Data, Version 2.0
Monthly mean evapo-transpiration, 1970-2000	•				CGIAR 1km Global-PET database
Hydrologic soil group	•				FutureWater 1km HiHydroSoil soil hydraulic properties database
Soil erodibility (K factor)		•			Global estimate of soil erodibility K-factor (Naipal et al., 2015)
Erosivity		•			European Commission 1km Global Rainfall Erosivity index
Aboveground live woody biomass			•		MODIS and modelled data (Baccini et al., 2017)
Soil Organic Carbon stocks				•	UNCCD unpublished data
IUCN Red List terrestrial mammals, amphibians and reptiles ranges				•	IUCN Red List of Threatened Species. Version 2018-1.

5.2 Baseline provision of ecosystem services

The extent of ecosystem services under current land uses are shown in Figure 8. The influence of different land use types is very clear for the sediment erosion, carbon sequestration and biodiversity habitat ecosystem services. Land uses that are less intensive, such as protected areas, will see less erosion, greater stores of carbon and a larger number of conservation-rated species than the intensive land uses. For water supply, the average baseflow is higher at the higher elevations of the Rajang River Basin, reflecting the higher rainfall amounts at higher elevations.

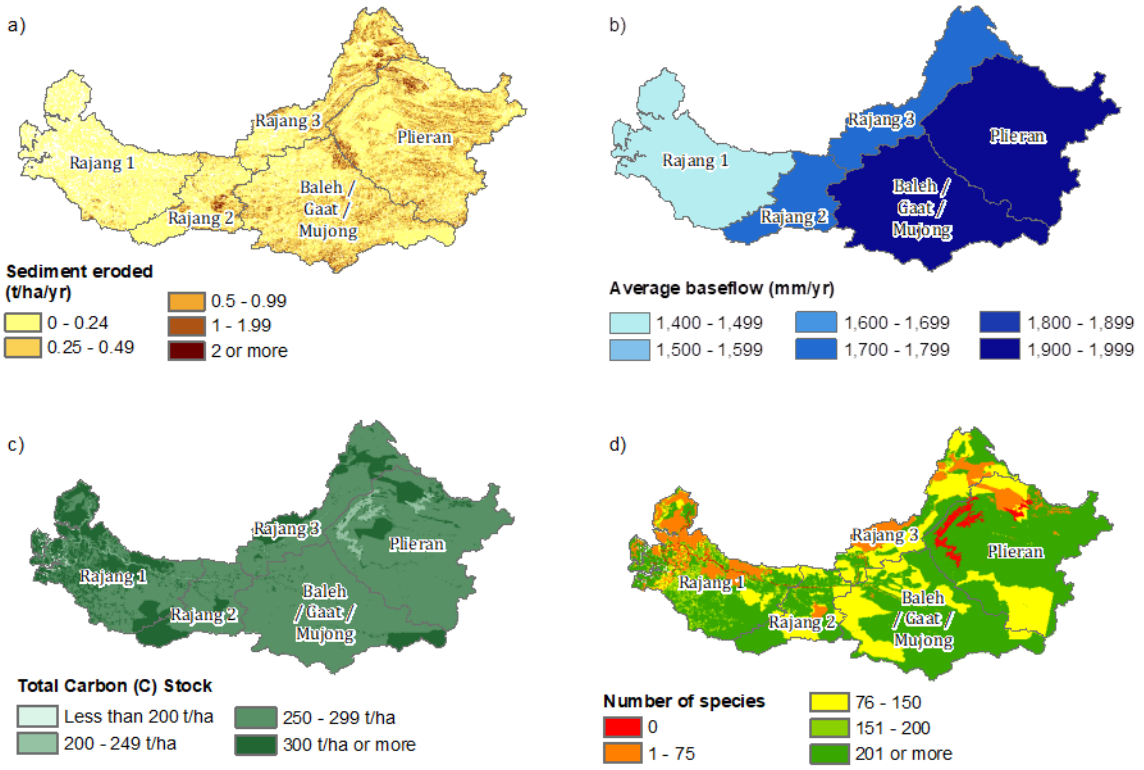

Figure 8. Ecosystem services under current land use: a) Sediment erosion; b) water supply; c) carbon sequestration, and; d) IUCN Red List species habitat.

5.3 Land use change scenarios and provision of ecosystem services

The land use scenarios for 2030 are shown in Figure 9. The 2030 economic development and 2030 green economy scenarios include existing land uses and land cover, but with the addition of the SCORE proposed oil palm (dark pink, left Figure 9), license for planted forests (LPF) (dark green, left Figure 9), proposed protected areas (tan, left Figure 9) and the area inundated by the Baleh dam (dark blue, left Figure 9). The 2030 conservation scenario includes the Forest Department Sarawak proposed protected areas (dark brown, right Figure 9), Sarawak Priority Conservation Areas identified from the SCP exercise (light brown, right Figure 9) and the Baleh Dam catchment area (red boundary, right Figure 9). The 8km diameter IWRM buffered intakes and gravity dams are shown as the dark blue circles in the 2030 conservation scenario.

The estimated supply of ecosystem services under the alternative 2030 land use scenarios are shown in Figures 10 - 13. For soil erosion in Figure 10, the total soil eroded annually is shown under the two different scenarios. Soil erosion in the Rajang and Baleh in many areas exceeds 1.5 tonnes/ha annually. The biggest differences between the scenarios are in the 2030 proposed protected areas where logging is stopped, forest restored, and erosion is then reduced.

The difference in annual water supply between the three 2030 scenarios is subtle (Figure 11). The most noticeable difference is in the lower Rajang, where water supply is marginally less under the 2030 conservation scenario. This is explained by the introduction in the 2030 conservation scenario of protected areas and alternative land management and restoration regimes in these areas that increase vegetation cover and slow runoff and reduce water yield in rivers. This also means that water is better retained in the catchments, thereby reducing flood risk and providing a more consistent water supply over time.

The differences in carbon sequestration between the current situation and the three 2030 scenarios are shown in Figure 12. The obvious changes are increases in carbon sequestered in the proposed protected areas in the 2030 conservation scenario, with more than 350 tonnes/ha of additional carbon sequestered by 2030 in these areas, based on the estimates of carbon stocks in tropical ecosystems by Baccini et al. (2017). To 2030 there are estimated net carbon emissions of more than 50 tonnes/ha in the areas inundated by the Baleh dam and in the new palm oil plantations (right, Figure 12). Adoption of the MSPO and MTCS standards could see additions to the carbon stocks of up to 50 tonnes/ha by 2030 (Figure 12).

The difference in biodiversity habitat between the current situation and the 2030 scenarios is obvious (Figure 13). Following a 2030 Economic Development scenario could see considerable declines in suitable habitat for the IUCN Red List mammal, reptile and amphibian species. Under the 2030 Green Economy and Conservation scenarios, land use intensity will decline and habitat will be more suitable for the Red List species with possible large gains in species (Figure 13).

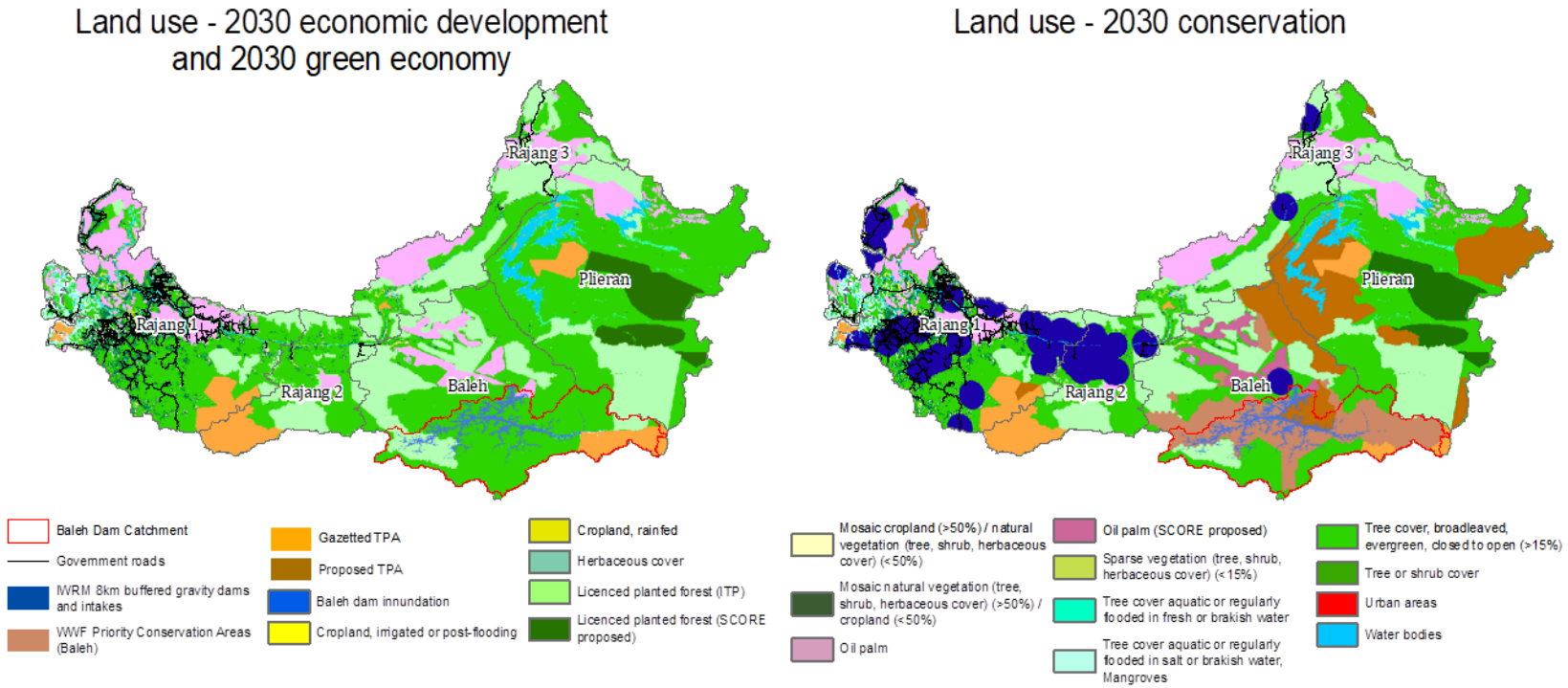

Figure 9. Land uses for the 2030 economic development, green economy and conservation scenarios

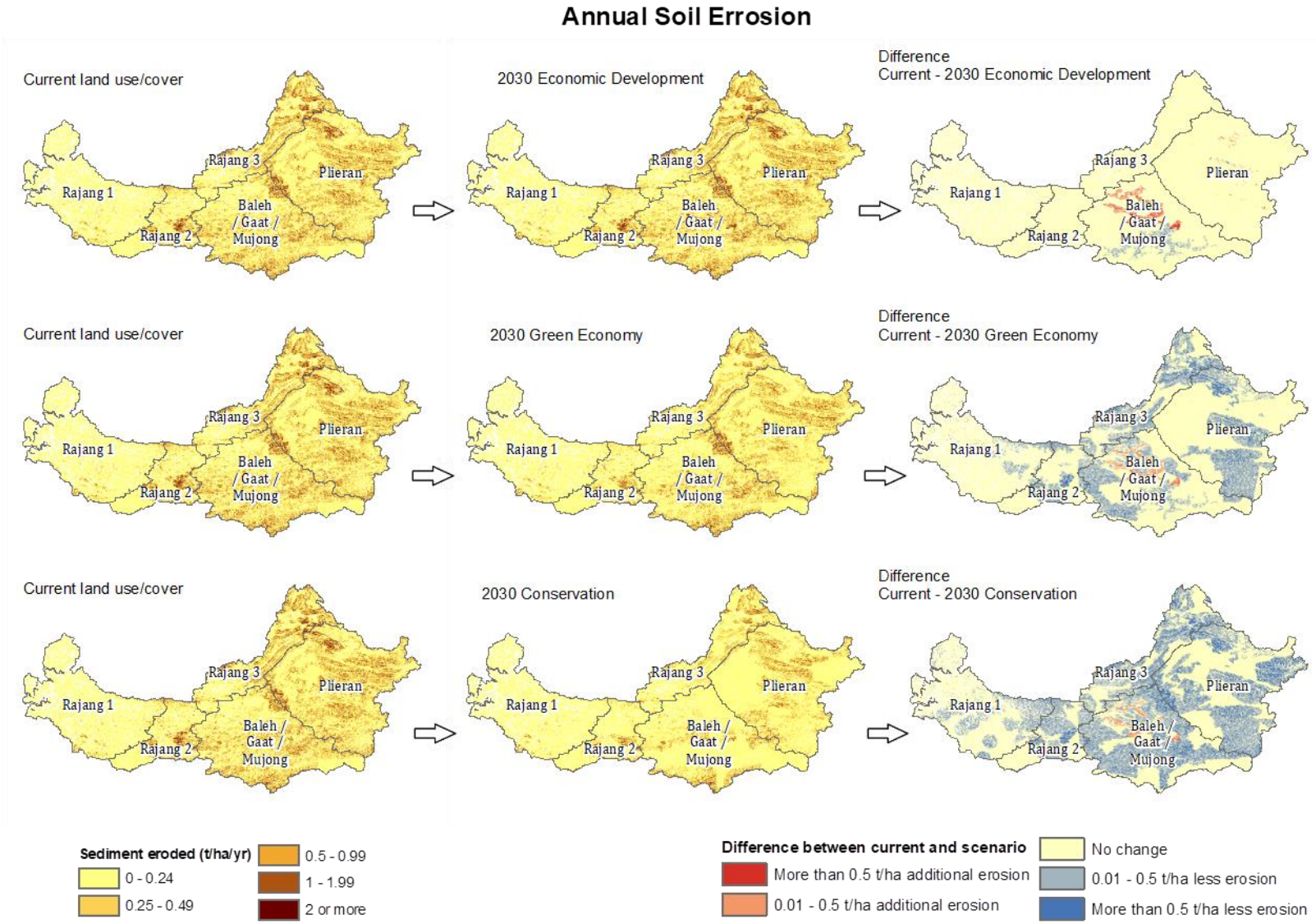

Figure 10. Sediment erosion (tonnes/hectare/year) for the 2030 economic development, green economy and conservation scenarios

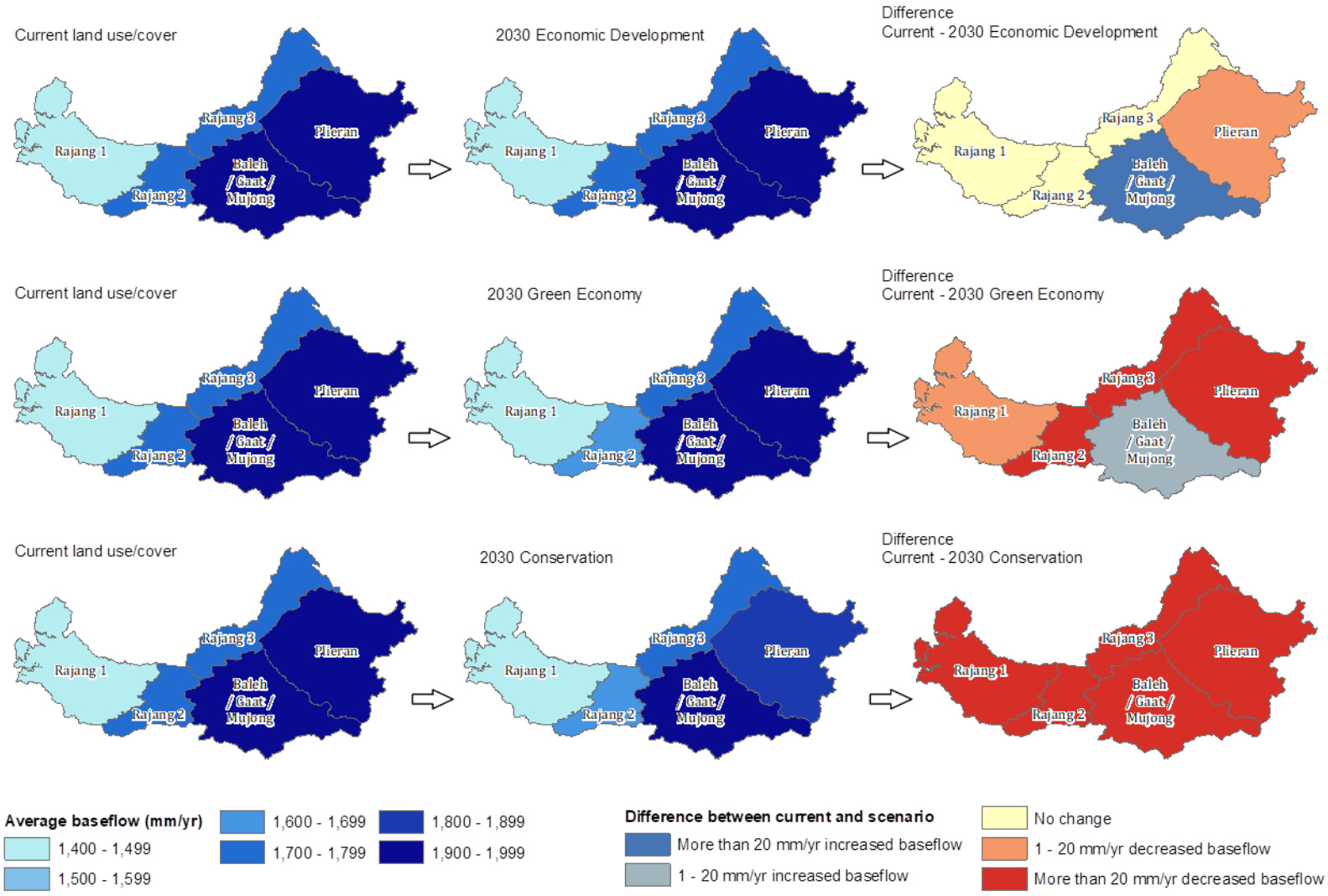

Figure 11. Water supply (average annual baseflow) for the 2030 economic development, green economy and conservation scenarios.

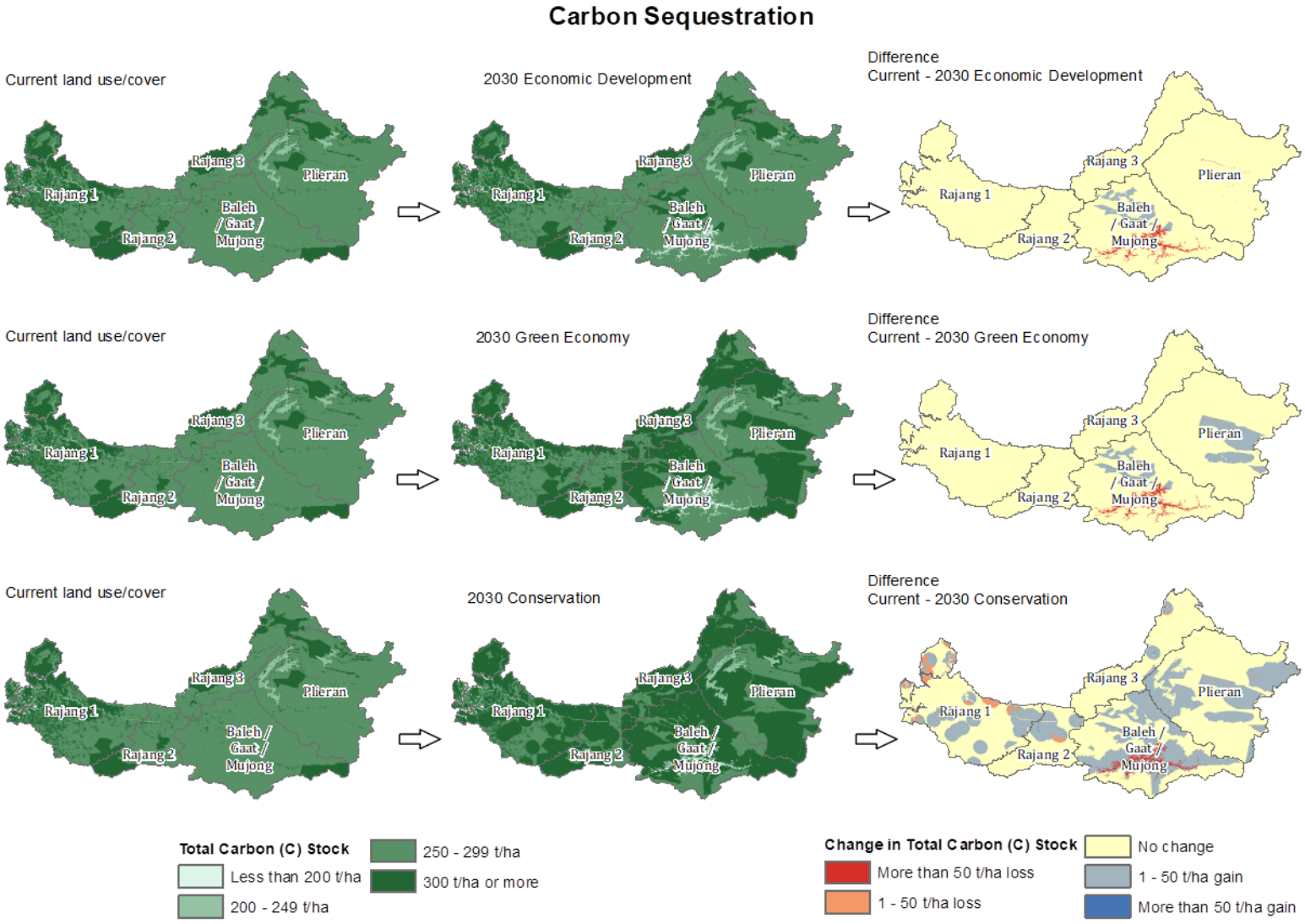

Figure 12. Carbon stock (tonnes carbon/ha) for the 2030 economic development, green economy and conservation scenarios

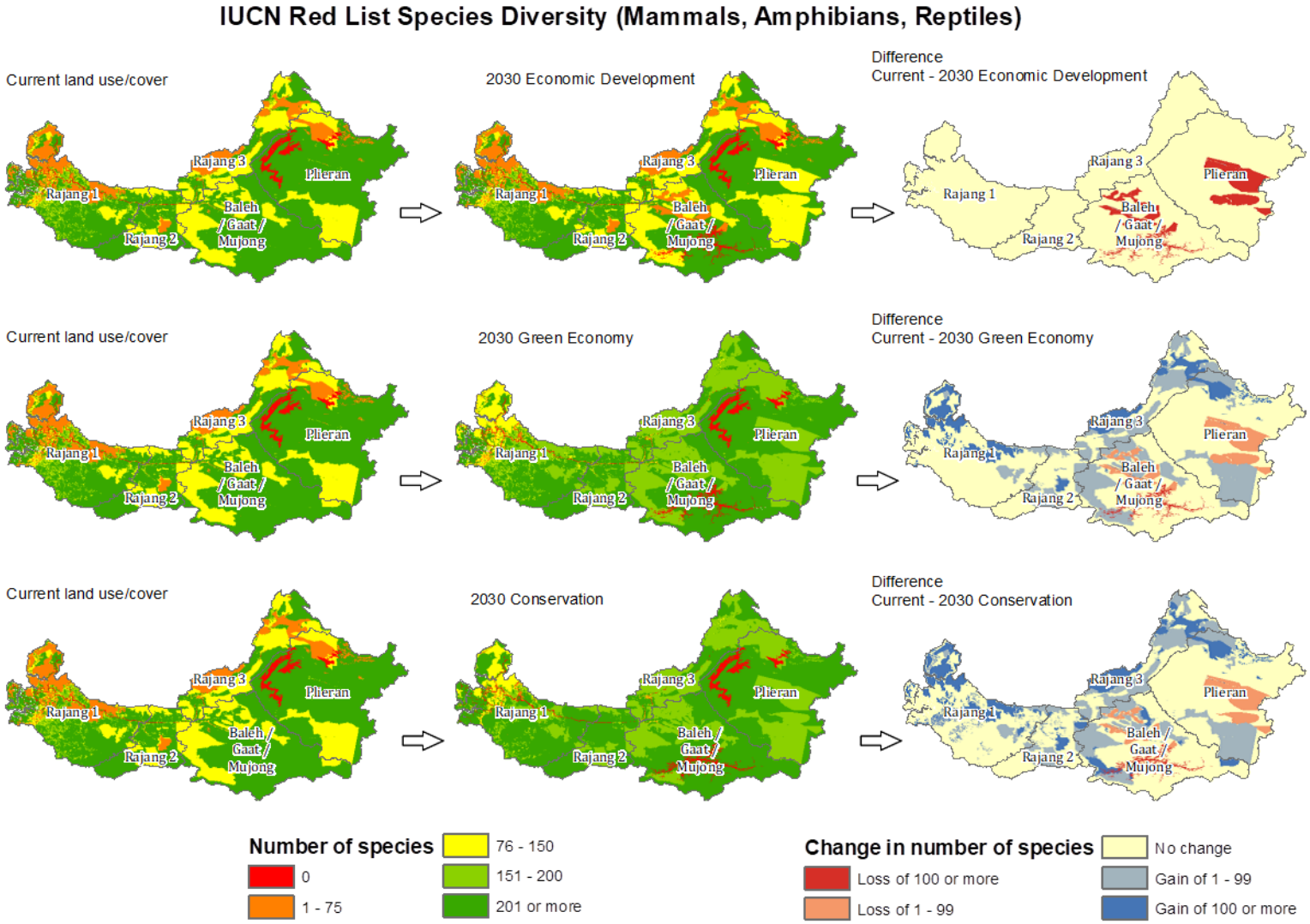

Figure 13. IUCN red list species (mammal, amphibians and reptiles) for the 2030 economic development, green economy and conservation scenarios

Chapter 6. Survey design and implementation

This chapter provides an overview of the collection of primary data used to conduct the valuation of ecosystem services in the Baleh watershed. Primary data collection primarily involved using survey methods targeting different stakeholder groups: longhouse communities, Sarawak general public, and tourists. The surveys are outlined below in terms of the target population, questionnaire development and implementation.

Figure 14. Different phases in the economic valuation exercise

6.1 Survey and questionnaire development

The following phases were undertaken as part of the process to estimate the economic values of ecosystem services in the Baleh watershed (see Figure 9).

The preparatory phase involved defining the objectives of the study to provide a baseline and an understanding of the values of the ecosystem services and natural capital in the Baleh watershed. Based on secondary data and literature, the study team identified potential key ecosystem attributes to be valued in the study. The TEEB ecosystem services typology was used in order to enable direct comparison and potential scaling up of valuation results to other policy sites within the Heart of Borneo. The study team also identified potential stakeholders based on the respective categories including:

i) Users/beneficiaries of the ecosystem services;
ii) Providers of ecosystem services
iii) Institutions and stakeholder networks;

As part of the planning and scoping phase, together with WWF-Malaysia, the study team undertook a scoping mission to Kuching, Sibu, Kapit and the surrounding Baleh watershed areas from 4 – 12 July 2017. The mission comprised of a series of face-to-face consultations with the relevant state and local government agencies, private sector representatives and local communities as well as field observations. The discussions enabled the study team to further refine the ecosystem attributes to

be valued. Based on insights gained from the scoping mission, the study team identified three target groups including longhouse communities, Sarawak general public, and tourists. The study team initiated the questionnaire development for the three target groups. Three sets of different questionnaires with their respective choice cards were developed. A brief overview of the contents of the questionnaires are presented in Table 22.

Table 22. Key features and contents of the questionnaires

Type	Content	Key features
Longhouse	• Background and socioeconomic details • Resource use patterns and abundance over time • Perception on environmental changes over time • Flooding occurrence and experience • Perception on environmental threats to the community • Choice experiment questions • Interest in tourism activities • Future plans for staying in the longhouse	• 31 questions • estimated time: 30-40 minutes • 8 sets of choice cards
General public	• Background information • Environmental awareness • Choice experiment questions • Socioeconomic information	• 20 questions, • estimated time: 15-20 minutes • 6 sets of choice cards
Tourists	• Background information • Visit to Sarawak (number of people, activities, expenditure) • Environmental awareness • Choice experiment questions • Socioeconomic background	• 26 questions • estimated time 15 minutes • 6 sets of choice cards

The study team also undertook sampling planning and logistics arrangements for the field survey based on the insights from the scoping mission. The study team also participated in several discussions over Skype and face to face meetings with the WWF-Malaysia team (12 and 13 October 2018) as part of the continuous process to refine the questionnaire and choice cards.

The targeted populations identified were communities living in the Baleh watershed, Kapit and Sibu towns and Kuching city. The rationale for choosing Kapit and Sibu residents as target populations was due to their connection to the Baleh Watershed. Kuching was chosen as another site due to its diverse populations for the general public questionnaire and representativeness of tourists that visit Sarawak.

The longhouse communities in the Baleh watershed were selected based on their location in terms of accessibility. Based on the map of the location of longhouses obtained from the district office, the team randomly selected 3 hard-to-access areas and 3 easy-to-access areas, visiting 18 longhouses altogether. In terms of the general public questionnaire, the survey team focussed on the central and outskirt areas of the cities in order to ensure that different groups of respondents were interviewed. In

terms of the tourist questionnaire, the survey team focussed on areas where tourists frequent including the Kuching city areas such as the waterfront and town areas and attractions outside Kuching city such as the Sarawak Cultural Village, Bako National Park, Damai beach and Semenggoh Wildlife Centre.

An advertisement to recruit a field supervisor and enumerators for the field survey were disseminated among university students, lecturers and relevant contacts. The announcement emphasised various requirements, among others the ability to speak Bahasa Melayu and Iban and being resident of Sarawak. A total of six graduates (of which five were at the Masters level) from the University Malaysia Sarawak (UNIMAS) were engaged as field enumerators and coordinator.

Three weeks prior to the field survey, with the support of WWF-Malaysia, the study team connected with the local district office to provide the background and intention of the survey. Through the local district office, pre-notice letters were sent to the relevant longhouses informing the longhouse heads of the potential visits by the study team.

Upon completion of the draft questionnaires, the longhouse questionnaire was translated into Bahasa Iban (native language) and the general public questionnaire was translated into Bahasa Melayu. The translations were checked and reviewed by WWF-Malaysia before being finalised.

6.2 Survey implementation

The survey implementation phase was conducted in Kapit, followed by Sibu and Kuching.

Table 23 summarises the schedule undertaken for the field surveys. One of the first steps was to organise a courtesy visit to the local district office in which the study team met the District Officer to provide an overview of the survey schedule and objectives.

Table 23. Overview of schedule for the survey implementation

No	Activity	Dates
1	Training	14 November
2	Courtesy visit to the District Office in Kapit	15 November
3	Pre-test of questions and revisions	15 November
4	Longhouse survey	16-30 November
5	General public and tourist survey in Kapit	16 – 19 November
6	General public and tourist survey in Sibu	20 November – 1 December
7	General public and tourist survey in Kuching	6 December – 10 January 2018

The survey team conducted a full day training for the enumerators and field coordinator (14 November 2017). The training included briefings on the logistics and practice sessions to be familiarised with the questionnaire. Specifically, the training provided an overview of the following features:

- Background on natural capital valuation and the study
- Questionnaire content and choice cards
- Survey protocol, practice and answer sheets
- Pre-test

- Sampling frame and logistics for Longhouse, General Public and Tourist questionnaires
- Overview of the survey schedule
- Reporting and payment
- Safety considerations

Among some of the pre-test questions that the enumerators were trained to assess were:

- Are the questions understandable?
- Are any questions/options not relevant?
- Are the questionnaires too long?
- Are the choice cards understandable?
- Are the payment levels too low/high?
- Feedback from respondents?

Based on the pre-tests, the questionnaires and choice cards were modified and revised to improve the questionnaires based on the feedback gained from the pre-test exercise.

While the team had intended to interview tourists in Kapit and Sibu, this proved to be a challenge even though numerous efforts were made to ensure that the survey obtained tourist respondents in the two towns. Due to the low visitation of tourists to the area, the majority of the tourists were interviewed in Kuching.

Upon the completion of the surveys, the data were compiled into excel sheets and checked for any errors in data entry. The data were reviewed, cleaned and verified before undertaking any quantitative data analysis.

Chapter 7. Longhouse survey results

This chapter presents the results of the longhouse survey including a description of the sampled population, their use of natural resources, perceptions of environmental change and threats, sense of social capital, opinions on tourism development in Baleh, and their preferences and willingness to pay for environmental conservation and development.

7.1 Sample description

The total sample for the longhouse survey is 237 households. Almost all respondents (91%) were originally from the longhouse at which the interview took place. The age of respondents ranged from 15-88 years old with an average age of almost 56. Household size varied substantially (1-15 adults) with the average household containing 3 adults of working age, 2 retirees and 3 children.

7.2 Income and use of natural resources

The average household income for the sample is just over RM 700 per month. Figure 15 represents the distribution of income levels across the sample. The sources of household income are varied (see Figure 16) but the majority is from paid employment (on average RM 380 per month) followed by remittances from family members living elsewhere (RM 200 per month). Income from farming is approximately RM 90 per month for the average household.

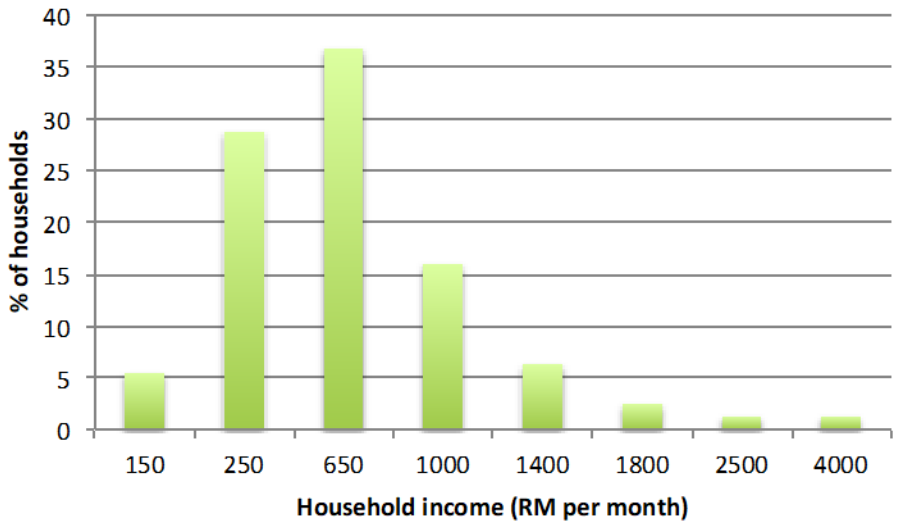

Figure 15. Proportion of households at each income level

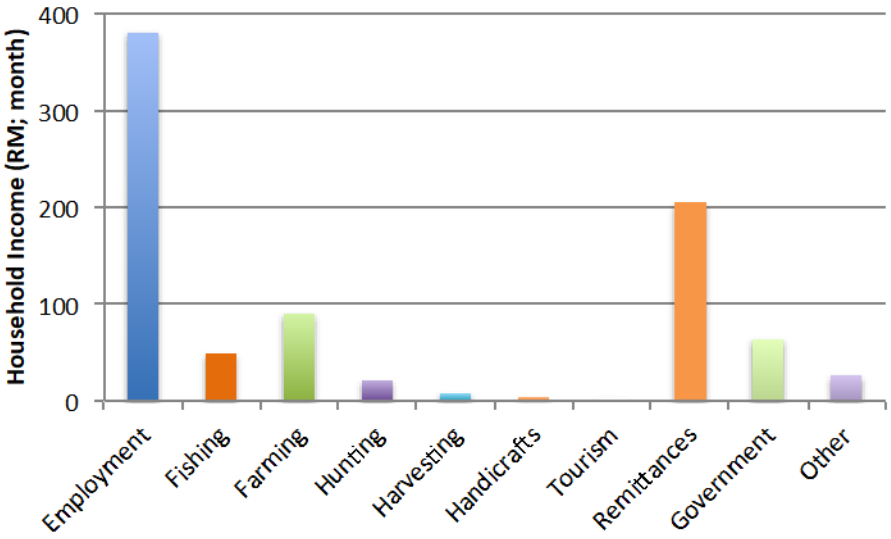

Figure 16. Sources of average household income (RM per month)

Regarding the harvest of forest resources, the average household makes use of a wide variety of provisioning services including wild vegetables, fuel wood, fish, wild fruit and materials for handicrafts (see Figure 17). Almost all households harvest wild vegetables, 60% harvest fish, and just over 20% hunt wild boar. Most of these harvested resources are consumed directly by the household itself, relatively little is given away to other households, and some is sold for cash income (see Figure 18). This implies that the majority of household income derived from provisioning services is non-market and non-cash. The type of use, however, varies considerably depending on the resource. Harvested materials such as fuel wood, timber and rattan are almost entirely consumed directly by the household; whereas fish, wild boar and deer are also sold.[31] Pepper is only harvested for sale.

[31] Any sale of wild meat is prohibited in Sarawak but this is hard to regulate in the interior. We report on the sale of wild meat for the purposes of quantifying the value of ecosystem services but do not condone this illegal activity.

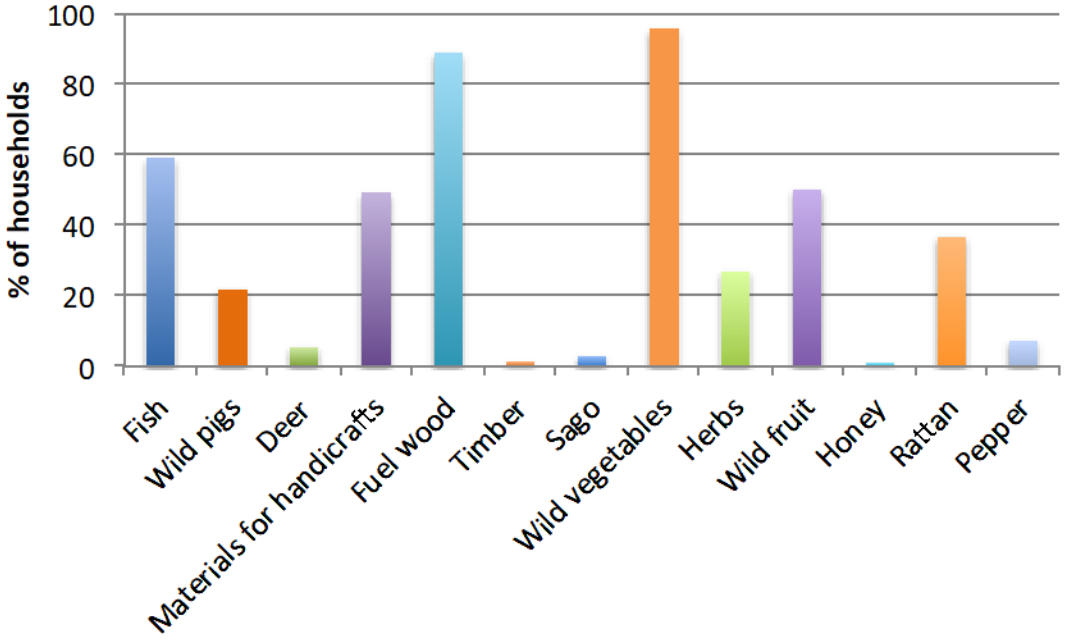

Figure 17. Harvest of natural resources

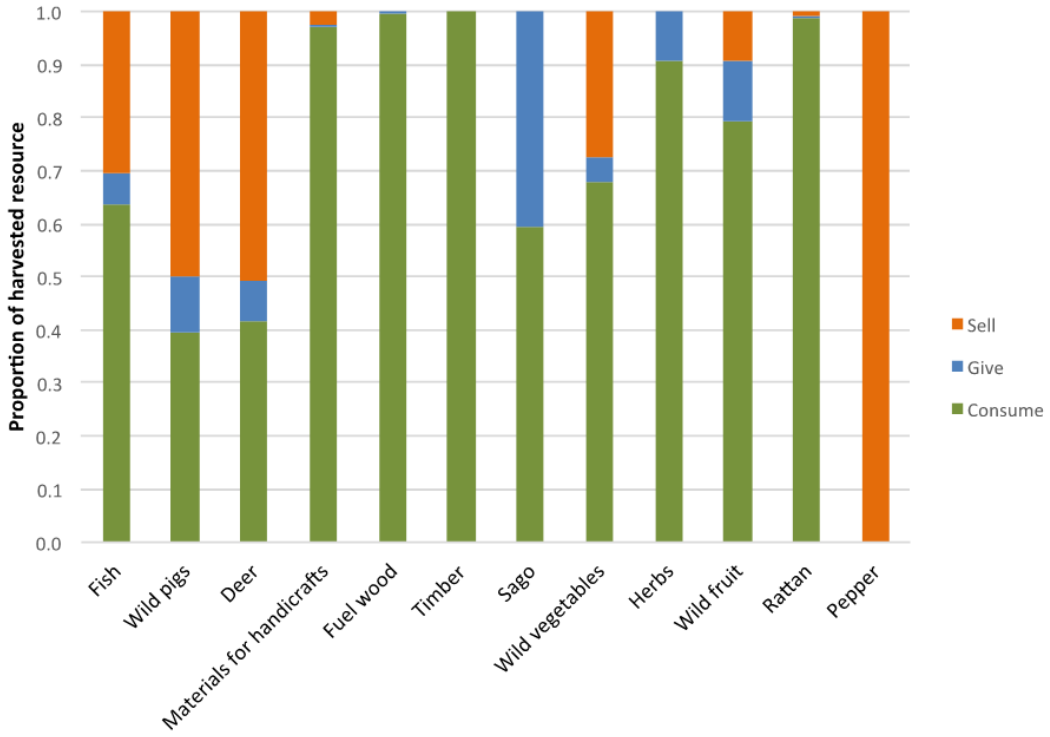

Figure 18. Use of harvested natural resources for own consumption, gifts or sale

The use of different sources of water for domestic use is represented in Figure 19. To some extent households make use of multiple water sources (the percentages in each category sum to over 100%). 80% of households obtain water through gravity feed system, almost 50% use rain catchment water, and 20% take water directly from the

river or streams. A very small proportion (less than 4%) buy water from the water board.

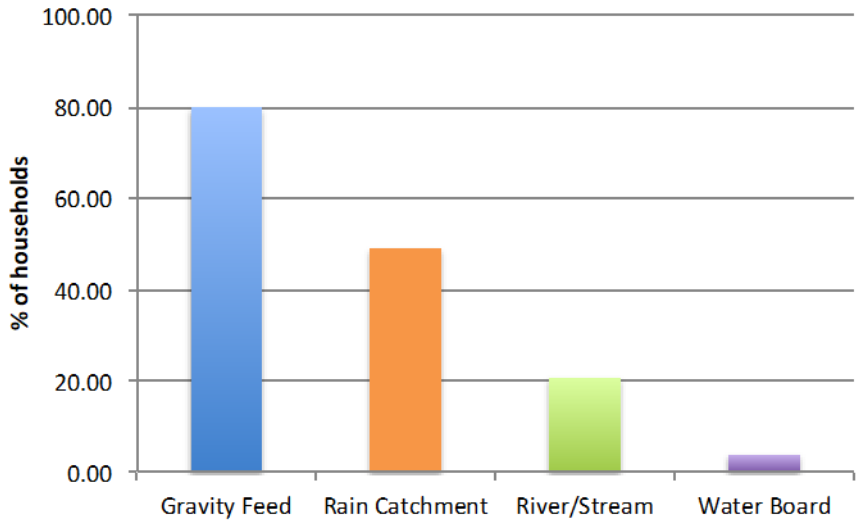

Figure 19. Sources of water for domestic use

7.3 Perception of environmental change

Respondents' perceptions of how the abundance of harvestable resources have changed during the past ten years are represented in Figure 20. The general view is that the abundance of most resources have declined over time, in particular the availability of timber, sago, honey and fish. The availability of wild pigs and deer is also perceived to have decreased. Some resources, however, are seen to have increased during the previous ten years including fuel wood, wild vegetables and rattan.

Perceived changes in other environmental conditions are represented in Figure 21. Some environmental conditions are seen to have worsened over time (reduced bird abundance and water quality; increased river sedimentation) whereas other aspects have seen improvement (reduced flooding and increased farm productivity).

Almost half of respondents reported that they had suffered damage from flooding during the previous 10 years. The estimated cost of damage incurred by a household from a single flood event ranged between RM 300-20,000, with an average damage cost of RM 3,250 per household. The household assets damaged by flooding are primarily crops, livestock, boats and water tanks (see Figure 22).

Regarding the importance placed on underlying environmental threats, over-fishing, over-hunting and deforestation are considered to be of highest concern (see Figure 23). Invasive species and river sedimentation are seen to be relatively less important, albeit still given a qualitative score above 3 on a 1-5 Likert scale.

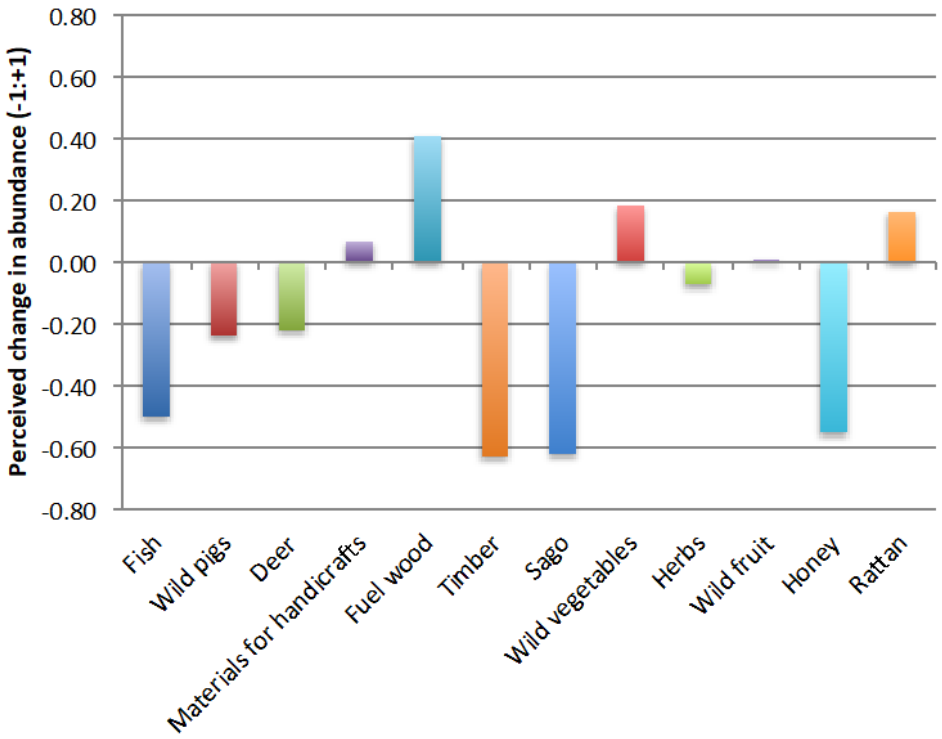

Figure 20. Change in resource abundance during the previous 10 years

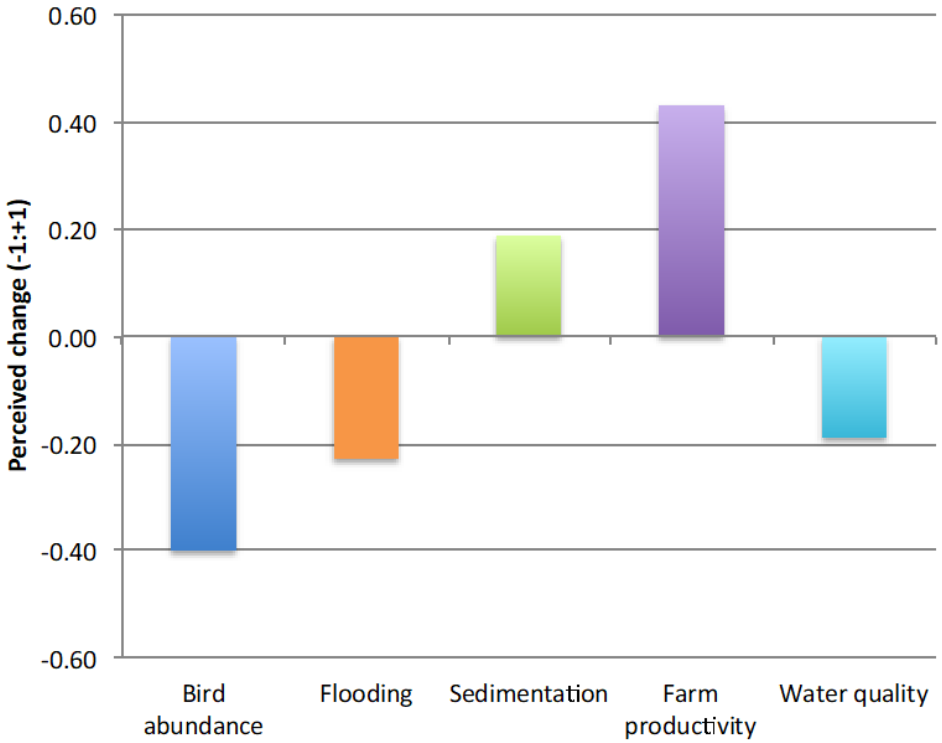

Figure 21. Environmental change during the previous 10 years

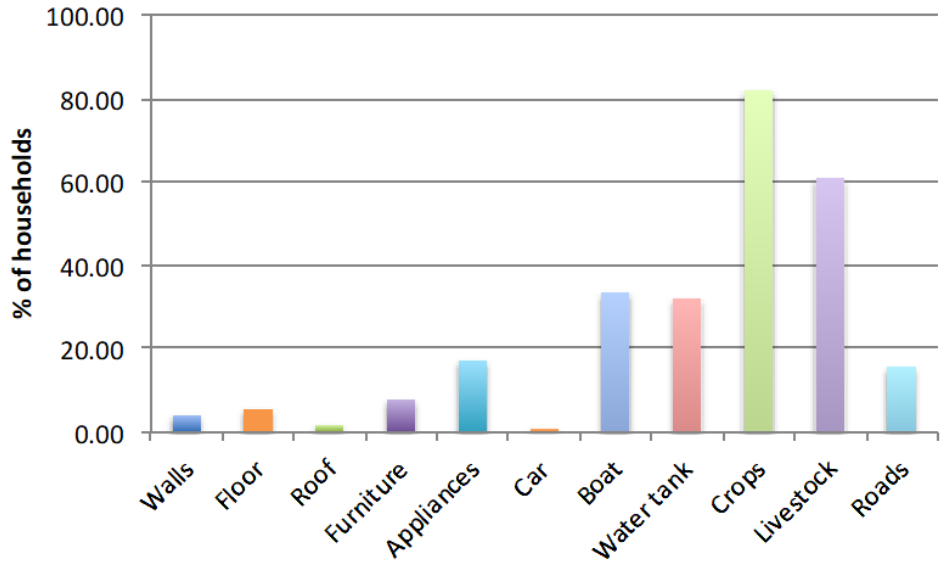

Figure 22. Assets damaged by floods

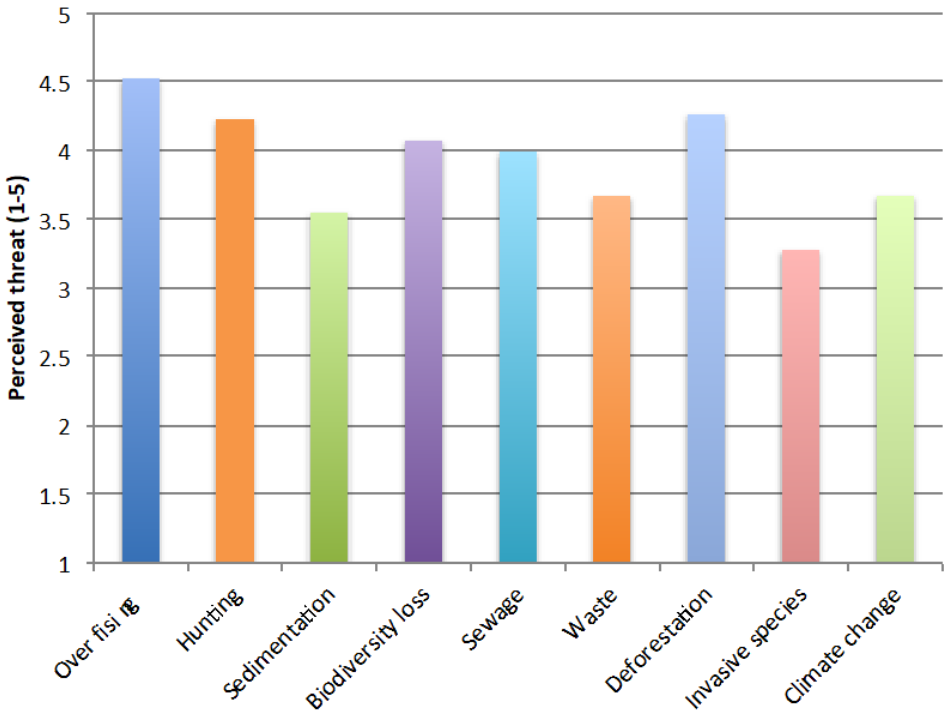

Figure 23. Importance of environmental threats

7.4 Social capital and migration

The term "social capital" broadly refers to the strength and complexity of relationships between people within their communities (Barnes-Mauthe et al., 2015). Social capital is often defined by its function, which emphasizes the notion that social bonds, trust, reciprocity and common rules enable the achievement of collective goals, including environmental management (Ostrom and Ahn, 2009). To assess the strength of social capital within each longhouse community, respondents were asked

to indicate the extent to which they agree or disagree with a set of statements related to aspects of social capital. The responses (summarised in Figure 24) indicate a strong sense of social capital with general agreement that the community is united, helps each other and that members participate in community meetings and activities. Respondents disagreed that there are often conflicts in the community or that there are serious conflicts.

Although the longhouse communities have a strong sense of identity and cohesion, approximately one third of respondents stated that they are considering moving from their longhouse. The main reasons for wanting to move are to earn a higher income, to join family that live elsewhere and due to the loss of traditional culture. Only one respondent stated that they consider moving due to declining resource availability. The intended destinations for those who consider moving are Kapit town and Sibu. For those that are considering moving, the timing is quite immediate with most considering moving within the next year (see Figure 25).

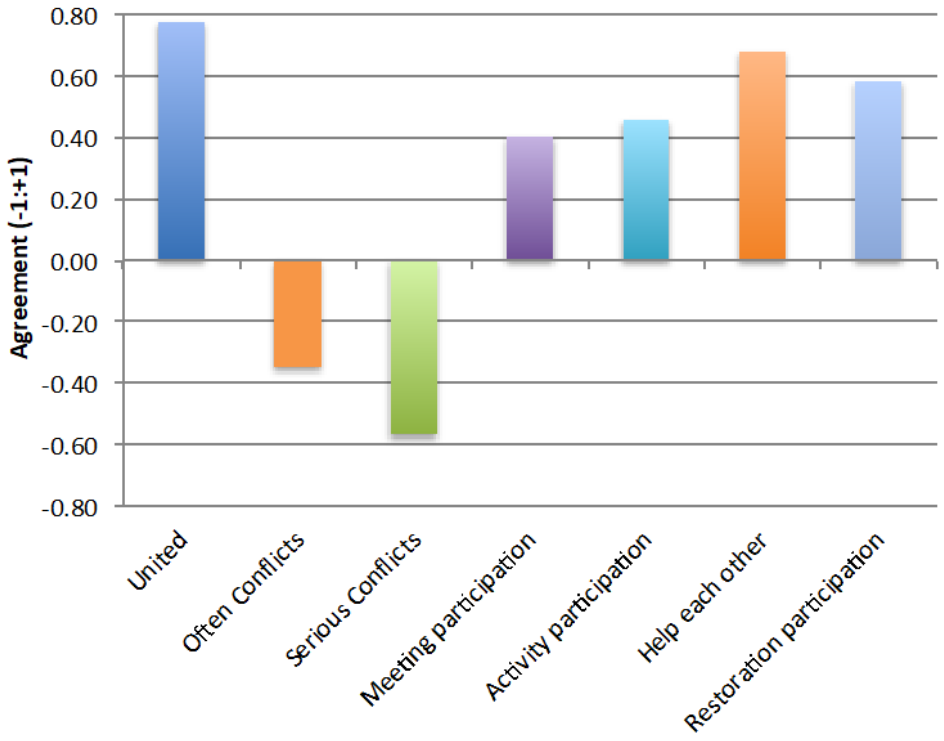

Figure 24. Extent of agreement with statements on social capital

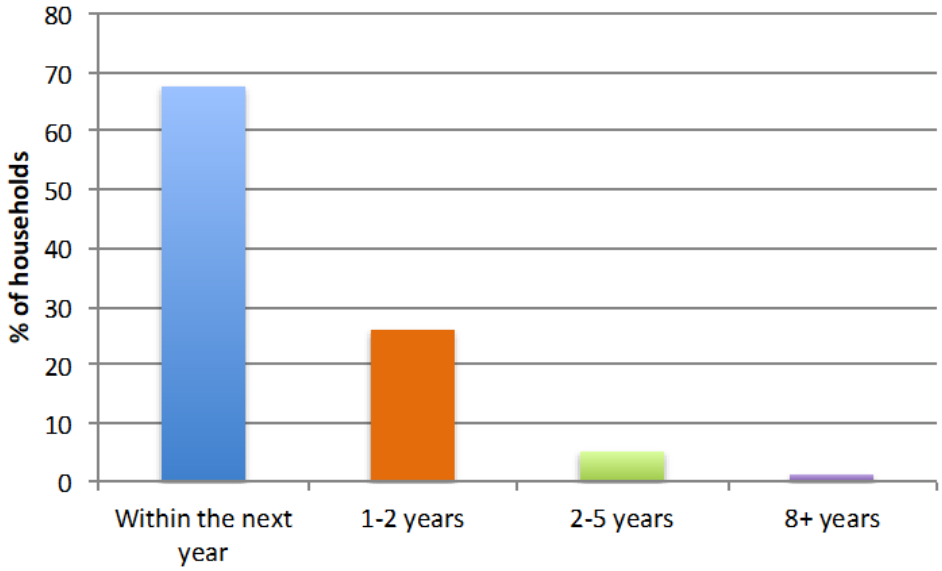

Figure 25. Timing of movement from longhouse

7.5 Tourism development

Tourism as an economic activity for longhouses in the Baleh watershed is almost non-existent. To assess the potential for developing this sector on the supply side, respondents were asked whether they are interested in developing tourism in their community. Just under 87% stated that they are interested. In particular, they are interested in developing homestays and bird watching (see Figure 26)

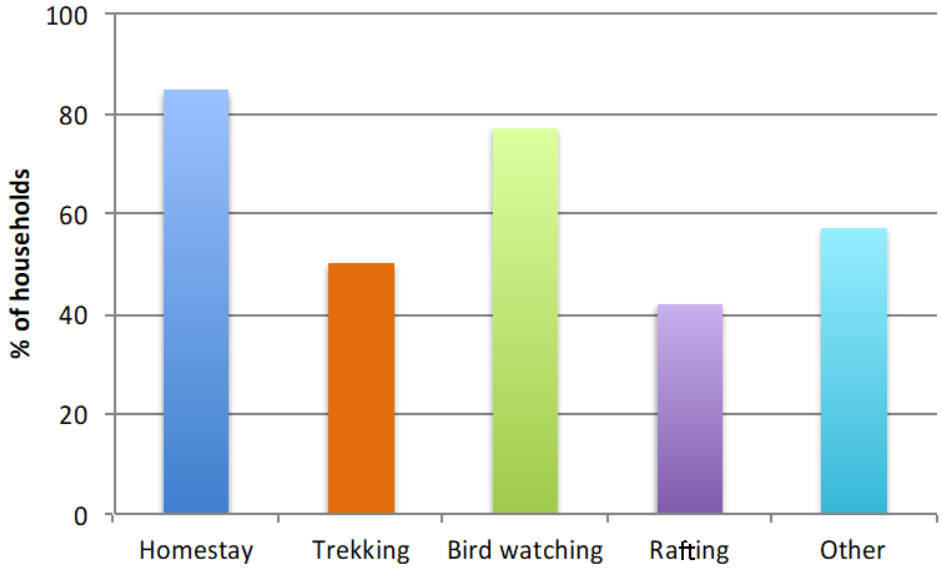

Figure 26. Interest in developing tourism activities

7.6 Preferences for environmental conservation

The choice experiment valuation method is used to elicit preferences for environmental conservation and development. A detailed explanation of the method

is provided in Appendix 5. In brief, respondents were asked to choose between two alternative future situations that are defined by five "attributes". These attributes are summarised in Table 24.

Table 24. Attributes in longhouse choice experiment

Attributes	Level 1	Level 2	Level 3
Availability of bush meat for hunting	Limited	Available	Abundant
Preservation of traditional hunting grounds	Few	Some	All
Availability of clean fresh water	Low	Moderate	High
Road access to the longhouse	No Road	Unpaved Road	Paved Road
Income from sale of agricultural products per month	RM 150	RM 250	RM 400

Each choice is represented on a "choice card" and respondents can choose either Option A or Option B (see Figure 27 for an example choice card). Each respondent is shown 8 cards in turn and asked to make a choice each time.

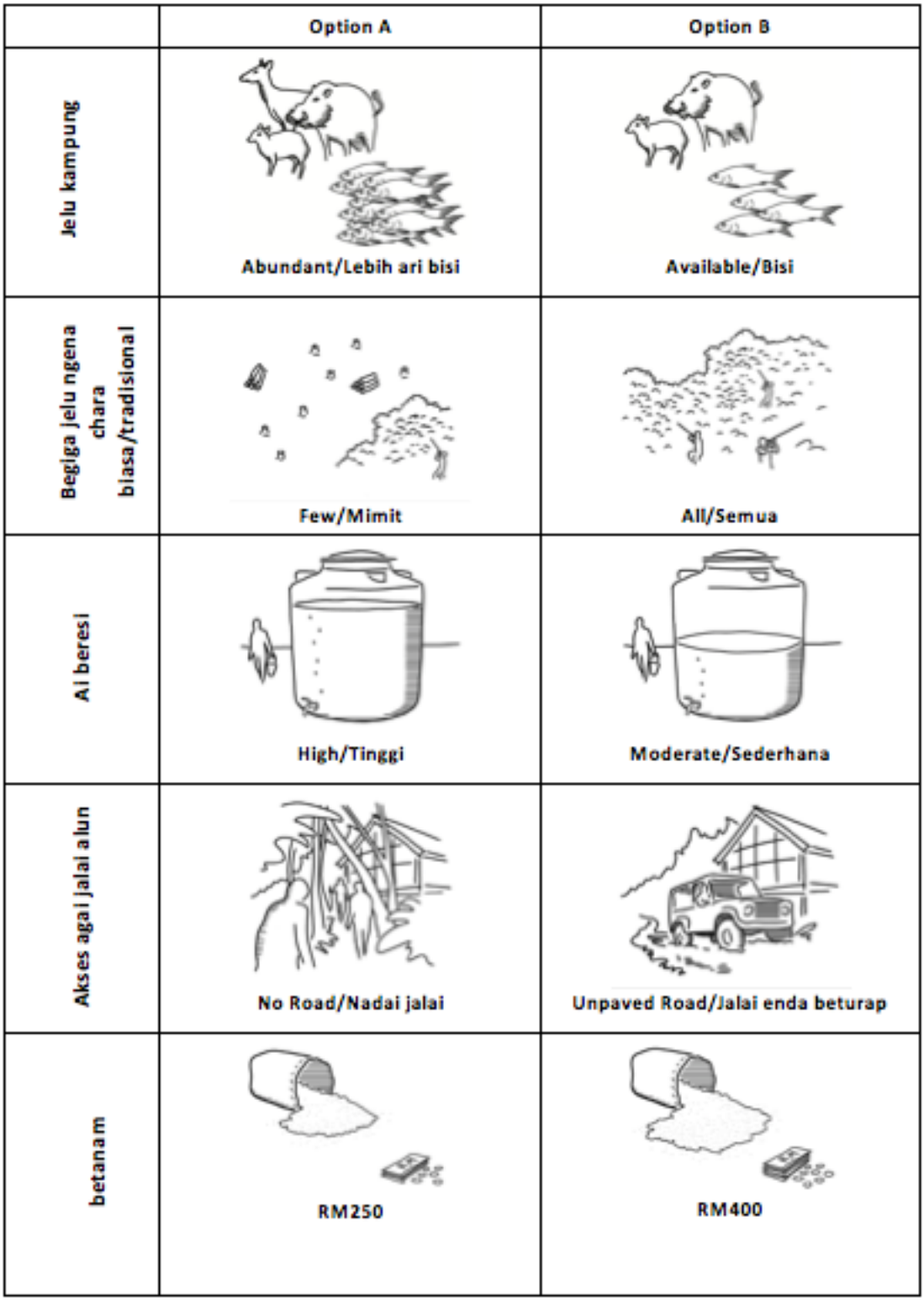

Figure 27. Example choice card for longhouse survey

After making their choices, respondents were asked a series of follow-up questions to obtain more information about how they made their choices. Most respondents indicated that they felt "certain" or "very certain" when making their choices (see Figure 28). In terms of the choice making process, most respondents stated that they considered all or a few of the attributes when making their choices (see Figure 29).

Only one respondent admitted to making random choices. The respondents were also asked to rank the five attributes in order of importance to their decisions. The relative importance of each attribute is summarised in Figure 30 and indicates that road access, clean fresh water availability and agricultural income were generally considered more important than bush meat and traditional hunting grounds.

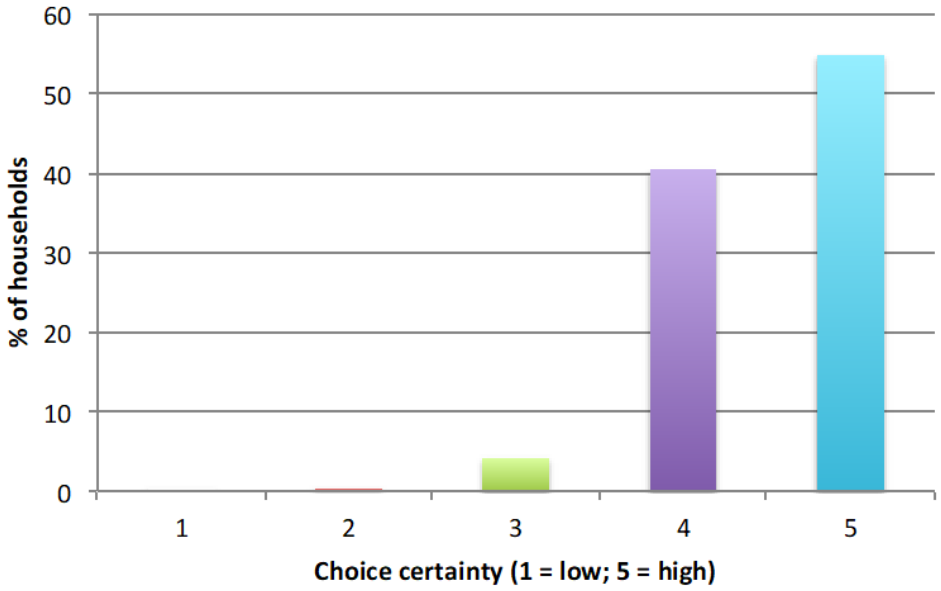

Figure 28. Choice certainty

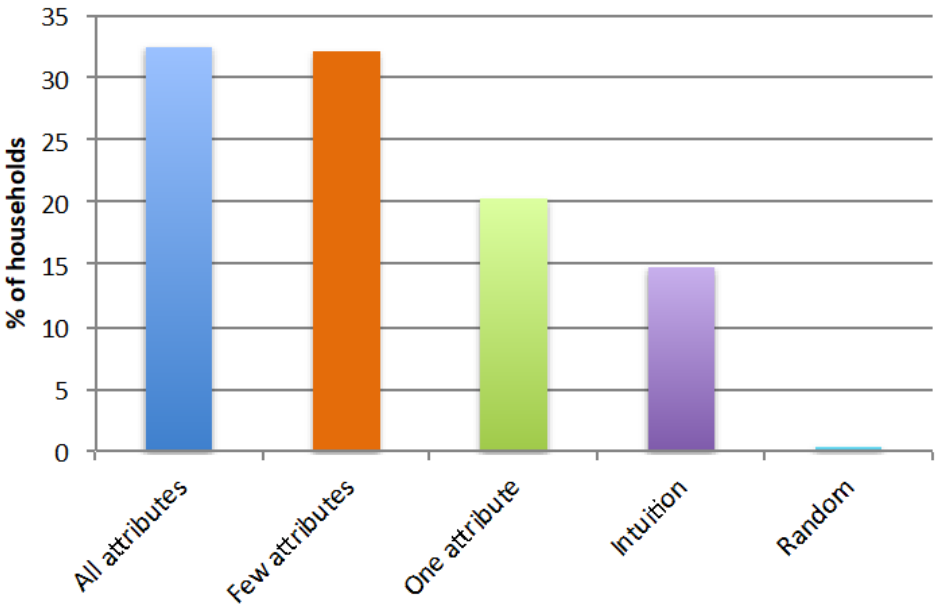

Figure 29. Choice process

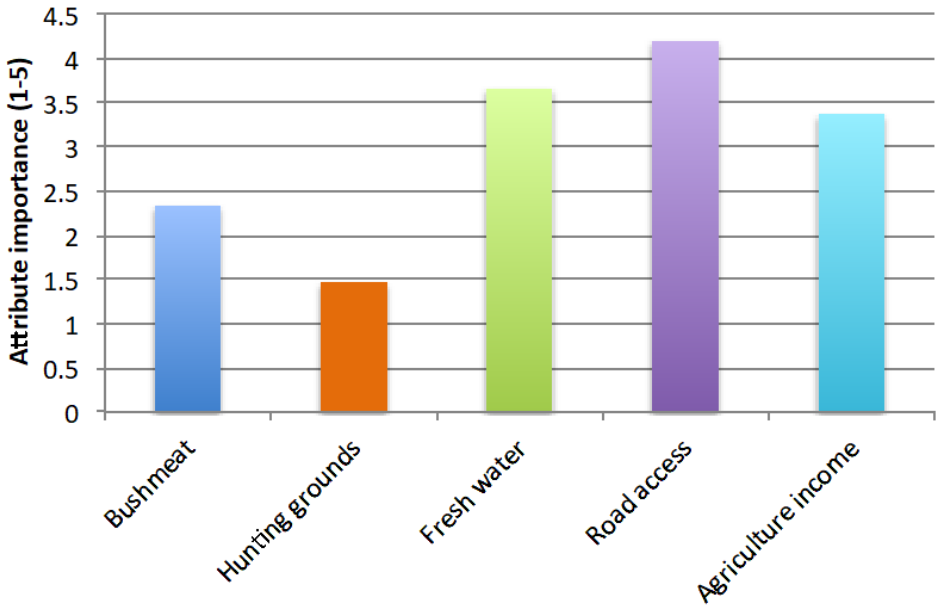

Figure 30. Importance of attributes to the choice process

Longhouse choice data were analysed using a multinomial logit (MNL) regression to examine the relative influence of each attribute level on respondent choice. The dependent variable in the MNL regression is binary and indicates whether an option is chosen or not; the explanatory variables are the attribute levels defining the option. The estimated coefficients for the explanatory variables quantify the relative influence of each attribute level on respondent choice and can be interpreted as the marginal utility of each attribute level. Attribute levels for bushmeat availability, hunting grounds, fresh water availability and road access are coded as dummy variables (taking either the value 0 or 1) and the lowest level of each attribute is used as the reference level and omitted from the regression equation. Agricultural income is coded as a continuous variable to enable more straightforward interpretation of willingness to pay for specific changes in environmental attributes.

The MNL regression results are presented in Table 25. All estimated coefficients have the expected sign and are statistically significant except for the hunting ground variables, which are not statistically significant indicating that respondents do not have strong preferences for continued access to traditional hunting grounds.

The results of the regression can be used to compute mean willingness to pay for changes in each attribute by taking the ratio of marginal utility for each attribute level to the marginal utility of agricultural income (i.e. how much agricultural income households are willing to give up to gain a specific positive change in the other attributes). Estimated willingness to pay for each attribute is reported in Table 26. Willingness to pay amounts, and all valuation results, are reported in US$ using a market exchange rate of 4 MYR to 1 USD. Note also that the willingness to pay amounts are reported as annual amounts. The Krinsky and Robb method is used to estimate 95% confidence intervals for WTP for each attribute.

Table 25. Longhouse CE multi-nomial logit regression results.

	Coefficient	SE	*t-ratio*	*P*
Bush meat medium	0.493	0.085	5.780	0.000
Bush meat high	0.494	0.083	5.916	0.000
Hunting grounds medium	-0.041	0.088	-0.471	0.638
Hunting grounds high	0.025	0.088	0.283	0.777
Fresh water medium	0.670	0.084	7.935	0.000
Fresh water high	0.929	0.087	10.683	0.000
Road access (unpaved)	1.220	0.083	14.625	0.000
Road access (paved)	1.950	0.093	20.954	0.000
Agricultural income (RM/month)	0.003	0.000	7.823	0.000
N	1888			
R^2 Pseudo	0.298			

Table 26. Longhouse willingness to pay for changes in bush meat, fresh water and road access (US$/household/year)

	Mean WTP	Lower CI	Upper CI
Bush meat (low to medium)	572	357	847
Bush meat (low to high)	570	359	823
Fresh water (low to medium	777	531	1,107
Fresh water (low to high)	1,078	794	1,466
Road access (no road to unpaved road)	1,416	1,086	1,876
Road access (no road to paved road)	2,264	1,778	2,965

Chapter 8. General public survey results

This chapter presents the results of the general public survey including a description of the sampled population, their perceptions of environmental threats, and their preferences and willingness to pay for environmental conservation.

8.1 Sample description

The total sample for the general public survey is 470 households. This sample is evenly drawn from Kapit town, Sibu and Kuching (see Figure 31). The age of respondents ranged from 15-65 years with an average age of 32. Household size varied substantially (1-22 adults) with the average household containing 4 adults of working age and 2 children.

The ethnicity of respondents is represented in Figure 32. Almost 50% are Iban and just over 20% are Malay. The level of education of respondents is mixed (see Figure 33). There is also a mix of employment sectors represented in the sample (see Figure 34) but the wholesale and retail sales sector is perhaps over-represented as a result of convenience sampling.

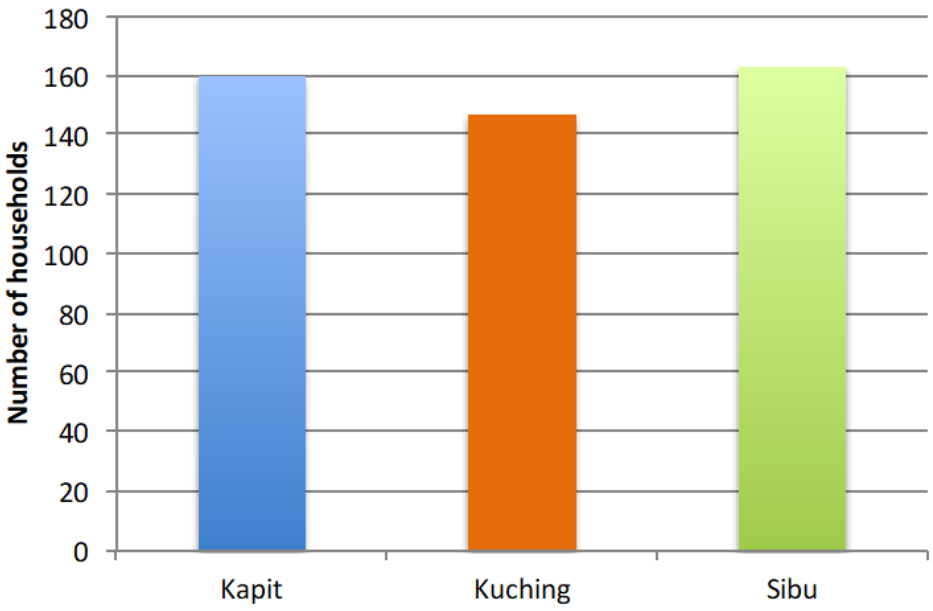

Figure 31. Location of sampled households

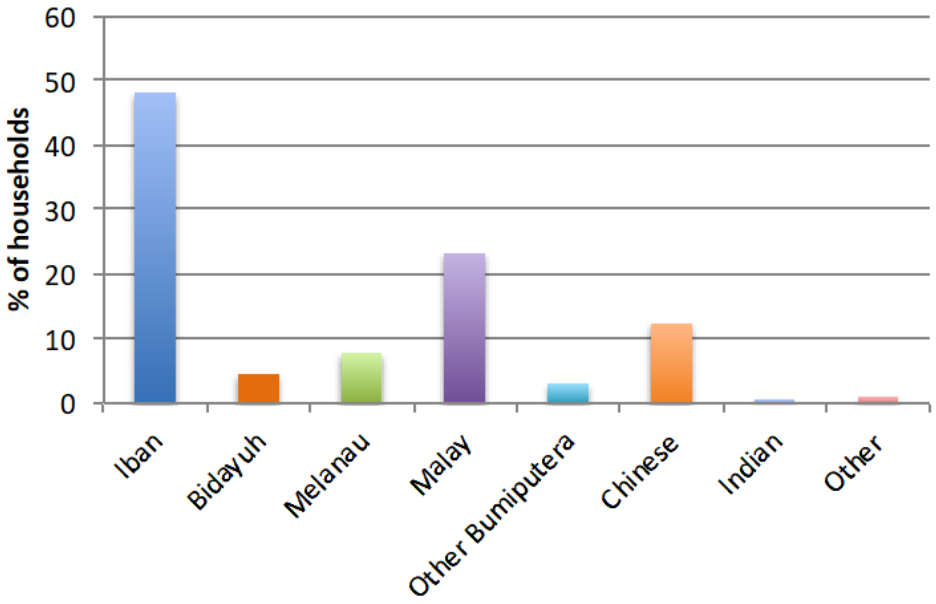

Figure 32. Ethnicity of respondents

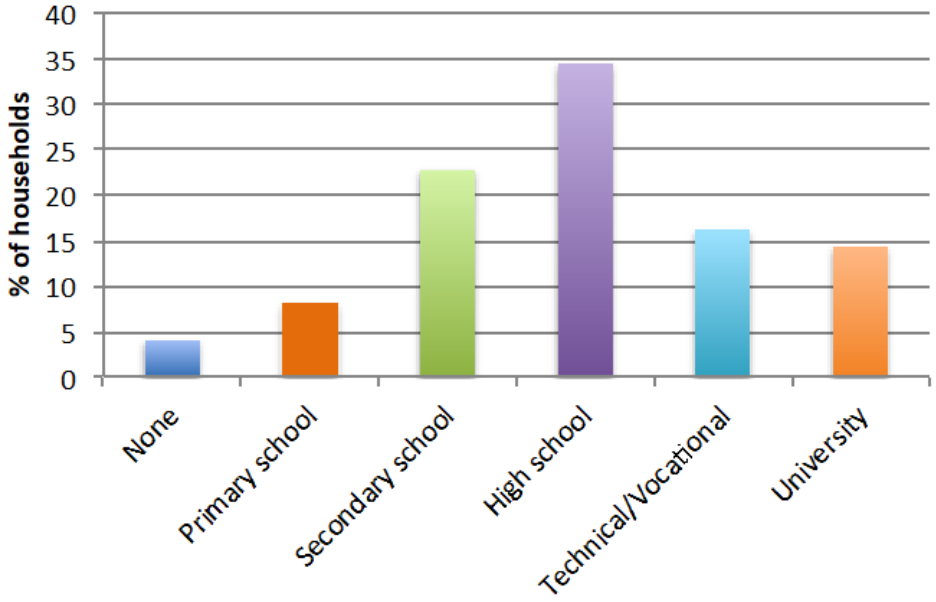

Figure 33. Level of education completed

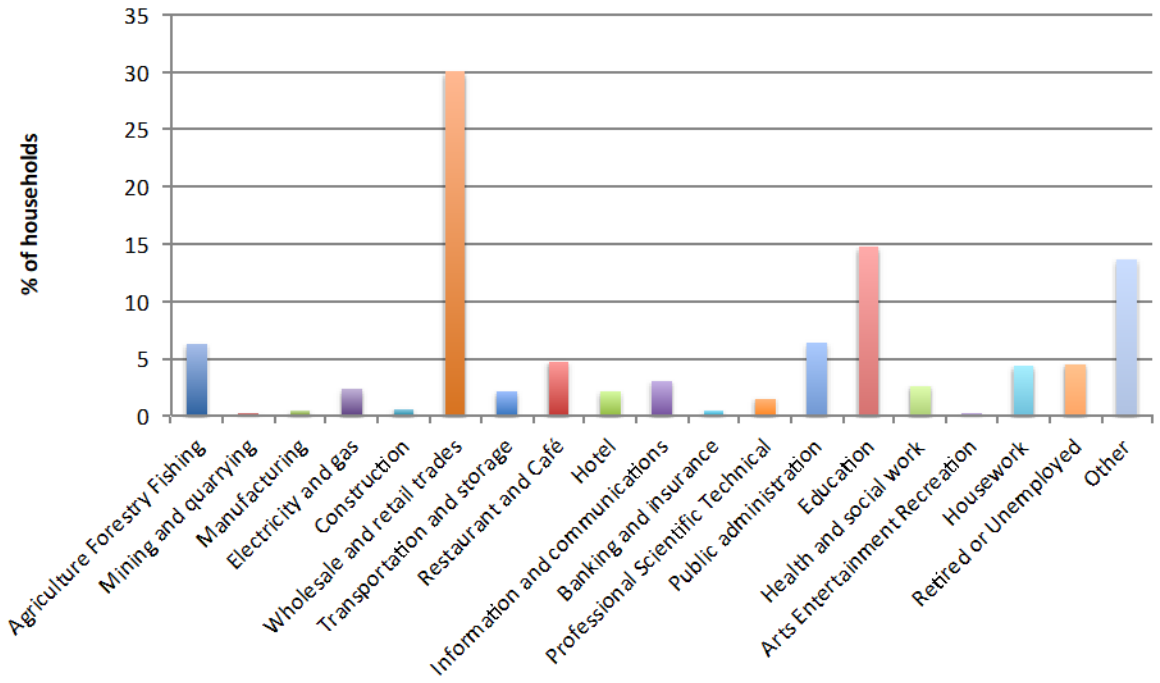

Figure 34. Employment sector

8.2 Household income

The average household income for the sample is approximately RM 3,200 per month. Figure 35 represents the distribution of income levels across the sample. Average income varies by location, with average household income in Kapit markedly lower than in Sibu and Kuching (see Figure 36).

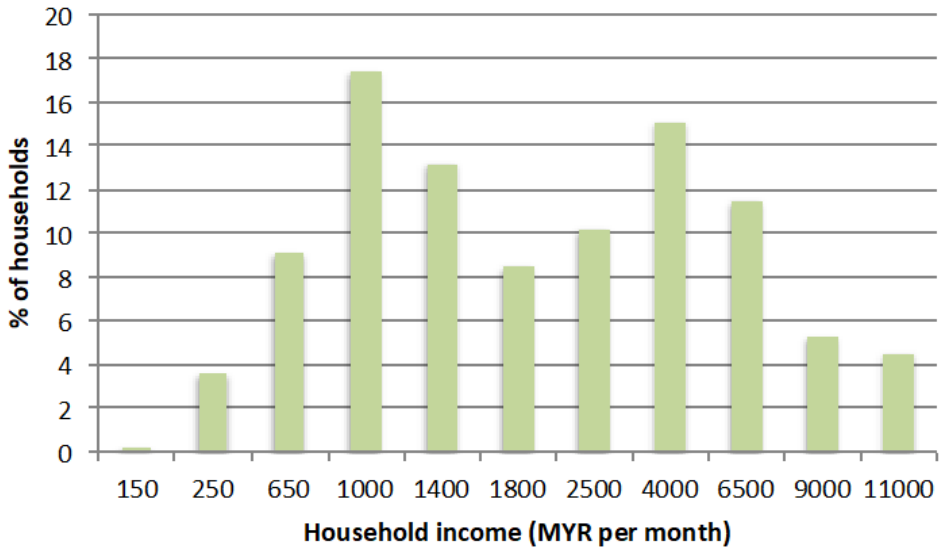

Figure 35. Proportion of households at each income level

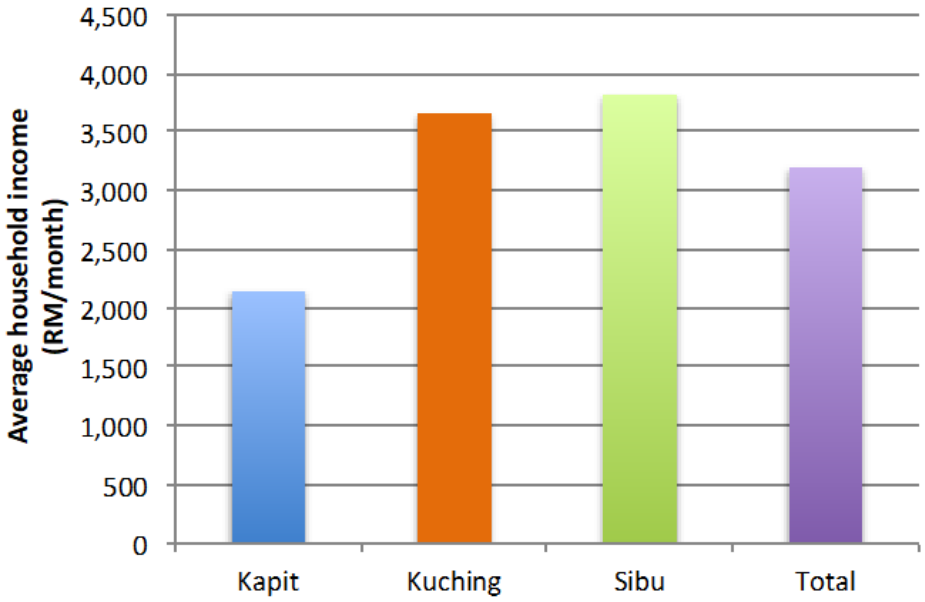

Figure 36. Average monthly household income by sample location

8.3 Environmental concern

Respondents generally expressed high levels of concern across a wide range of environmental issues (see Figure 37). In particular, litter and waste, water pollution, deforestation and climate change were assigned qualitative scores above 4 on a 1-5 Likert scale. Forest fires and over fishing are considered to be of lower concern.

Almost half of respondents stated that they made some form of donation to an environmental cause in the past 12 months. The average money donation (from sub-sample of respondents that do donate money) is RM 55 per year. The average donation of time (from sub-sample of respondents that do donate time) is 6 days per year.

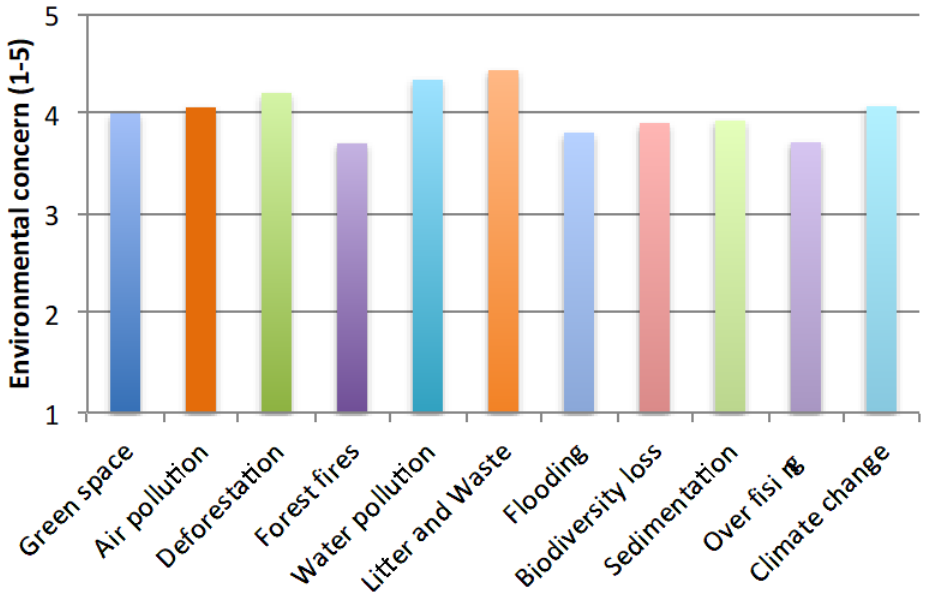

Figure 37. Concern for environmental issues

8.4 Preferences for environmental conservation

The choice experiment valuation method was again used to elicit preferences for environmental conservation. Respondents were asked to choose between three alternative future situations that are defined by five "attributes". These attributes are summarised in Table 27 One of the three options describes the expected future situation without additional environmental management and is defined by level 1. of each attribute.

Table 27. Attributes in general public choice experiment

Attributes	Level 1	Level 2	Level 3	Level 4	Level 5
Rare and endangered species	Few	Some	Many	-	-
Clean rivers	Dirty	Moderate	Clean	-	-
Frequency and severity of floods	Frequent	Moderate	Rare	-	-
Healthy forests	Deforested	Degraded	Pristine	-	-
Increase in monthly water bill	RM 0	RM 2	RM 5	RM 10	RM 20

Each choice is represented on a "choice card" and respondents can choose either Option A, Option B or the Expected Future without additional management (see Figure 38 for an example choice card). Each respondent is shown 6 cards in turn and asked to make a choice each time.

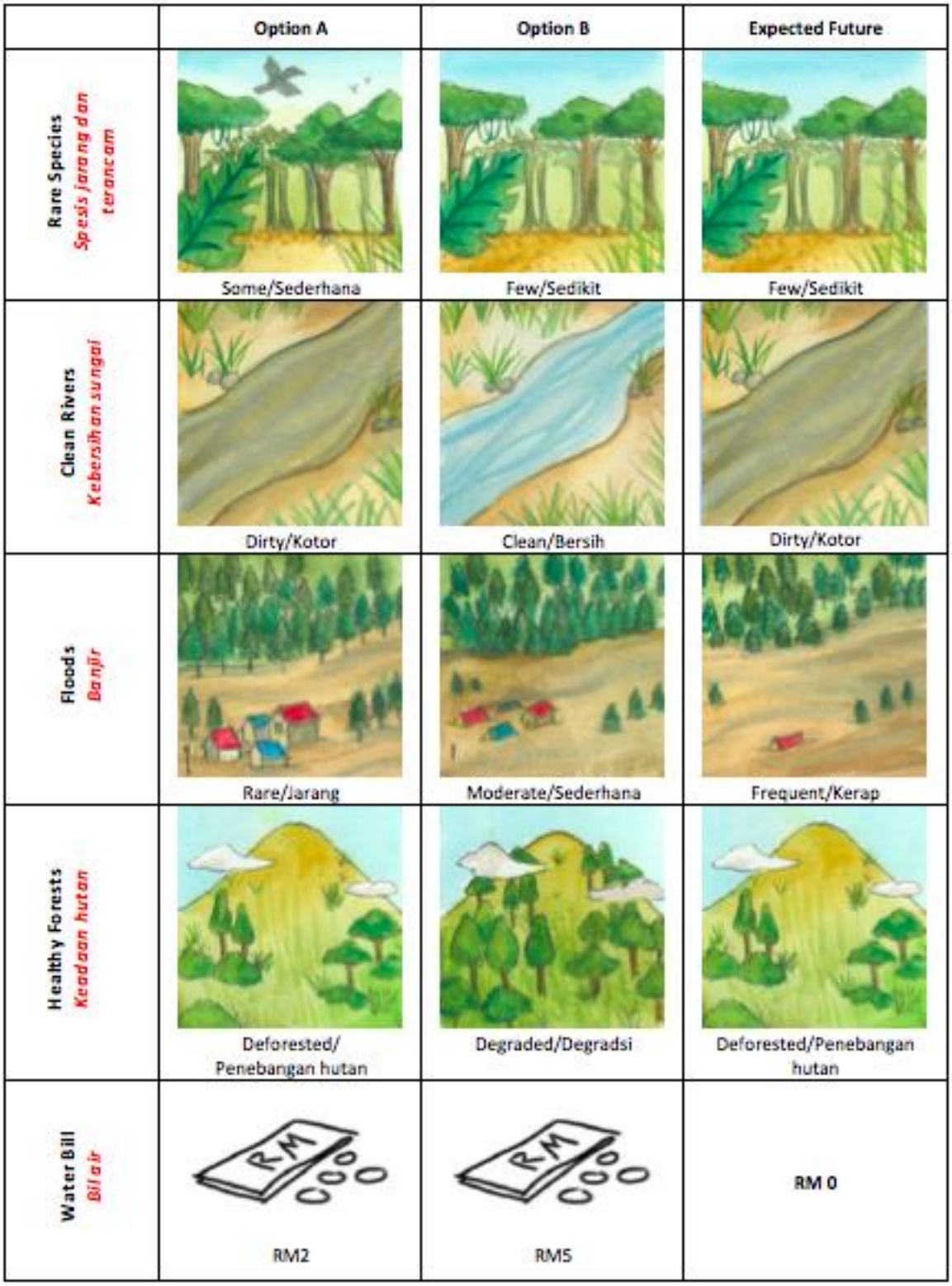

Figure 38. Example choice card for public survey

After making their choices, respondents were asked a series of follow-up questions to obtain more information about how they made their choices. Most respondents indicated that they felt "certain" or "very certain" when making their choices (see Figure 39). In terms of the choice making process, most respondents stated that they

considered all or a few of the attributes when making their choices. 10 respondents admitted to making random choices (see Figure 40). The respondents were also asked to rank the five attributes in order of importance to their decisions. The relative importance of each attribute is summarised in Figure 41 and indicates that clean rivers, healthy forests and rare species were generally considered more important than flood frequency and increases in the water bill.

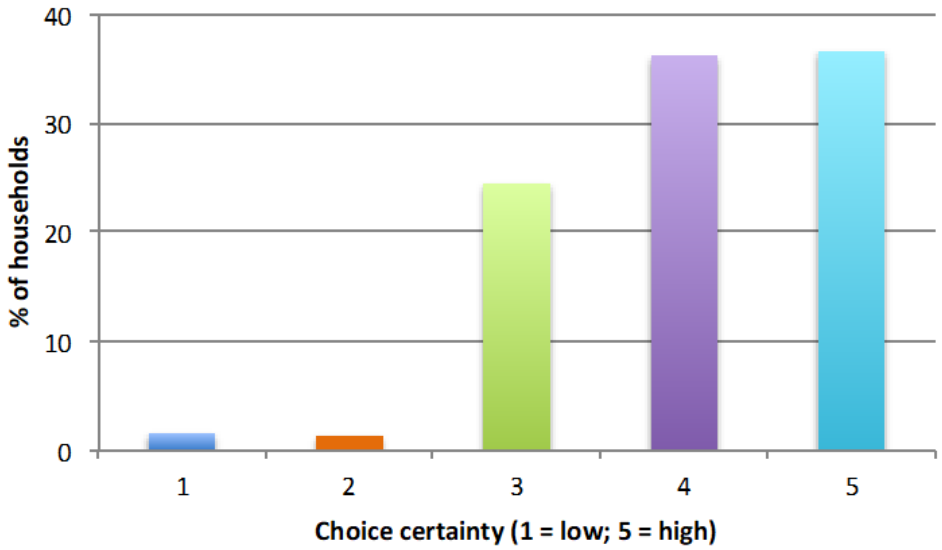

Figure 39. Choice certainty

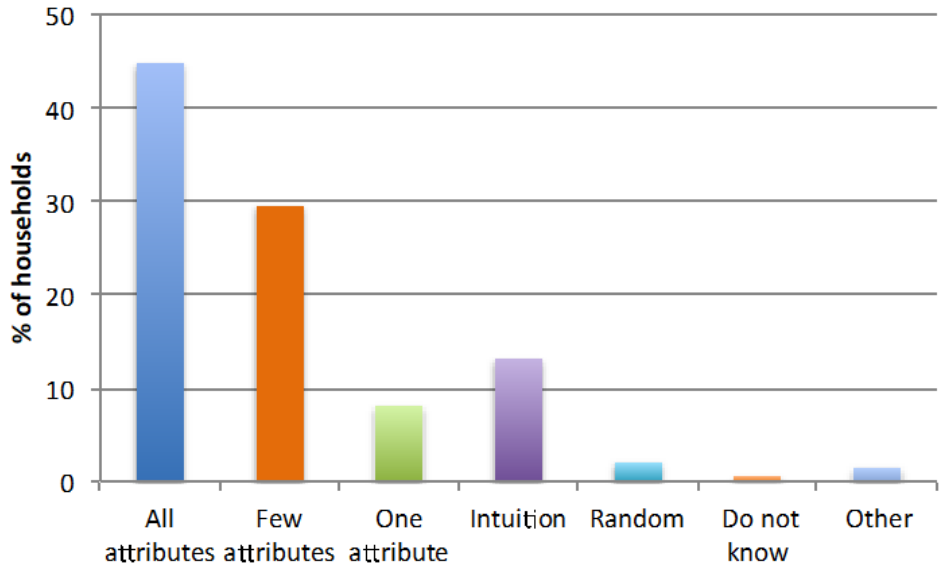

Figure 40. Choice process

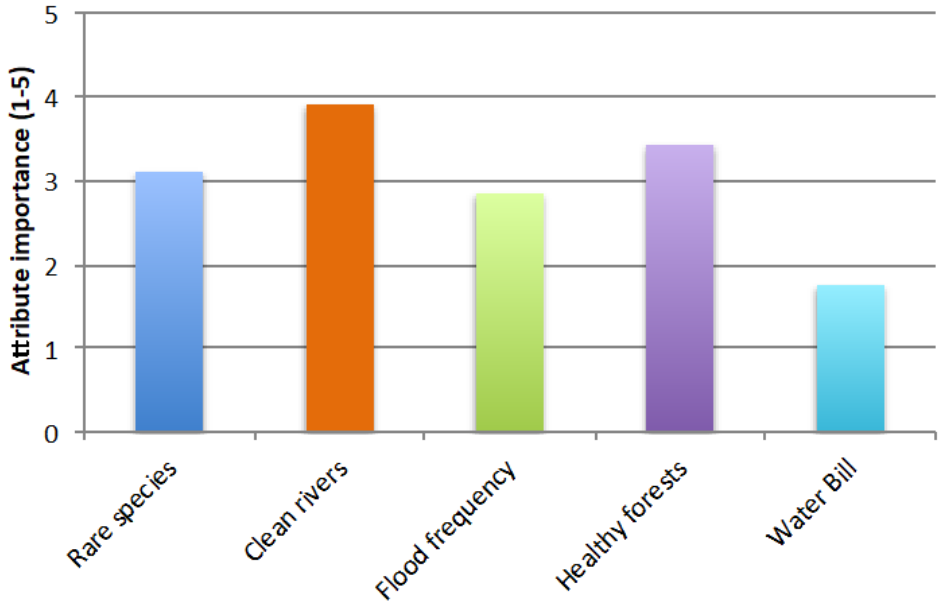

Figure 41. Importance of attributes to the choice process

Choice data from the general public survey were analysed using a multinomial logit (MNL) regression to examine the relative influence of each attribute level on respondent choice. Attribute levels for species abundance, river quality, flood frequency and forest health are coded as dummy variables (taking either the value 0 or 1) and the lowest level of each attribute is used as the reference level and omitted from the regression equation. The payment through increases to the household water bill is coded as a continuous variable to enable more straightforward interpretation of willingness to pay for specific changes in environmental attributes.

The MNL regression results are presented in Table 28. All estimated coefficients have the expected sign and are statistically significant except for the water bill variable. In general, respondents treated this attribute as the least important in influencing their choices and this non-attendance means that it is not possible to quantify the importance of monetary payment. We attempted to mitigate the effect of attribute non-attendance on the regression results by restricting the sample size to exclude respondents that indicated that the water bill was the least important attribute. For this restricted sample the estimated coefficient on the water bill variable remains statistically insignificant. Further examination of the influence of the payment using a dummy coded variable indicates that respondents may have positive preferences for small increases in their water bills. This requires further examination but in order to estimate willingness to pay values we proceed with the current results recognising that they are characterised by high uncertainty.

The results of the regression can be used to compute mean willingness to pay for changes in each attribute by taking the ratio of marginal utility for each attribute level to the marginal utility of money (i.e. how much additional water bill respondents are willing to pay to gain a specific positive change in the other attributes). Estimated willingness to pay for each attribute is reported in US$ per year in Table 29. The Krinsky and Robb method is used to estimate 95% confidence intervals for WTP for each attribute. Lower bound values are truncated at zero.

Table 28. General public CE multi-nomial logit regression results

	Coefficient	SE	*t-ratio*	*P*
Rare species (medium)	0.256	0.119	2.153	0.031
Rare species (high)	0.344	0.114	3.006	0.003
Clean rivers (medium)	1.502	0.123	12.246	0.000
Clean rivers (high)	2.091	0.127	16.480	0.000
Flooding (medium)	0.565	0.116	4.857	0.000
Flooding (high)	0.502	0.119	4.221	0.000
Forest quality (medium)	0.227	0.118	1.933	0.053
Forest quality (high)	0.554	0.116	4.784	0.000
Water bill (RM/month)	-0.008	0.008	-1.030	0.303
N	1029			
R^2 Pseudo	0.298			

Table 29. General public willingness to pay for changes in rare species, clean rivers, flood frequency and forest quality (US$/household/year)

	Mean WTP	Lower CI	Upper CI
Rare species (low to medium)	122	0	836
Rare species (low to high)	216	0	1,131
Clean rivers (low to medium)	1,043	0	5,104
Clean rivers (low to high)	1,351	0	6,850
Flooding (low to medium)	132	0	2,022
Flooding (low to high)	197	0	1,498
Forest quality (low to medium)	211	0	705
Forest quality (low to high)	350	0	1,956

Chapter 9. Tourist survey results

This chapter presents the results of the tourist survey including a description of the sampled population, the tourist activities they engage in, their perceptions of environmental threats, and their preferences and willingness to pay for environmental conservation.

9.1 Sample description

The total sample for the survey is 400 tourists. This sample is drawn mainly from visitors in Kuching with relatively few tourists interviewed in Damai (cultural village), Bako and Sibu (see Figure 42). The age of respondents ranged from 20-65 years with an average age of 40. Household size varied substantially (1-10 adults) with the average household containing 3 adults of working age and 1 child.

The sample of tourists is a mix of international and domestic tourists. 44% are from Europe and 23% are from Peninsular Malaysia (see Figure 43).

The level of education of respondents is high with 70% of respondents having completed a university degree (see Figure 44). The majority of the tourists interviewed are employed (see Figure 45).

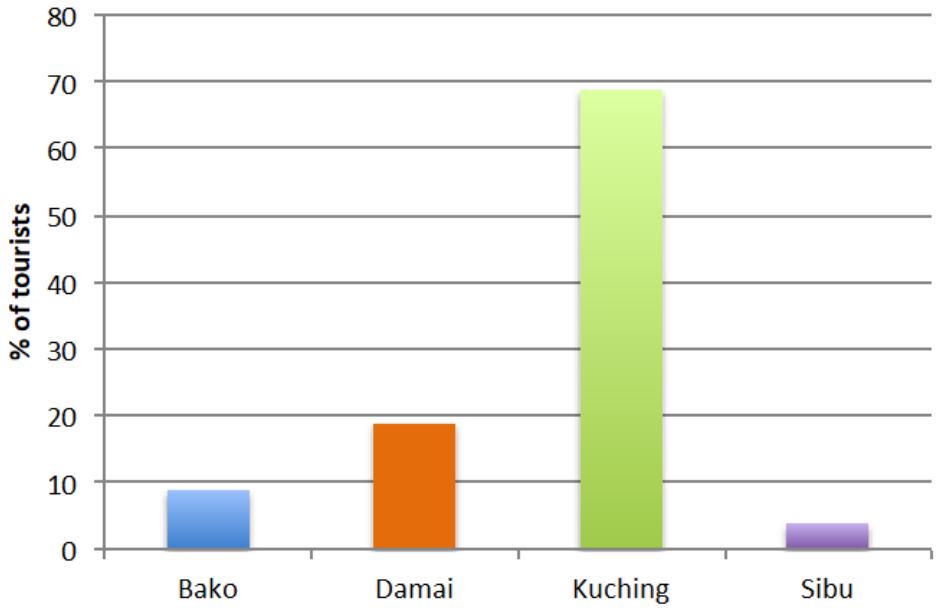

Figure 42. Location of sampled tourists

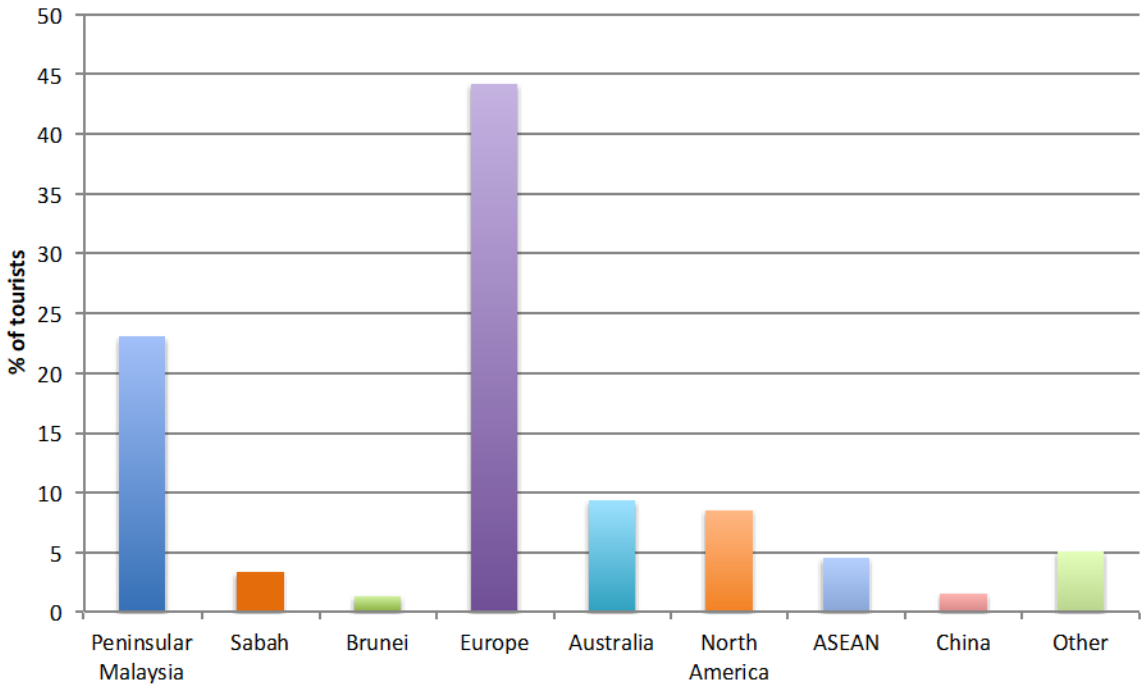

Figure 43. Origin of sampled tourists

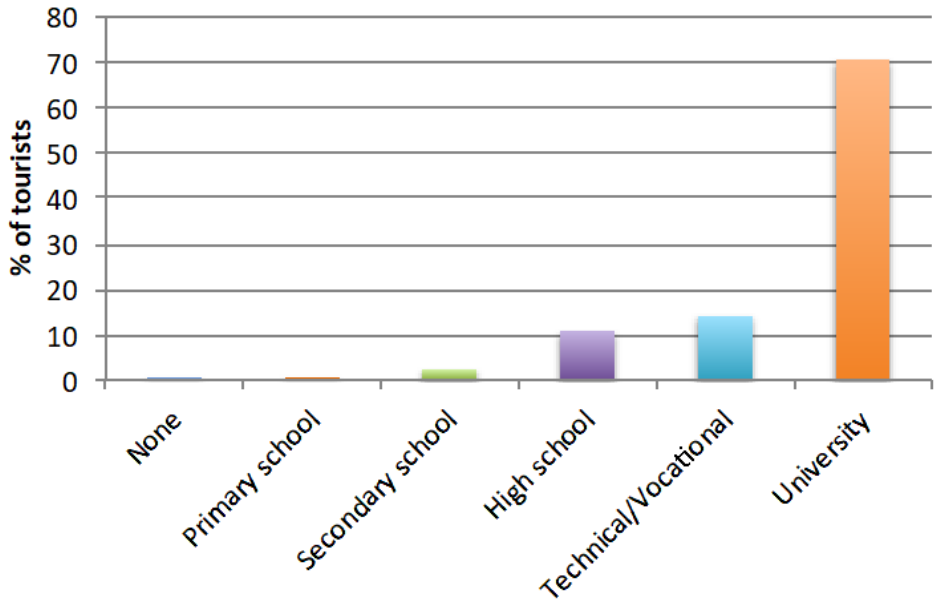

Figure 44. Level of education completed

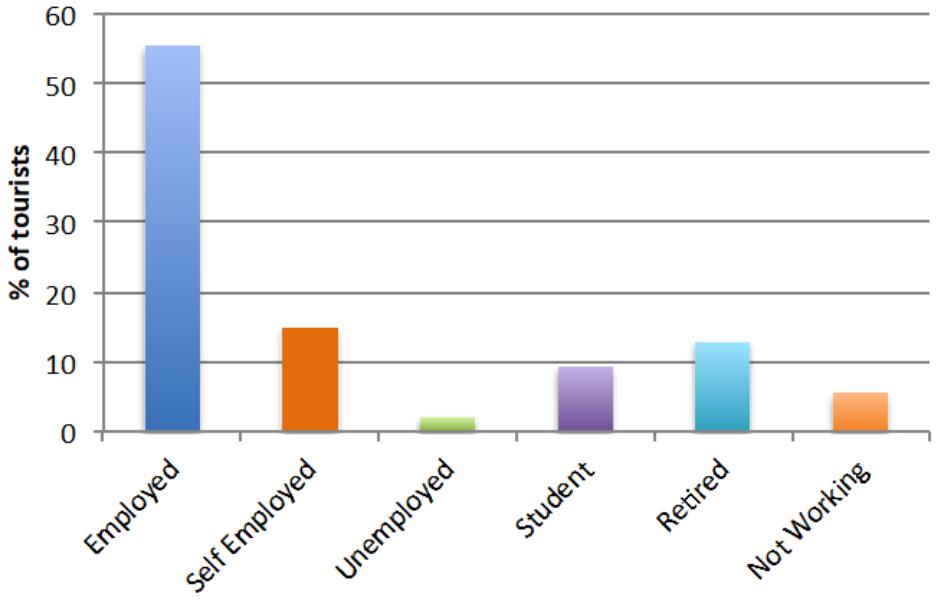

Figure 45. Employment status

9.2 Household income

The average household income for the sample is approximately US$ 2750 per month. Figure 46 represents the distribution of income levels across the sample.

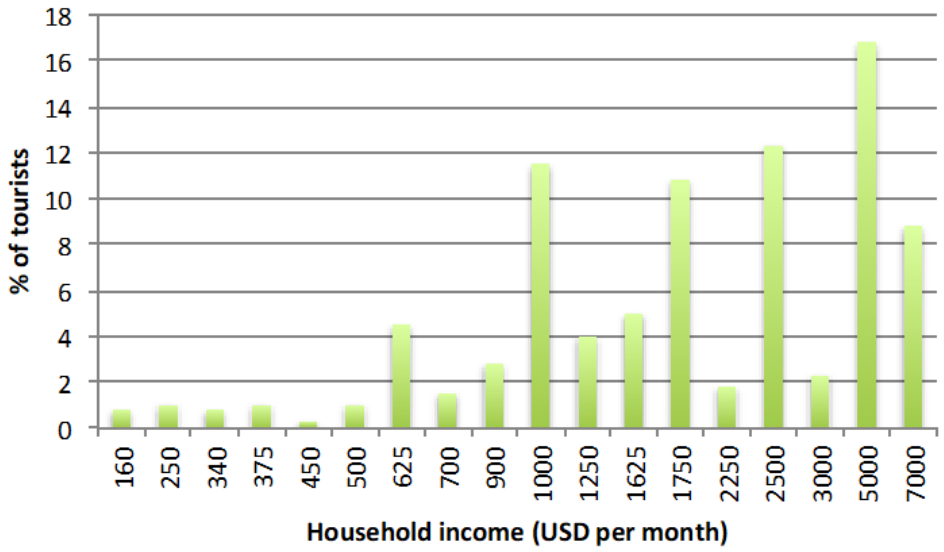

Figure 46. Proportion of households at each income level

9.3 Characteristics of tourist visits

Almost all of the sampled tourists travelled to Sarawak by aeroplane. A small number had arrived by cruise ship. For most of the respondents, the current trip was their first time to Sarawak. Approximately 25% of the sample are repeat visitors (see

Figure 47). The majority of sampled tourists stay in Sarawak for a week or less (see Figure 48). Figure 49 represents the proportion of tourists that engage in different tourist activities, which indicates that tourists engage in a range of activities during their visit. Almost 90% of tourists visit historic/cultural sights, national parks and wildlife refuges. Even the least popular activity (bird watching) attracts 50% of tourists.

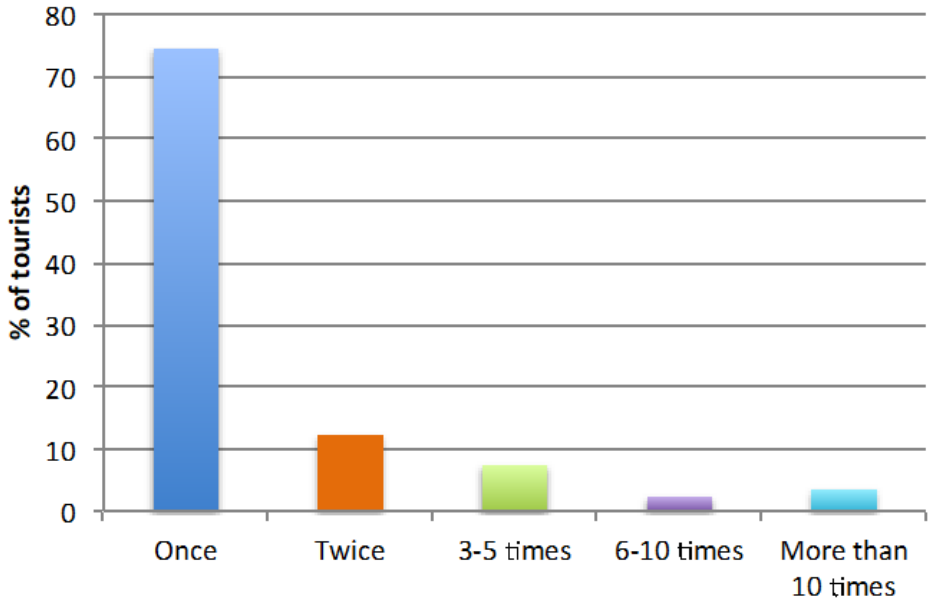

Figure 47. Number of visits to Sarawak

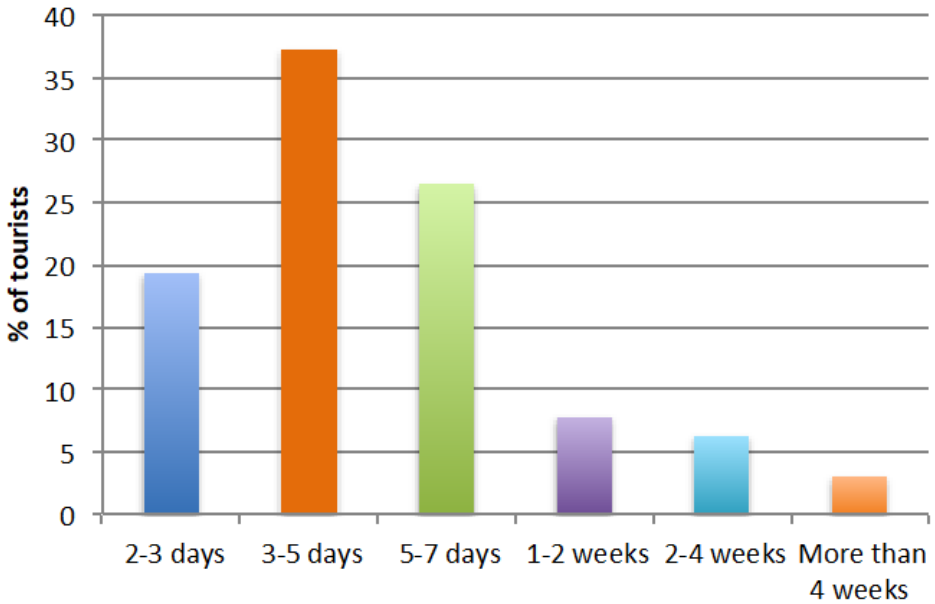

Figure 48. Duration of current visit to Sarawak

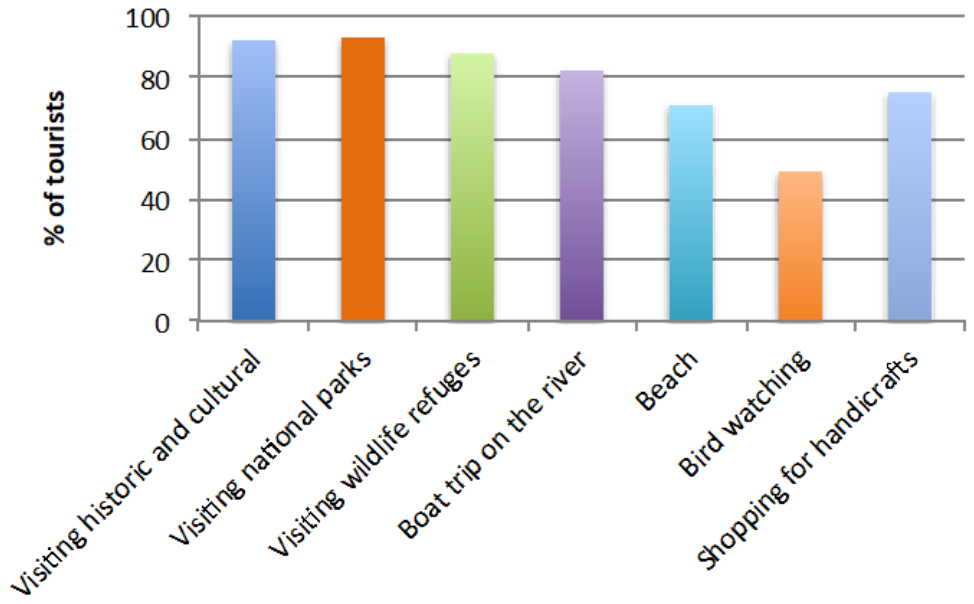

Figure 49. Tourist activities

9.4 Tourist interest in Baleh National Park

The questionnaire included a set of questions on tourists' interest in the proposed Baleh National Park. Respondents were asked whether they had heard of the proposed national park, to which only 18 (4.5%) replied yes. All respondents were then provided with information about the Baleh national park including a map showing its location. They were then asked whether they would be interested in visiting the national park. 82.5% of respondents replied that they would be interested to visit if they visit Sarawak again (i.e. on a future trip). 17% of respondents said that they would not be interested; and one respondent expressed interest in visiting during their current trip. The respondents that showed interest in visiting were subsequently asked to indicate the activities that they would like to undertake during a visit to Baleh National Park. The responses are represented in Figure 50. The activities of highest interest are viewing wildlife and plants, forest trekking, photography and bird watching. There is also substantial interest in cultural events and homestays in longhouses, which is of potential importance as an economic activity for longhouse communities. The activity that draws the lowest interest is fishing.

The respondents that indicated interest in visiting the Baleh National Park were also asked to state the maximum that they would be willing to pay for a 5 day tour to the national park (including accommodation, guide, food, water and the activities that they indicated). The average stated WTP is US$ 290, which provides an indication of the potential revenue that could be generated from tourism to the Baleh National Park.

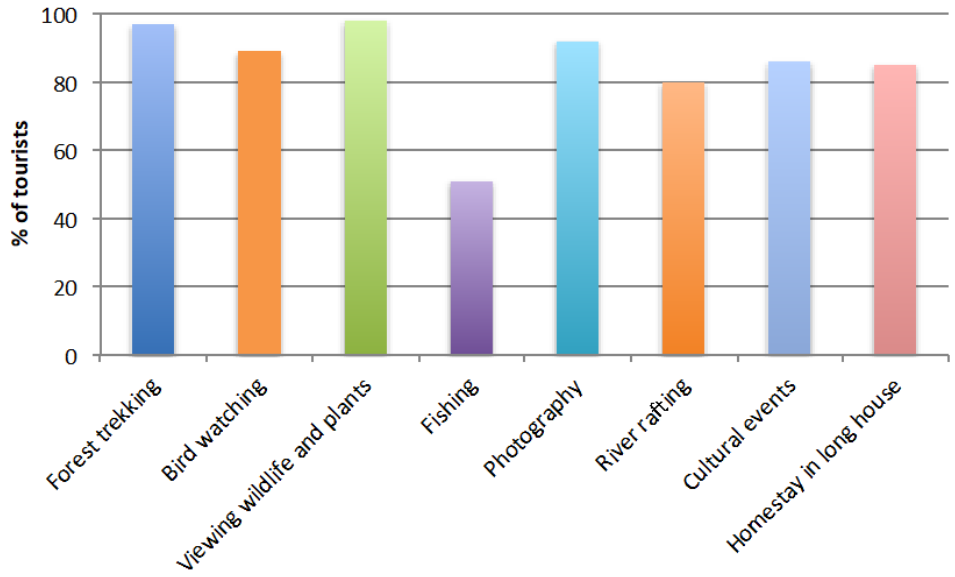

Figure 50. Interest in tourist activities at Baleh National Park

9.5 Environmental concern

Tourists generally expressed high levels of concern across a wide range of environmental issues (see Figure 51). In particular, litter and waste, water pollution, deforestation and loss of biodiversity were assigned qualitative scores above 4 on a 1-5 Likert scale. Flooding was considered to be of relatively lower concern.

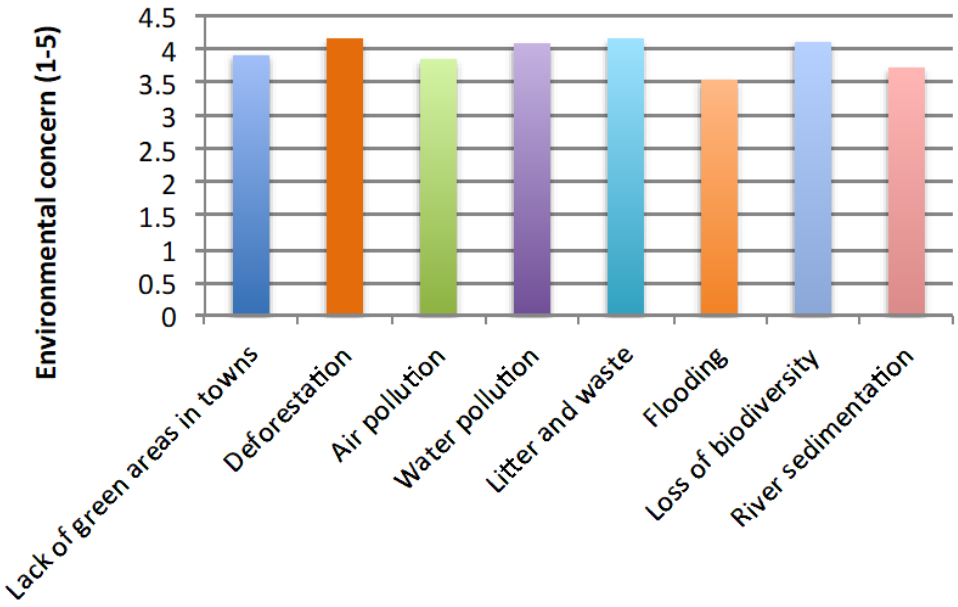

Figure 51. Concern for environmental issues

9.6 Preferences for environmental conservation

The choice experiment valuation method was again used to elicit preferences for environmental conservation. Respondents were asked to choose between three alternative future situations that are defined by five "attributes". These attributes are summarised in Table 30. One of the three options describes the expected future situation without additional environmental management and is defined by level 1 of each attribute.

Table 30. Attributes in tourist choice experiment

Attributes	Level 1	Level 2	Level 3	Level 4	Level 5
Rare and endangered species	Few	Some	Many	-	-
Clean rivers	Dirty	Moderate	Clean	-	-
Frequency and severity of floods	Frequent	Moderate	Rare	-	-
Healthy forests	Deforested	Degraded	Pristine	-	-
Green tourist fee	RM 0	RM 10	RM 20	RM 50	RM 100

Each choice is represented on a "choice card" and respondents can choose either Option A, Option B or the Expected Future without additional management (see Figure 52 for an example choice card). Each respondent is shown 6 cards in turn and asked to make a choice each time.

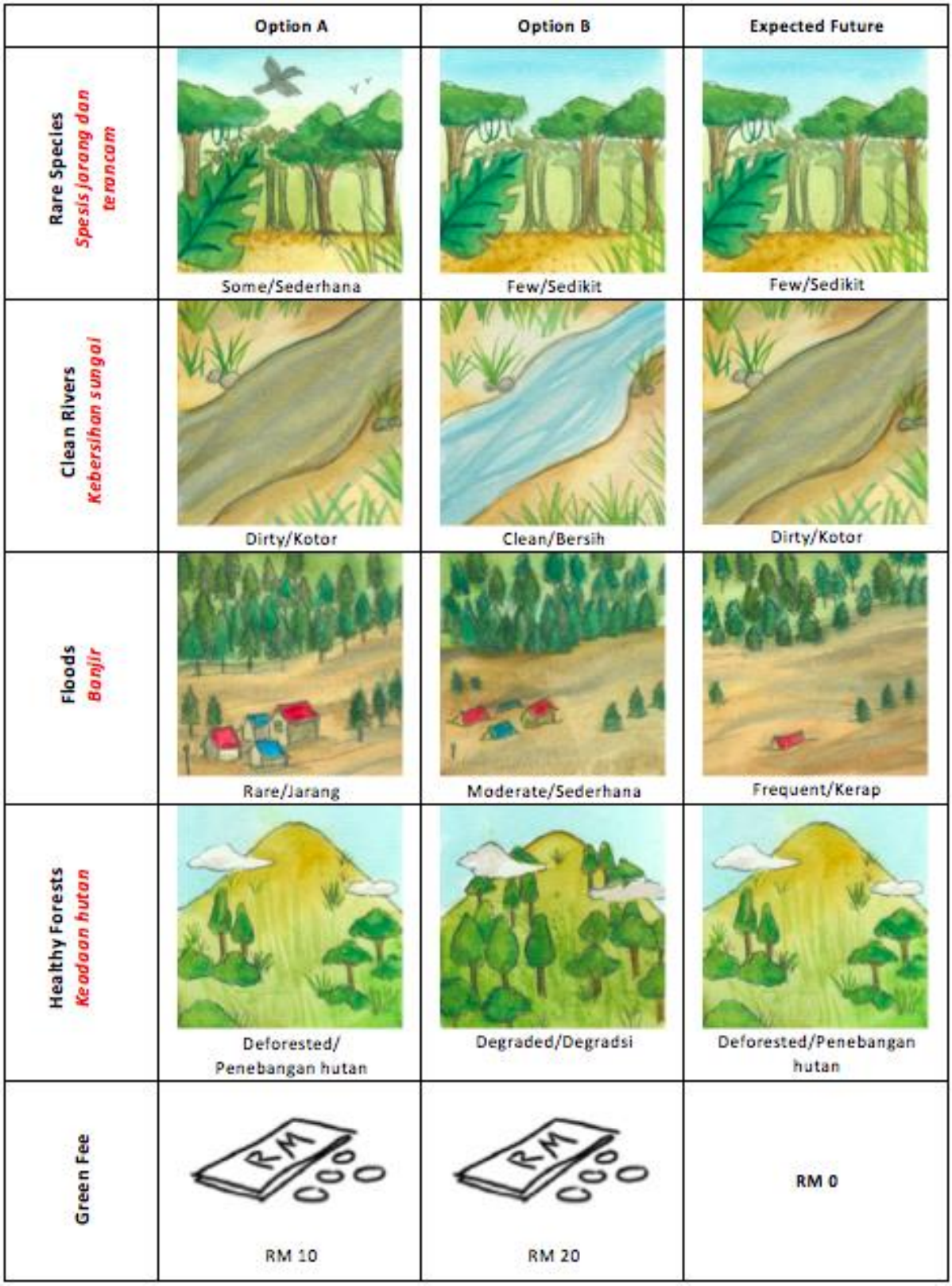

Figure 52. Example choice card for tourist survey

After making their choices, respondents were asked a series of follow-up questions to obtain more information about how they made their choices. Most respondents indicated that they felt "certain" or "very certain" when making their choices,

although 25% were neutral (see Figure 53). In terms of the choice making process, most respondents stated that they considered all or a few of the attributes when making their choices (see Figure 54). Only one respondent admitted to making random choices. The respondents were also asked to rank the five attributes in order of importance to their decisions. The relative importance of each attribute is summarised in Figure 55 and indicates that healthy forests, clean rivers and rare species were generally considered more important than flood frequency and the green tourist fee.

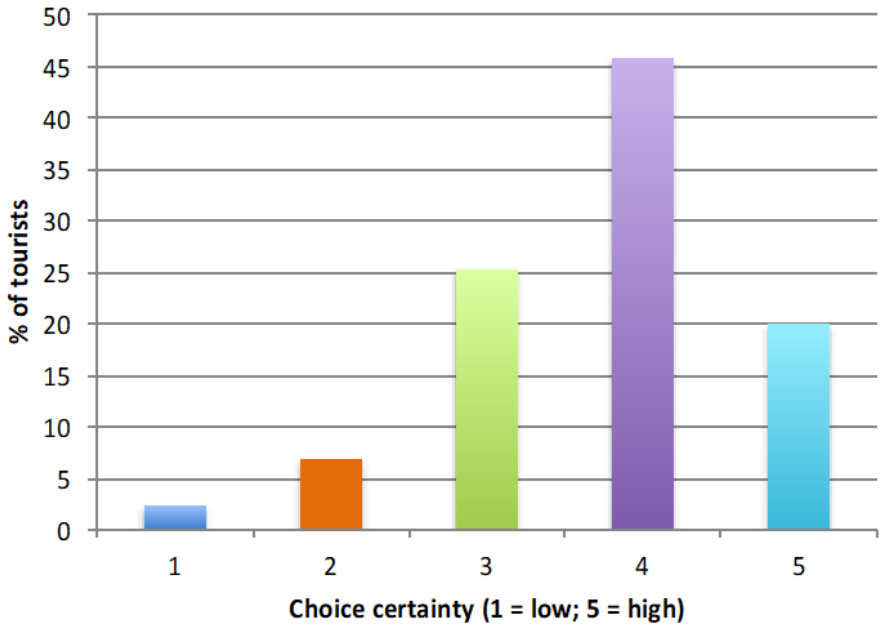

Figure 53. Choice certainty

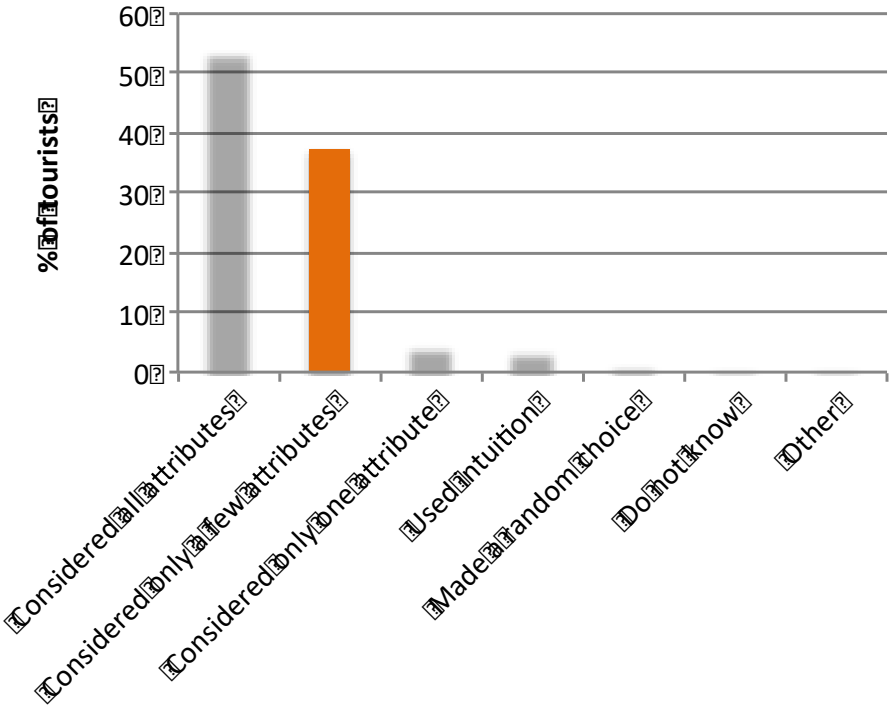

Figure 54. Choice process

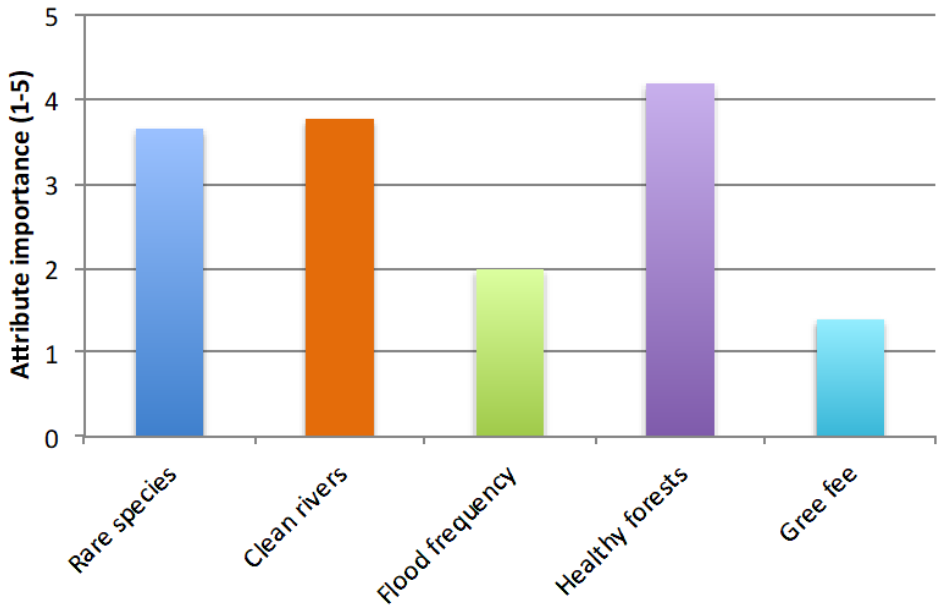

Figure 55. Importance of attributes to the choice process

Choice data from the tourist survey were analysed using a multinomial logit (MNL) regression to examine the relative influence of each attribute level on respondent choice. Attribute levels for species abundance, river quality, flood frequency and forest health are coded as dummy variables (taking either the value 0 or 1) and the lowest level of each attribute is used as the reference level and omitted from the regression equation. The payment through a tourist green fee is coded as a continuous variable to enable more straightforward interpretation of willingness to pay for specific changes in environmental attributes.

The MNL regression results are presented in Table 31. All estimated coefficients have the expected sign and are statistically significant.

The results of the regression can be used to compute mean willingness to pay for changes in each attribute by taking the ratio of marginal utility for each attribute level to the marginal utility of money (i.e. how much additional green fee respondents are willing to pay to gain a specific positive change in the other attributes). Estimated willingness to pay for each attribute is reported in Table 32. The Krinsky and Robb method is used to estimate 95% confidence intervals for WTP for each attribute. Lower bound values are truncated at zero.

Table 31. Tourist CE multi-nomial logit regression results

	Coefficient	SE	*t-ratio*	*P*
Rare species (medium)	0.754	0.079	9.549	0.000
Rare species (high)	1.258	0.084	15.023	0.000
Clean rivers (medium)	1.060	0.082	12.849	0.000
Clean rivers (high)	1.590	0.083	19.113	0.000
Flooding (medium)	0.430	0.073	5.897	0.000
Flooding (high)	0.498	0.075	6.671	0.000
Forest quality (medium)	0.269	0.071	3.787	0.000
Forest quality (high)	1.266	0.083	15.293	0.000
Green fee (RM/visit)	-0.010	0.005	-2.136	0.033
N	2382			
R^2 Pseudo	0.269			

Table 32. Tourist willingness to pay for changes in rare species, clean rivers, flood frequency and forest quality (US$/household/visit)

	Mean WTP	Lower CI	Upper CI
Rare species (low to medium)	36	0	89
Rare species (low to high)	63	0	152
Clean rivers (low to medium)	61	0	120
Clean rivers (low to high)	90	0	186
Flooding (low to medium)	29	0	50
Flooding (low to high)	31	0	55
Forest quality (low to medium)	26	0	32
Forest quality (low to high)	85	0	147

Chapter 10. Economic valuation of ecosystem services

This chapter presents the results of the economic valuation analysis. Values are estimated for each ecosystem service and for three groups of beneficiary (local, regional, global). Local beneficiaries are the longhouse residents; regional beneficiaries are households living within the Baleh-Rajang watershed; and global beneficiaries are people living outside Sarawak and include tourists that visit Sarawak and, in the case of beneficiaries of carbon storage, the global population that is impacted by climate change.

The economic values of ecosystem services provided by the Baleh watershed are presented in the following three sub-sections in terms of marginal values (the value of an incremental or unit change in ecosystem service supply), annual values for current ecosystem service supply and use (i.e. representing the current environmental condition and level of use), and changes in value under each of the future scenarios described in Chapter 5.

10.1 Marginal values for ecosystem services

This section presents the marginal values of ecosystem services in the Baleh watershed to different groups of beneficiary (see Table 33). Marginal values indicate the change in value for a small incremental change in the quantity of each ecosystem service. The units in which each ecosystem service is measured varies depending on the nature of the service. These marginal values may be useful in subsequent analyses of ecosystem service change or to other Heart of Borneo studies that rely on value transfer methods.

Table 33. Marginal values for ecosystem services in the Baleh watershed

	Ecosystem Service	US$	Unit	Beneficiary	Valuation Method
Provisioning	Food	3.95	USD/kg pig	Local	Market price equivalent
	Raw materials	7.50	USD/bundle rattan	Local	Market price equivalent
	Fresh water	0.014	USD/litre	Local	Choice experiment
Regulating	Carbon	62.00	USD/tCO2-eq	Global	Damage cost avoided
	Flood reg.	16.04	USD/1% flood probability/hh/year	Local	Damage cost avoided
	Flood reg.	1.52	USD/1% flood probability/hh/year	Regional	Choice experiment
	Flood reg.	0.32	USD/1% flood probability/hh/visit	Global	Choice experiment
	Sediment reg.	5.53	USD/million tonnes/hh/year	Regional	Choice experiment
	Sediment reg.	0.81	USD/million tonnes/hh/visit	Global	Choice experiment
Cultural	Tourism	92.80	USD/visit	Local	Contingent valuation
	Tourism	46.40	USD/visit	Regional	Contingent valuation
	Tourism	58.00	USD/visit	Global	Contingent valuation
	Species conservation	0.48	USD/species/hh/year	Regional	Choice experiment
	Species conservation	0.32	USD/species/hh/visit	Global	Choice experiment
	Forest conservation	1.97	USD/% forest cover/hh/year	Regional	Choice experiment
	Forest conservation	1.06	USD/% forest cover/hh/visit	Global	Choice experiment

10.2 Annual values for current ecosystem service supply and use

This section reports the current annual value of ecosystem services provided by the Baleh watershed (see Table 34). The total annual value is estimated to be US$ 180 million per year. This annual value can be used to compute the capital asset value as the discounted sum of the stream of annual values over a specified time horizon. Using a time horizon of 30 years and a discount rate of 5%, the value of the natural capital asset is US$ 2.8 billion.

The total economic value is dominated by the value of carbon sequestered by the forest, which is a global value derived from the damage costs of climate change that are avoided due to the removal of carbon dioxide from the atmosphere. This is a real value but very difficult to capture by institutions in Sarawak for the purposes of funding forest management and conservation. In order to more closely examine the value of non-carbon services provided by the Baleh watershed, we present further results excluding carbon values. Figure 56 represents the current value of ecosystem services. Provisioning services such as bush meat, materials and fresh water have relative low values because they accrue to only a small population of beneficiaries. Regulating services (e.g. flood and sediment regulation) and cultural services (e.g. values placed on conservation of rare species and intact forest) accrue to a broader population of beneficiaries including tourist visitors to Sarawak and have higher annual values.

Table 34. Current annual value of ecosystem services provided by the Baleh watershed (million US$ per year)

	Ecosystem Service	US$/millions/year
Provisioning	Food	1.06
	Raw materials	0.08
	Fresh water	1.28
Regulating	Carbon	86.95
	Flood regulation	12.47
	Sediment regulation	27.26
Cultural	Species conservation	21.98
	Forest conservation	29.60
Total		180.33
Total excluding carbon		93.72

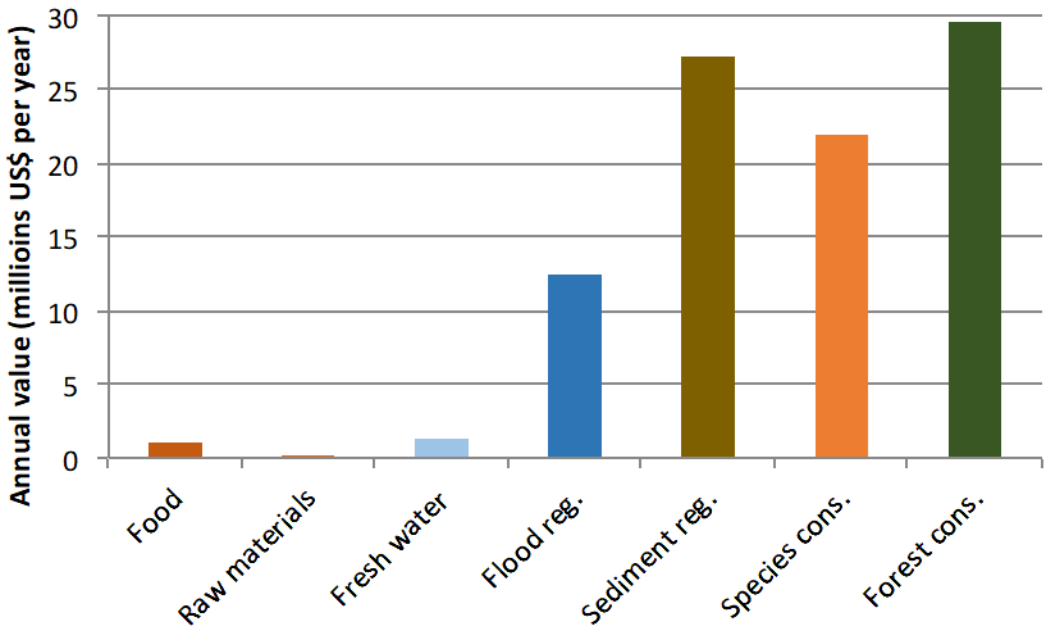

Figure 56. Current annual value of ecosystem services (millions US$ per year)

Each estimated annual value is derived from a specific set of methods, data and assumptions. For transparency we explain the derivation of each value estimate here.

The value of pigs harvested from the forest for food by the longhouse communities is estimated as the market equivalent value of selling the meat. The total annual value is estimated by multiplying the average quantity of pigs harvested (longhouse survey), the market price of pig meat (longhouse survey) and the total number of households living in longhouses in Baleh (District Office).

The value of raw materials harvested from the forest by the longhouse communities is estimated as the market equivalent value of selling the rattan that is harvested. The total annual value is estimated by multiplying the average quantity of rattan harvested (longhouse survey), the market price of rattan (longhouse survey) and the total number of households living in longhouses in Baleh (District Office).

The value of freshwater that is utilised by the longhouse communities is estimated as the total willingness to pay for the quantity that is currently used. The total annual value is estimated by multiplying the average annual household water use (longhouse survey) by the willingness to pay per litre of water (choice experiment) and the total number of households living in longhouses in Baleh (District Office).

The annual value of carbon sequestered by ecosystems in the Baleh watershed is estimated as the avoided damage costs of climate change attributable to the quantity of carbon that is sequestered per year. The annual rates of carbon sequestration for each land use class are highly uncertain and dependent on several factors, including plant species and age structure, which we are unable to fully assess. The annual rates of carbon sequestration per hectare of each land use class are therefore approximated as the annualised difference in carbon stored in the land use class vs. the amount stored in the land use class with lowest carbon (shrub). The estimated rates of carbon sequestration range from 0.3 tC/ha/year for herbaceous cover to 1.2 tC/ha/year for totally protected area. The avoided damage costs of climate change are obtained from the US Interagency Working Group on the social cost of carbon (US EPA, 2016). The reported value in 2011 prices was converted to 2018 prices using a GDP

deflator from the World Bank World Development Indicators. The unit value of the social cost of carbon used in the analysis is US$ 62/tCO_2-equivalent.

The annual value of flood regulation to the longhouse communities is estimated as the avoided damage cost of flooding attributable to the current extent and quality of forest cover in the watershed. The current probability of a flood that causes major damage is estimated to be 0.45, i.e. just under one major flood every two years (source: longhouse survey). We assume that without high forest cover, the probability of flooding would increase to 1, i.e. one major flood event per year. This is considered to be a conservative assumption given that the flood return period could plausibly exceed 1/year without flow regulation by forests. The reduction in flood probability attributable to current forest cover is computed to be 0.55, which is multiplied by the average cost of flood damage per household (longhouse survey) and the total number of households living in longhouses in Baleh (District Office).

The annual values of flood regulation to the general public and tourists are estimated as their respective willingness to pay for the reduction in flood probability attributable to current forest cover. The results of the choice experiments are used to estimate willingness to pay for a percentage point change in flood probability by assuming that the low, medium and high flood attribute levels correspond to flood probabilities of 0.05, 0.1 and 1 respectively, i.e. return periods of 1:20 years, 1:10 years, 1:1 years. These unit willingness to pay values (US$/% flood probability/hh/year) are multiplied by the estimated reduction in flood probability attributable to current forest cover and by the respective number of households in the Rajang basin (2010 census) and number of tourist visitors to the region.

The annual values of sediment regulation to the general public and tourists are estimated as their respective willingness to pay for cleaner rivers attributable to current forest cover. The results of the choice experiments are used to estimate willingness to pay per 1 million tonnes of sediment by assuming that the low, medium and high river quality attribute levels correspond to sediment loads of 120, 65 and 10 million tonnes per year respectively, i.e. low river quality is equivalent to the current sediment discharge. These unit willingness to pay values (US$/million tonnes/hh/year) are multiplied by the estimated reduction in sediment load attributable to current forest cover and by the respective number of households in the Rajang basin (2010 census) and number of tourist visitors to the region. The reduction in sediment load attributable to current forest cover is assumed to be equivalent to the current sediment discharge, i.e. sediment export would be twice as high without regulation provided by current forest cover.

The annual values of species conservation to the general public and tourists are estimated as their respective willingness to pay for the number of species maintained by current forest cover. The results of the choice experiments are used to estimate willingness to pay per species by assuming that the low, medium and high species attribute levels correspond to total species numbers of 100, 200 and 300 respectively, i.e. distributed around current (modelled) number of species in the watershed. These unit willingness to pay values (US$/species/hh/year) are multiplied by the estimated number of species maintained by current forest cover and by the respective number of households in the Rajang basin (2010 census) and number of tourist visitors to the region. The number of species maintained by the current forest cover is estimated to be 226 (see Chapter 5).

The annual values of forest conservation to the general public and tourists are estimated as their respective willingness to pay for the current forest cover. The results of the choice experiments are used to estimate willingness to pay per percentage point of forest cover by assuming that the low, medium and high forest quality attribute levels correspond to forest cover of 20%, 60% and 100% respectively. These unit willingness to pay values (US$/% forest cover/hh/year) are multiplied by the current percentage of forest cover and by the respective number of households in the Rajang basin (2010 census) and number of tourist visitors to the region. The current forest cover is conservatively estimated to be 80%.

Figure 57 represents the share of annual ecosystem service values received by each group of beneficiary. In order to reflect the importance of different ecosystem services to the three groups of beneficiary, Figures 58-60 represent the current value of each relevant ecosystem service to local, regional and global beneficiaries respectively.

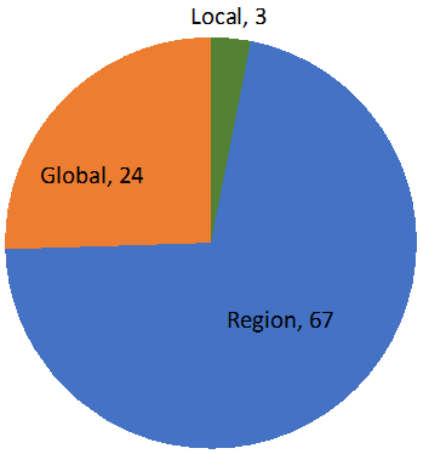

Figure 57. Distribution of annual ecosystem service values across beneficiaries (millions US$ per year)

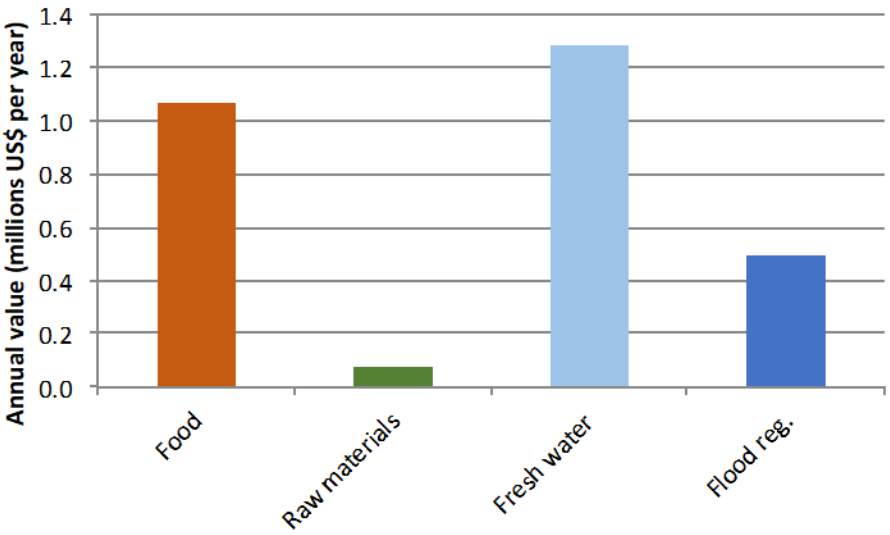

Figure 58. Local annual value of ecosystem services (millions US$ per year)

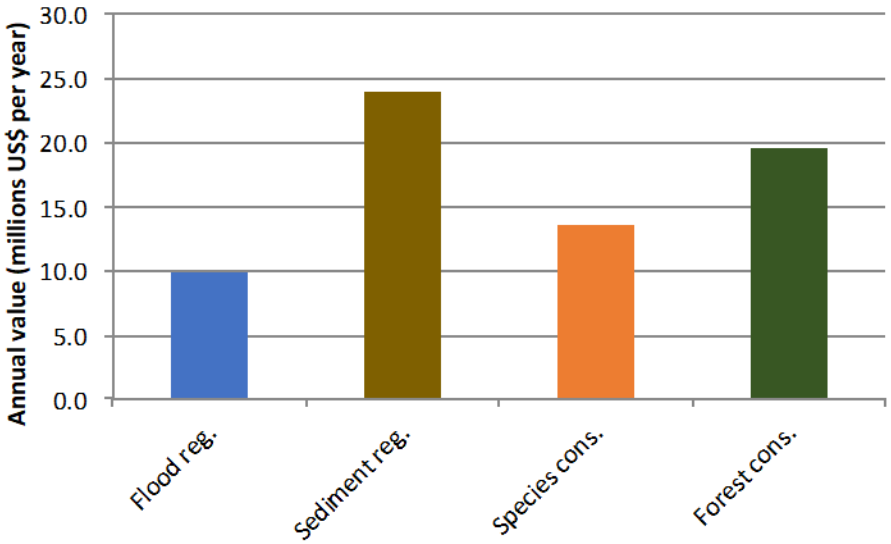

Figure 59. Sarawak public annual value of ecosystem services (millions US$ per year)

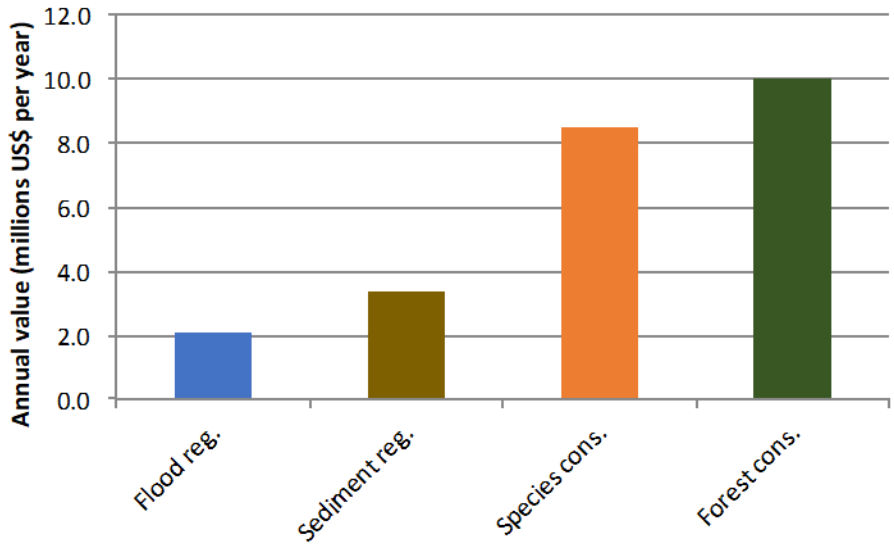

Figure 60. Sarawak tourists' annual value of ecosystem services (millions US$ per year)

10.3 Changes in ES values under future scenarios

This section presents the economic value of changes in ecosystem service provision under each of the three future scenarios described and modelled in Chapter 5. The results are presented in terms of changes in annual value in the year 2030 relative to the current annual value (see Table 35). The assumptions used to model changes in ecosystem service values are summarised and justified in Table 36.

The estimated values are again dominated by the value of changes in carbon stocks. This is an important impact but in order to also examine changes in other ecosystem services we again exclude carbon values from subsequent results.

Table 35. Change in annual value of ecosystem services under future scenarios relative to current annual values (US$ per year in 2030)

		Economic Development	Green Economy	Conservation
Provisioning	Food	-60,512	-19,969	58,300
	Raw materials	-4,281	-1,413	4,124
	Fresh water	-49,793	216,176	740,986
Regulating	Carbon	-131,600,176	-43,427,855	126,789,218
	Flood regulation	-34,656	-13,902	28,937
	Sediment regulation	-1,059,674	4,600,588	15,769,419
Cultural	Tourism	591,600	591,600	591,600
	Species cons.	-2,703,931	-737,691	-200,987
	Forest cons.	-1,392,109	-459,394	1,341,218
Total		-136,313,531	-39,251,860	145,122,814
Total excluding carbon		-4,713,355	4,175,995	18,333,597

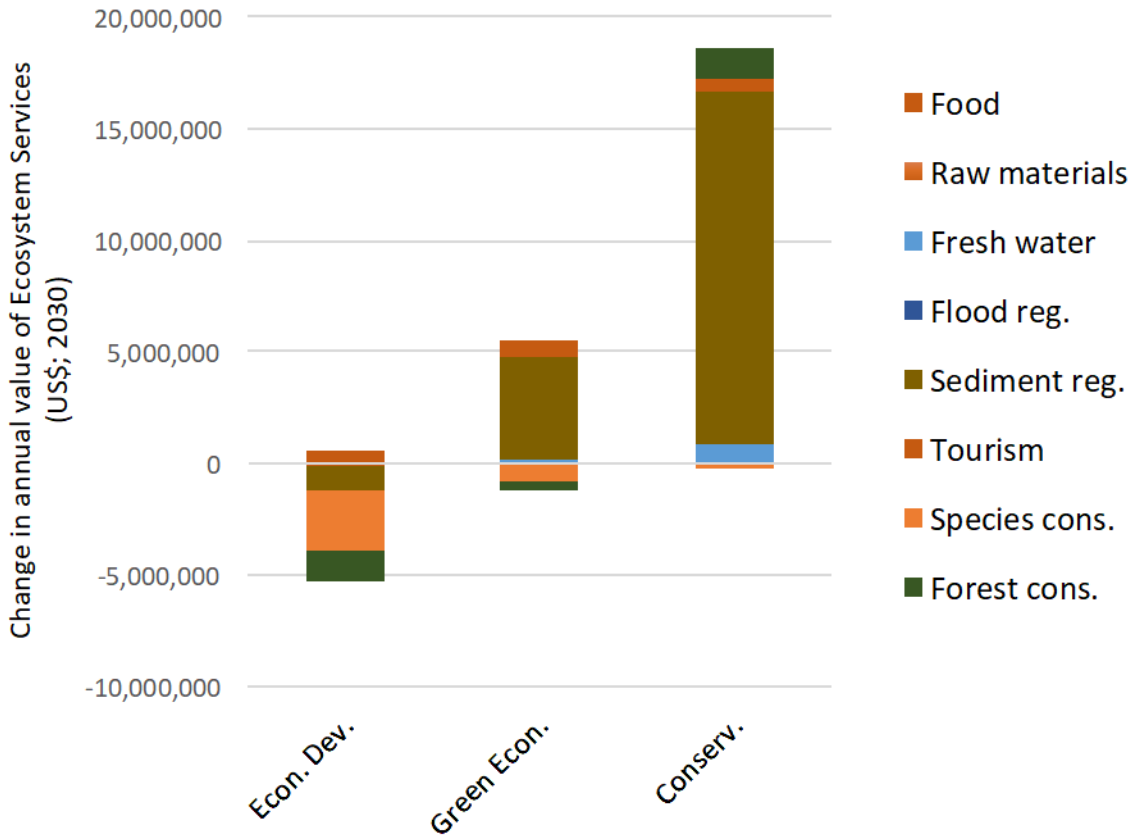

Figure 61. Changes in the annual value of ecosystem services under future scenarios relative to the present (US$ per year; 2030)

Figure 61 represents the change in ecosystem service values under each scenario in the year 2030. Relative to the current annual value of ecosystem services, the Economic Development scenario results in a loss of ecosystem service value of almost US$ 5 million. The only ecosystem service to change positively is tourism, which is expected to develop following the establishment of the Baleh National Park.

The Green Economy scenario represents an improvement relative to the Economic Development scenario. All negative impacts on ecosystem services are reduced and several show a positive change relative to the current situation. The largest positive effect is on the value of sediment regulation. Overall the Green Economy scenario results in an increase in the value of ecosystem services by just over US$ 4 million per year.

The Conservation scenario delivers substantial increases in the value of ecosystem services from the Baleh watershed, particularly in terms of sediment regulation, forest conservation and fresh water availability. In total, the increase in the annual value in 2030 is just over US$ 18 million.

The estimated changes in ecosystem service values under each scenario are derived from a specific set of methods, data and assumptions. For transparency, Table 36 sets out the key assumptions that are used to link modelled bio-physical changes to economic values.

Table 36. Key assumptions used to link bio-physical change to economic impact

Ecosystem Service	Assumption	Justification
Food and materials	Change in harvest of food and materials by longhouse communities is directly proportional to change in forest area under each scenario	Results from the longhouse survey describe change in resource availability with forest quality. This is considered a conservative assumption given that the % change in forest cover is low
Fresh water	Change in the availability of fresh water at longhouses is inversely proportional to changes in sedimentation	Sediment load affects water abstraction and treatment
Flooding	Change in the probability of flooding is directly proportional to changes in river base flow	Total discharge is a key determinant of flood risk. This is considered a conservative estimate since changes in base flow are low
Forest cover	Change in forest cover is directly proportional to changes in carbon storage	Forest cover is closely related to above ground carbon. This is considered a conservative assumption since the proportionate changes in carbon stock are low

Changes in annual values of ecosystem services are driven by changes in the provision of each service due to changes in land use and management practices. Note that socio-economic drivers of change to the use and value of ecosystem services are not modelled in the scenarios, e.g. changes in population and income. Essentially the populations of beneficiaries are held constant at current levels so that we are only assessing changes in value due to land use and management.

There is an exception to this restriction, however, in the case of tourism. The current number of tourists visiting the Baleh watershed is close to zero. Following the designation of the Baleh National Park, and based on the results of the tourist survey, the number of tourists to the watershed is expected to increase. Although a high proportion of respondents to the tourist survey indicated an interest to visit the Baleh National Park on a subsequent visit to Sarawak, we use a conservative estimate that only 1% of tourists to Sarawak will visit. This gives an estimated number of visits of 3,000 per year, which is multiplied by the average stated willingness to pay for a five day tour (US$ 290) to estimate the total value of tourism. To apportion this total value across beneficiaries, the assumed split is 40% to local longhouse tourism service providers (e.g. accommodation, food, transportation, guides), 40% to regional tourism operators and 20% as tourist consumer surplus. To estimate net producer surplus, cost factors for local and regional tourism operators are assumed to be 20% and 60% respectively.

Chapter 11. Policy recommendations to support sustainable use of natural capital

This chapter outlines the following policy recommendations to promote the sustainable use of natural capital in the Baleh Watershed.

- Recognise and integrate the importance of ecosystem services into socio-economic and development planning
- Strengthen the credibility of MTCS
- Promote group certification and improve the credibility of MSPO scheme
- Be REDD+ ready
- Adopt a landscape approach to maintain and enhance the natural capital
- Develop ecotourism
- Introduce tourism green fee
- Payments for ecosystem services (PES)

11.1 Recognise and integrate the importance of ecosystem services into socio-economic and development planning

The study has demonstrated that the Baleh Watershed provides a wide range of valuable ecosystem services that benefit the local communities within the watershed, the wider public residing in the Rajang basin, and visitors to the state.

Provisioning services provide a crucial safety net for the rural communities in Baleh where almost all households harvest some form of forest resources including wild vegetables, fuel wood, fish, wild fruit and materials for handicrafts. The majority of household income derived from provisioning services is from subsistence use (i.e., it is non-market and non-cash). Based on the longhouse survey results regarding household income, over 70% of households fall below the hardcore poverty line of RM660/month.[32]

Recognising the importance of ecosystem services in poverty eradication initiatives is critical in strengthening the Government's delivery systems of aid to poor target groups. Efforts need to be put in place to extensively integrate and mainstream the maintenance of ecosystem services into existing policy and government initiatives by relevant Ministries and programmes working on poverty relevant issues. There is a strong complementarity between existing government efforts to reduce poverty and efforts to conserve forests and riverine ecosystems. There is a need to ensure that besides rural infrastructure development and private sector investments, the core ecosystem services to the communities are safeguarded and enhanced. Key agencies and programmes include:

[32] Borneo Post, 30 March 2017. 41,836 households above poverty line- Fatimah http://www.theborneopost.com/2017/03/30/41836-households-above-poverty-line-fatimah/

- Sarawak Rural Transformation Programme, which is formed under a cabinet committee and chaired by Deputy Chief Minister Tan Sri Dr James Masing. The programme is monitored by Sarawak Implementation Monitoring Unit, Chief Minister's Department Sarawak
- Ministry of Modernisation of Agriculture, Native Land and Regional Development, Sarawak
- Ministry of Welfare, Women and Community Wellbeing
- Ministry of Infrastructure Development and Transportation

11.2 Strengthen the credibility of MTCS

Implementation of Sustainable Forest Management (SFM) certification entails multi-stakeholder approach, promotion of good forest governance, application of sustainable forest practices, and better stakeholder engagement. All these are fundamental to maintaining the ecological integrity of the Baleh Watershed.

The State Government has made it mandatory for all timber licensed areas to obtain SFM certification by 2022 under the Malaysian Timber Certification Scheme (MTCS).

In line with the directive, Ta Ann Holding Berhad, one of the major timber companies operating in and around the Baleh Watershed had in July 2018 completed its SFM certification (Natural Forest Certification) process for its Kapit Forest Management Unit (FMU). The FMU covers an area of 149,756 ha in the southern part of Kapit District. Its two other FMUs in the Song-Kapit region, namely Raplex and Pasin, are expected to receive similar certification in 2019 and 2020, respectively. Spanning 196,059ha, Raplex and Pasin together are 23.6% larger than the Kapit FMU[33].

These are commendable efforts and should be supported. Other timber companies operating in and around the Baleh Watershed should also accelerate their certification efforts.

However, the credibility of the MTCS should be further enhanced to ensure that it is strong enough to bring about real positive impacts on the ground. More specifically, MTCS should encourage more active and balanced participation from a wide range of stakeholders in its governance system for greater independence and transparency.[34]

There are improvements in the Malaysian Timber Certification Council's (MTCC) standards for forest plantation management, as found in its revised standard for Malaysian Criteria and Indicators for Forest Management Certification (Forest Plantation) (2015 MC&I Forest Plantation.V2).

[33] http://www.theedgemarkets.com/article/ta-ann-gets-sustainable-timber-management-certification-its-local-operations and http://www.kapitfmu.com.my/about-us/

[34] https://wwf.panda.org/?246871/WWF-Forest-Certification-Assessment-Tool-CAT

The MTCC shall resume its effort to review the MC&I (Natural Forest) in 2018, having putting it on hold in 2017.[35] The revision is timely and MTCC should focus on improving its management standards to cover exclusion of natural forest conversion, safeguarding High Conservation Values, better producer communication and addressing greenhouse-gas emissions. MTCC should also better address indigenous peoples' rights and community relations.[36] Furthermore, MTCC should put in place criteria relating to conversion of certified forests and strengthen the on-the-ground interpretation and compliance with the criteria. In the first place, forest areas scheduled for conversion should be excluded from the certified forests.

Additionally, the MC&I Forest Plantation V2 should be reviewed from time to time to ensure it aligns with global standards such as those prescribed under Forest Stewardship Council (FSC).

[35] https://mtcc.com.my/status-update-on-the-review-of-mcinatural-forest/
[36] https://wwf.panda.org/?246871/WWF-Forest-Certification-Assessment-Tool-CAT

11.3 Promote group certification and improve the credibility of MSPO scheme

In general, sustainable palm oil certification schemes are aimed to ensure that fundamental rights of local communities, plantation workers and small farmers are respected and protected; no conversion of primary forests or high conservation value areas for palm oil production; and mills and plantation owners minimise their environmental footprint. When properly implemented, such schemes help to minimise the negative consequences associated with conventional palm oil cultivation, resulting in better protection of natural capital.

Group certification

Consistent with the directive of the Federal Government, palm oil industry in Sarawak is required by the State Government to implement the Malaysian Sustainable Palm Oil (MSPO) certification scheme beginning December 2019. The aim is to produce more certified sustainable palm oil to meet the growing external demand.

Implementation of the certification scheme will make the industry more responsible and sustainable. This study welcomes the directive.

Expansion and upgrading of road networks in the Rajang river basin, including building of access roads to the proposed Baleh Dam will result in more lands in the area being opened up by local communities for oil palm cultivation. Small and medium sized growers in the area, however, may not have the resources and expertise to implement the certification scheme.

To spur the uptake of MSPO certification in the basin, special attention should be given to small holders to get "group certification" at no cost to them. Ideally, the mills or companies that the small holders are supplying to should bear the cost of getting the group certificate. Technical assistance should be given to the small holders with the objective of linking them to MSPO certified mills and providing them with training and assistance for group certification under the MSPO Certification Scheme.

Credibility

There is a need to enhance the MSPO scheme, making it more robust and credible. To this end, special attention should be given to improving the governance, chain of custody and accreditation of the MSPO Scheme.

MSPO is seen as a potential starting point to achieve basic sustainability in the Malaysian palm oil industry. Once MSPO certified, producers should aim towards a time-bound goal and commitment towards continued improvement and eventually towards Roundtable on Sustainable Palm Oil (RSPO) certification.[37]

The industry will have better access to international markets through adopting a more credible certification scheme. The recent proposal by the European Union to ban palm oil biofuels by 2020 has clearly demonstrated that less credible sustainable palm oil certification schemes face mounting challenges to gain a foothold in EU market.

[37] WWF-Malaysia (2018). Roundtable on Sustainable Palm Oil (RSPO) vs Malaysian Sustainable Palm Oil (MSPO), A comparison based on WWF's Certificate Assessment Tool (CAT)

11.4 Be REDD+ ready

The results of this study show that carbon storage is a highly valuable ecosystem service provided by forests in the Baleh Watershed. The beneficiaries of this regulating service are global in the sense that storing carbon mitigates climate change and reduces its negative impacts to current and future populations everywhere. It is challenging to capture even part of this value to incentivise the State Government, timber concessionaires and forest communities to invest in forest conservation.

Performance payments could play an important role in providing visible and tangible incentives for these stakeholders to keep the forests in the Baleh Watershed standing, which would deliver global carbon benefits and also protection of the watershed from erosion and biodiversity loss. At present, however, there is an absence of a robust performance payment scheme at the Federal and State level to reward forest conservation in the area.

The results of this study underline the need to recognize forests as ecological public goods and call for adoption of a fiscal transfer scheme that will allow the Federal Government to transfer a certain percentage of its total tax revenue to states based on how much forest they have maintained or restored. Within Sarawak, the State Government may introduce a similar form of ecological fiscal transfer that aims at rewarding those divisions, districts or municipalities that invest in forest conservation and watershed protection. The idea of such performance transfer scheme is not new and has been adopted by the state of Paraná in Brazil since 1991, by Portugal since 2007 and by India since 2015. Empirical studies have shown that the schemes had a positive impact on increasing the size of protected areas in those countries.[38]

In the context of international climate change mitigation under the United Nations Framework Convention on Climate Change (UNFCCC), the “pay for performance” scheme is known as REDD+, or reducing emissions from deforestation and forest degradation, with sustainable management of forests, conservation of forest carbon stocks and enhancement of forest carbon stocks constituting the "+". REDD+ is one of the most promising and politically viable options for climate change mitigation and entails paying countries with tropical forests to reduce their rates of deforestation.

The effectiveness of the REDD+ mechanism has been hampered by a lack of funding and weak institutional framework since it was agreed at the thirteenth session of the Conference of the Parties (COP-13) to the UNFCCC in Bali in 2007[39]. However, there have been signs that implementation of REDD+ has begun to gain traction and momentum in recent years. Below are some examples:

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[38] Loft. L, Gebara M.F. & Wong G.Y. (2016). The Experience of Ecological Fiscal Transfers, Lessons for REDD+ Benefit Sharing, Occasional Paper, Center for International Forestry Research; and Center for Global Development (2015). Look to the Forests. How Performance Payments Can Slow Climate Change

[39] Globally, funding for REDD+ between 2006 and 2014 totalled US$10 billion, a fraction of annual ODA funding of around $130 billion and annual climate finance that reached US$62 billion in 2014. And the amount offered to reward performance is only about a third of total REDD+ funding (source: https://www.cgdev.org/blog/paying-tropical-forest-countries-keep-trees-standing-no-brainer)

- After a decade of international effort, the REDD+ framework was completed in 2015 and enshrined in Article 5 of the 2015 Paris Agreement. The article provides the necessary political commitment to mobilize much-needed action around forests through payments for performance
- Payments for performance are on the rise as more forest countries are taking ownership of forest-preservation programs and strengthening their own forest governance, and traditional funders are finding ways to manage the fiduciary, social, and other risks they face when they support the REDD+ pay for performance approach.[40]
- While waiting for robust global and national REDD+ frameworks to emerge, subnational implementation of REDD+ has become increasingly popular.[41] This jurisdictional approach provides a vital missing link between pilot projects and full national implementation.
- Entered into force on 4 November 2016, the 2015 Paris Agreement has resulted in renewed interest in market mechanisms and the resurgence of carbon markets. Article 6 of the Paris Agreement is the new window of opportunity for market-based mechanisms and sets the framework for the post-2020 carbon markets at a regional and international level.[42]
- In October 2016, the member states of the International Civil Aviation Organization (ICAO) made the historic decision to adopt a global market-based measure for aviation emissions. The ICAO Carbon Offsetting Reduction Scheme for International Aviation (CORSIA) allows airlines to contribute towards the aviation industry's goal of carbon neutral growth from 2020 onwards by financing greenhouse gas emission reductions outside of the aviation sector. Through airlines' purchases of REDD+ credits, CORSIA is expected to generate significant finance that will drive developing countries' performance in reducing emissions from deforestation.[43]

Given these positive developments, Sarawak should consider embarking on REDD+ program in the state based on a sub-national approach. The Baleh Watershed could be a pilot site for REDD+.

Malaysia is a party to the UNFCCC. It ratified the Convention in July 1994 and Kyoto Protocol in September 2002. At the COP 15 held in Copenhagen in 2009, Malaysia adopted an indicator of a voluntary reduction of up to 40% in terms of emissions intensity of GDP by the year 2020 compared to 2005 levels. Implementation of REDD+ in Sarawak will be seen as a proactive step towards realising the emissions reduction target.

Sub-national Approach and National REDD Plus Strategy of Malaysia

The sub-national approach, as recommended in this report, was formally acknowledged by the 2010 United Nations Climate Change Conference held in Cancun, Mexico. The approach allows public and private demonstration projects to

[40] https://www.cgdev.org/blog/paying-tropical-forest-countries-keep-trees-standing-no-brainer
[41] https://gcftf.org/
[42] https://www.adb.org/sites/default/files/publication/418831/article6-paris-agreement.pdf
[43] https://www.climateadvisers.com/wp-content/uploads/2018/03/Forests-and-Flight.pdf

begin addressing greenhouse gas emissions at sub-national/project level, while national governments embark on a potentially lengthy process of developing national REDD+ policies, data, and capacities. Eventually, these sub-national activities will need to be brought under national-level accounting frameworks to ensure that any carbon credits issued to projects or programs "add up" and be measured and rewarded based on national-level accounting systems[44].

In this context, REDD+ implementation is coordinated and monitored at national level while implementation of actions is at state/sub-national level.

The sub-national approach is consistent with Section 2.5 of the National REDD Plus Strategy of Malaysia (2017) which, among other, states:

> "*By 2025, capacity for implementation of national and* ***subnational*** *climate change, biodiversity, forest related strategies and other related MEA has significantly increased;*
>
> *Key indicator:*
>
> • *2018,* ***at least 5 states*** *have formulated and began implementing* ***state level*** *biodiversity strategies and action plan"*[45]

In fact, Sabah has been implementing three sub-national REDD+ pilot projects with technical and financial support from the European Union (EU) since 2014[46].

The Sabah Forestry Department, as the sub-national implementing agency, makes regular reporting on the implementation status of the projects to the Federal Ministry of Water, Land and Natural Resources which is the national coordinator of REDD+.

The Federal Ministry in turn reports the status of these sub-regional REDD+ projects to the UNFCCC. The most recent reporting was done via the Malaysia Third National Communication and Second Biennial Update Report to the UNFCCC (September 2018)[47].

Such periodical reporting to the UNFCCC is needed in order for the projects to meet the UNFCCC requirements for REDD+ results-based payments.

The Sandakan (Sabah) based EU REDD+ Project Team was optimistic that such payments were forthcoming through the Government of Malaysia-UNDP channel[48] (UNDP is the designated UN counterpart of the Government of Malaysia for supporting the implementation of REDD+ program in the country).

To get the program off the ground, Sarawak will need to formulate a sub-national REDD+ strategic plan towards sustainable land use and sustainable forest management through a performance-based payment mechanism. The State Government should work closely with the national focal agency of the national

[44] https://theredddesk.org/sites/default/files/resources/pdf/2011/nested_redd_briefing_final_draft_2_may_11.pdf

[45] https://redd.unfccc.int/files/malaysia_national_redd__strategy.pdf

[46] http://www.forest.sabah.gov.my/REDD+/

[47] https://unfccc.int/sites/default/files/resource/Malaysia%20NC3%20BUR2_final%20high%20re_0.pdf

[48] pers. comm., with Ms. Ms. Rosila Anthony, the EU REDD+ Project Coordinator, 24 October 2018

REDD+ program, i.e. the Federal Ministry of Water, Land and Natural Resources in developing the sub-national REDD+ strategic plan. This is to ensure the sub-national REDD+ program meets the conditions of the UNFCCC and is consistent with the National REDD+ initiative which is still in its draft form.

The sub-national REDD+ strategic plan should outline clear steps to make Sarawak REDD+ ready and eventually full implementation of the program. The REDD+ ready phase should involve getting the basic institutional arrangements in place. This should involve designating a state agency/department (e.g. Forest Department Sarawak) to lead and coordinate the program; getting the program funded; and conduct awareness and capacity building activities. Equally important is to propose a REDD+ financing structure, benefits sharing mechanisms and safeguard measures.

Subsequently, the State should focus on the more technical aspect of REDD+ readiness, as follows:

- Developing and adopting a Measurement, Reporting and Verification (MRV) system[49], which is a critical element necessary for the successful implementation of any REDD+ mechanism.
- Developing a Reference Emission Level (REL) and Reference Level (RL) for assessing additionally.[50] Given the complexity and time required to implement and manage relevant systems at the national level, Sarawak may adopt a nested approach to deal with the many challenges of establishing REL and RL. The approach allows REDD+ activities to occur at the sub-national (state) and project level (in Baleh Watershed) and generate carbon credits and revenue based on emissions reductions independently from the overall national performance with the obligation that carbon accounting and crediting would eventually be scaled-up to the national level.[51]
- Section 40 of the Forest Ordinance 2015 enables payments for ecosystem services to be collected in permanent forests as part of the powers of the Director of the Forest Department Sarawak. According to the Ordinance, "Permanent forests" means all forests reserves, protected forests, communal forests, Government reserves and planted forests in the State. Section 40 therefore provides an enabling legal framework for REDD+ in which REDD+ is a form of PES. However, there is still a need to include carbon as a forest produce in the Sarawak Forest Ordinance 2015.

Having taken these steps, pilot projects may be carried out in the Baleh Watershed with the view of testing, fine-tuning and enhancing the REDD+ framework and mechanisms and for its eventual full implementation.

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[49] MRV is a series of procedures associated with the communication of all mitigation actions of developing countries. Measurement refers to the quantification of (i) anthropogenic forest-related emissions by sources and removals by sinks; (ii) forest carbon stocks; and (iii) changes in forest carbon stocks and forest area resulting from the implementation of REDD+ activities. Reporting refers to communication to the international community following the Intergovernmental Panel on Climate Change best practices guidelines. Verifying refers to checks on the accuracy of the estimation by UNFCCC designated entities. https://www.cifor.org/redd-case-book/glossary/

[50] Additionality is the requirement that a REDD+ activity or project should generate benefits, such as reduced emissions or increased removals that would not have happened without the activity (i.e. the business as usual scenario) https://www.cifor.org/redd-case-book/glossary/

[51] https://theredddesk.org/encyclopaedia/nested-approach

It appears that there is already expressed commitment from the private sector to fund carbon reduction projects in Sarawak in partnership with the Forest Department Sarawak. The Baleh Watershed is no doubt an ideal pilot site for such projects given that its natural capital has already been valued under this study.

Under the UN REDD+ framework, results-based payments can come from a variety of sources, including public, private, bilateral and multilateral sources. To increase the likelihood of scale up and sustainability, including to gain traction on the REDD+ results-based payments, it is advisable to place such sub-national pilot projects under the Government of Malaysia-UNDP REDD+ framework.

It may take many years before the international REDD+ frameworks and institutions become mature and a REDD+ credit market to develop. In this light, it is important for Sarawak to take a long-term perspective in its endeavour to develop its REDD+ program. There may be hardly any revenue generated under its REDD+ program in the short to medium term. But by being REDD+ ready and positioning itself as a REDD+ early mover, Sarawak should stand to benefit from it over the long run.

11.5 Adopt a landscape approach to maintain and enhance natural capital

Sarawak should adopt a landscape approach to integrate all the solutions proposed above. This is to enable solutions at an adequate scale to achieve sustainable land-use mosaics and balance trade-offs among competing land uses.

In this context, land use planning in the Baleh Watershed should take into consideration the following recommendations:

- Forest landscape restoration, i.e. for degraded areas to be restored with native tree species

- Identifying wildlife corridors to facilitate movements of animals, and improving connectivity between protected areas through conservation areas within production forest landscape and plantations. For this to succeed, there must be strong enforecement on the ground to deal with illegal hunting activities, etc

- Expanding and strengthening networks of protected areas, along with governance arrangements to ensure these networks are able to withstand pressure of land conversion
- Natural forest in the watershed should be protected permanently with zero conversion. Implementation of SFM shall contribute towards this objective
- Expansion of plantations should be focused on degraded land and non-forested and non-peat areas, while safeguarding the rights and livelihoods of indigenous peoples and local communities
- Avoiding human activities (e.g. farming, hunting, infrastructure development and human settlement) on high conservation value and high carbon stock areas.
- Crop yields are increased through improved cultivars and intensive management
- Key natural areas are recognised and maintained to provide natural mitigation for flooding events
- Mainstreaming approaches to (a) conserve the geophysical stage; (b) protect climatic refugia; (c) enhance regional connectivity; (d) sustain ecosystem process and function; and (e) capitalize on conservation opportunities emerging in response to climate change (e.g., REDD+)
- Promoting transboundary integration of protected areas, wildlife corridors and sustainable land-use areas under the Heart of Borneo framework
- Undertaking integration and sustainable management of water resources in the Baleh Watershed. This includes application of the Priority Catchment and Management Principles recommended under the Sarawak Integrated Water Resources Management Master Plan Study.
- Section 38 (1), Chapter 81 of the Sarawak Land Code 1958 stipulates that all land (unalienated) within 66 ft/20.1m on each side, along the banks of all navigable rivers, streams, canals or creeks is reserved to the Government; and where the width of any such stream, canal or creek is less than 33 ft/10m, the reserve on each bank shall be twice the width of the stream, canal or creek. The State Government should turn these reserve lands into permanent buffer zones to protect the rivers, streams, canals or creeks found in the Baleh Watershed.
- Enhancing the enforcement of the regulation which states that there should be no human activities within the 8km radius from the water intake, where possible (e.g. in upstream areas).

11.6 Develop eco-tourism

Eco-tourism has also been recognised as an important ecosystem service in the study. The results of the tourist survey indicates high demand for visiting protected areas in Sarawak include the Baleh national park, which represents a unique niche experience for eco-tourism. Due to the remoteness of the area, appropriate planning and marketing efforts are needed to support the eco-tourism to the area. It is proposed to strengthen the existing efforts and initiatives to develop eco-tourism in Kapit (e.g. river safari, ecotourism centre etc) and extend this to Baleh. The activities that tourists indicated strong interest in are forest trekking, viewing wildlife and plants, bird watching and photography. There is also strong interest in cultural events and homestays at longhouses. There are a wide range of opportunities for the local communities to provide these services. The whole value chain can be assessed in terms of developing a marketable and sustainable tourism product to benefit the local communities and the state of Sarawak.

11.7 Tourism green fee

In addition to interest in eco-tourism in the Baleh watershed itself, tourists also place high value on environmental quality in Sarawak and expressed high willingness to pay for clean rivers, conservation of rare and endangered species and for forest conservation. The idea of paying a tourist green fee when visiting Sarawak was widely accepted by surveyed tourists. Tourist green fees, also termed eco-tax or eco-charge, are revenue raising mechanisms that collect payment from tourists for the explicit purpose of environmental protection. In general such mechanisms collect a flat fee from all tourists entering or leaving a country, state or island, and hypothecate the revenue for specific environmental management efforts (e.g. protected area management, pollution clean up, fisheries management etc.). An example of a green fee is Palau's environment fee, which is a US$ 100 charge paid by every tourist and collected by the airlines. The feasibility of alternative mechanisms should be considered for Sarawak and could be an important source of sustainable finance for environmental conservation in the state.

11.8 Payments for ecosystem services (PES)

The sale of carbon credits through REDD+ and charging tourism green fees can be broadly described as payments for ecosystem services (PES). PES is a relatively new policy instrument in resource conservation that establishes a mechanism through which ecosystem service beneficiaries compensate service providers (Kumar and Thiaw, 2013). PES schemes are based on the principle that people located in ecosystems that provide the services (providers) should be compensated for the continuous provision of such services, while the people who benefit (beneficiaries) from ecosystem services should pay for the protection of such ecosystems (Macandog, 2014).

The term "payments for ecosystem services" covers a broad set of mechanisms through which incentives for the provision of ecosystem services are established. In a PES scheme, providers of an ecosystem service (e.g. upstream communities that conserve forests, which in turn control water flow) are incentivized to provide that service through some form of payment or compensation, which may be paid by the beneficiaries of the service (e.g. downstream residents that benefit from lower exposure to flooding). PES schemes attempt to provide incentives for the continued or enhanced provision of services and address the commonly observed problem that markets do not exist for ecosystem services (Wunder, 2007; Engel et al., 2015, Wunder et al. 2018). It is the creation of incentives that is crucially important since the provider of an ecosystem service may otherwise be better off using the ecosystem resource in another way (e.g. the upstream community might convert forest area to oil palm plantation).

The results of our survey of the Sarawak general public shows that they place a high value on cleaner rivers, forest conservation, protection of endangered species and reduced flood risk. As beneficiaries of these ecosystem services, the general public appears to be willing to pay for additional environmental management to safeguard or improve the level of provision. Moreover, the suggestion that water bills could be used as a mechanism through which payments are made for environmental management was widely accepted. General guidance on scoping PES schemes is available (see UNESCAP 2009; Fripp 2014) but an understanding of the applicability of PES in Sarawak requires specific study. We therefore recommend that the potential for PES is further explored through a study of the legal, policy and institutional frameworks necessary for implementing PES in Sarawak. A subsequent step would be to implement pilot PES schemes at a small scale to establish functioning mechanisms that can be scaled up across the Baleh watershed and potentially other areas of Sarawak.

The current framing of payments for ecosystem services is that downstream beneficiaries pay for continued provision or improvements in the services they receive. It may be the case, however, that downstream beneficiaries have seen a degradation in the services they enjoy due to activities upstream (e.g. logging and plantation developments). In this case, there may be an argument in favour of "the polluter pays" and for those activities causing river sedimentation to pay compensation for damage to ecosystem services. The valuation results in this study could be used as a basis for setting such compensation.

Chapter 12. Conclusions

The results of this study show that the natural capital of the Baleh Watershed delivers a wide range of ecosystem services that have a high economic value. Annually, the total economic value of ecosystem services from the Baleh Watershed is over US$ 180 million. This implies a capital asset value of almost US$ 2.8 billion.

The ecosystem services assessed in the study include provisioning services (US$ 2 million/year), carbon sequestration (US$ 87 million/year), sediment regulation (US$ 27 million/year), flood regulation (US$ 12 million/year), and conservation value attached to the preservation of species and forests (US$ 52 million/year).

The people that benefit from these ecosystem services are diverse, including local longhouse communities, downstream residents in the Rajang basin, the general public of Sarawak, and international tourists that visit Sarawak. Although the number of people in the longhouse communities making direct use of the forest is small, their use of forest services constitutes a substantial proportion of their real income and this should not be overlooked in decisions regarding forest management and development.

The results of the scenario analysis reveal that the future value of ecosystem services provided by the Baleh Watershed will vary substantially depending on the development and conservation path that is taken. A path of "Economic Development", comprising conversion of forest to oil palm and timber plantations without sustainable production practices, leads to a loss of ecosystem services worth US$ 136 million annually. This is primarily due to the reduction in stored carbon but there are also significant negative impacts to sediment regulation and species conservation.

Taking an alternative "Green Economy" path, comprising the same extent of oil palm and timber plantation development but with adherence to sustainable production practices, greatly reduces the loss in valuable ecosystem services and even sees improvements in some services, such as sediment regulation, compared with the current situation.

The difference between Economic Development and Green Economy in terms of ecosystem services value is almost US$ 100 million per year, which indicates the potential upside of investing in sustainable economic development. Taking an alternative "Conservation" path, in which conservation is prioritised over development and large areas are given protected status, results is substantial increases in the provision of ecosystem services that are valued at US$ 145 million per year. A large proportion of this is attributed to increased carbon storage but there is also a substantial increase in the value of sediment regulation, which is of particular importance to downstream residents in the Rajang basin. The potential to generate more valuable ecosystem services through conservation provides a strong economic argument for including conservation options in developing planning. The returns on conservation investments are potentially high.

The scenario analysis provides estimates of the economic value of ecosystem services under alternative future development or conservation paths. In other words, it estimates the costs or benefits of each scenario only in terms of changes in ecosystem services. It does not, however, assess all of the costs and benefits associated with each scenario (e.g. infrastructure, transportation, agriculture and timber production) and evaluate the net benefits. As such, the results reported in this study could be

used as input into future economic appraisals (e.g. Cost-Benefit Analysis) of alternative development and conservation spatial plans.

A final point of conclusion from this study relates to the specific tension between development and conservation from the perspective of the longhouse communities. It is evident that both economic development and conservation is important to the welfare of local communities. The results of the survey of households at the longhouses show that there is a strong desire for the development of road access and also for out-migration to larger towns. The challenge is to enable development without destroying the natural capital on which these communities depend; and to stimulate new economic activities (e.g. eco-tourism, carbon credits, land restoration) that have low or positive impact on the Baleh watershed. This is crucial to avoiding depopulation of the Baleh watershed and to ensure that the longhouses continue to exist as functioning communities.

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About WWF-Malaysia
WWF-Malaysia (World Wide Fund for Nature-Malaysia) was established in Malaysia in 1972. It currently runs more than 90 projects, covering a diverse range of environmental conservation and protection work, from saving endangered species such as tigers and turtles, to protecting our highland forests, rivers and seas. The national conservation organisation also undertakes environmental education and advocacy work to achieve its conservation goals. Its mission is to stop the degradation of the earth's natural environment and to build a future in which humans live in harmony with nature, by conserving the nation's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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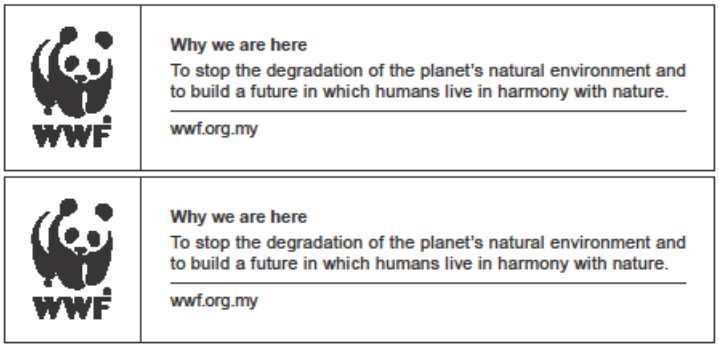

Appendix 1. Correspondence of TEEB, MA and CICES classifications

TEEB	MA	CICES (V4.3)
Food	Food (fodder)	Biomass [Nutrition]
		Biomass (Materials from plants, algae and animals for agricultural use)
Water	Fresh water	Water (for drinking purposes) [Nutrition]
		Water (for non-drinking purposes) [Materials]
Raw Materials	Fibre, timber	Biomass (fibres and other materials from plants, algae and animals for direct use and processing)
Genetic resources	Genetic resources	Biomass (genetic materials from all biota)
Medicinal resources	Biochemicals	Biomass (fibres and other materials from plants, algae and animals for direct use and processing)
Ornamental resources	Ornamental resources	Biomass (fibres and other materials from plants, algae and animals for direct use and processing)
		Biomass based energy sources Mechanical energy (animal based)
Air quality regulation	Air quality regulation	[Mediation of] gaseous/air flows
Waste treatment (water purification)	Water purification and water treatment	Mediation [of waste, toxics and other nuisances] by biota
		Mediation [of waste, toxics and other nuisances] by ecosystems
Regulation of water flows	Water regulation	[Mediation of] liquid flows

TEEB	MA	CICES (V4.3)
Moderation of extreme events		
Erosion prevention	Erosion regulation	[Mediation of] mass flows
Climate regulation	Climate regulation	Atmospheric composition and climate regulation
Maintenance of soil fertility	Soil formation (supporting service)	Soil formation and composition
Pollination	Pollination	Lifecycle maintenance, habitat and gene pool protection
Biological control	Pest regulation	Pest and disease control
	Disease regulation	
Maintenance of life cycles of migratory species (incl. nursery service)	Primary production	Lifecycle maintenance, habitat and gene pool protection
	Nutrient cycling (supporting services)	
		Soil formation and composition
		[Maintenance of] water conditions
Maintenance of genetic diversity (especially in gene pool protection)		Lifecycle maintenance, habitat and gene pool protection
Spiritual experience	Spiritual and religious values	Spiritual and/or emblematic
Aesthetic information	Aesthetic values	Intellectual and representational interactions
Inspiration for culture, art and design	Cultural diversity	Intellectual and representational interactions
		Spiritual and/or emblematic

TEEB	MA	CICES (V4.3)
Recreation and tourism	Recreation and ecotourism	Physical and experiential interactions
Information for cognitive development	Knowledge systems and educational values	Intellectual and representational interactions
		Other cultural outputs (existence, bequest)

Appendix 2. Longhouse questionnaire

LONGHOUSE RESIDENTS QUESTIONNAIRE
Borang pansik penduduk rumah panjai

I. Name interviewer		
II. Date of interview		
III. Location of interview		**HH Number:**
(Start/end time of	**IV. Start:**	**V. End:**

Hello, my name is ……..We are conducting a survey on behalf of WWF-Malaysia regarding the economic importance of the Baleh watershed. Your input is very valuable for this research.There are no right or wrong answers and we only want your honest opinion. The interview will take about 30 minutes. Would you be willing to participate?
Hai, nama aku …… Kami wakil ari WWF-Malaysia deka bejalaika pansik ti bekaul enggau penting ekonomi ba Balleh. Penemu ari kita penting dalam pengawa pansik tu. Nadai saut ti betul tauka salah. kami semina deka nemu penemu enggau runding kita aja. Pengelama pansik tu iya nya 30 minit. Nyadi, ulih nuan enggau pansik tu?

1. What is your name? ……
Sapa nama nuan?……
2. What is your age? ……
Berapa umur nuan? ……
3. [Record gender: M / F]
[Jantina: M/F]

4. Are you originally from this longhouse (i.e. born here)?
Nuan asal ari rumah panjai tu (Nuan ada ba ditu?)

1.	Yes	☐☐(Go to Question 6)
2.	No	☐

5. If not, where are you from? ……
Enti ukai, nuan asal ari ni?

6. How many years have you lived in this longhouse?
Ni pengelama nuan diau ba rumah panjai tu?

1.	0-5 years	☐
2.	>5-10 years	☐
3.	>10-25 years	☐
4.	25 years or more	☐

5.	Whole life	☐

7. How many people are in your household?
Berapa iko kita sebilik?

		Live at longhouse *Diau ba rumah*	Live elsewhere *Diau ba alai*	Specify where *Spesifik, ba dini*
1.	Adults (of working age)			
2.	Adults (retired) *Dewasa (pencen)*			
3.	Children *Nembiak*			

8. What is your total household monthly income (before tax)?
Berapa penyampau penatai pemisi kita sebilik sebulan?(sebedau cukai)?

1.	Less than RM 199	☐
2.	RM200-499	☐
3.	RM500-799	☐
4.	RM800-1,199	☐
5.	RM1,200-1,599	☐
6.	RM1,600-1,999	☐
7.	RM2,000-2,999	☐
8.	RM 3,000-4,999	☐
9.	RM5,000-7,999	☐
10.	RM8,000-9,999	☐
11.	RM10,000 and above	☐
12.	Other, specify	☐
13.	Refused	☐

9. Where does your household income come from? (Estimated percentage of income from each category. If useful, can use codes: 1=Everything, 2=More than half, 3=Approximately half, 4=Less than half, 5=Hardly anything, 6=Nothing)

Ari ni penatai pemisi kita sebilik? (Jangka peratus penyampau penatai pemisi atai ari tiap kategori). Enti ulih,ngena kod: 1=Semua, 2=Lebih ari setengah, 3=Lebih kurang setengah, 4=kurang setengah, 5=Baka ke bisi baka ke nadai, 6=Nadai)

	Income Source ***Sumber Pendapatan***	**%**
1.	Paid employment: Specify ..... *Kereja ke dibayar: spesifik .....*	
2.	Fishing/ *Nginti*	
3.	Farming/ *Betanam*	
4.	Hunting/ *Ngasu tauka begiga jelu*	
5.	Other harvested products/ *Utai bukai ti digumpul/ditanam*	
6.	Handicrafts/ *Kraf tangan*	
7.	Tourist services / *Dagang temuai*	
8.	Remittances from family members *Duit belanja diberi/dikirum bala*	
9.	Government benefits/*Tulung ari perintah*	
10.	Other: Specify ...../*Lain-lain: Nyatakan*	

10. Do you harvest the following resources? If so, please indicate whether these resources are used for own consumption, given to other members of your longhouse, or sold at the market?

[**Record answers using codes:** 1=Everything, 2=More than half, 3=Approximately half, 4=Less than half, 5=Hardly anything, 6=Nothing]

Nuan bisi begiga/begumpul ke asil kampung tu? Enti bisi, ni bagi asil kampung tu ti dipakai/dikena nuan empu, diberi ngagai bala rumah panjai tauka dijual nuan ba pasar? Tulis jawapan ngena kod 1=Semua, 2=Lebih ari setengah, 3=Lebih kurang setengah, 4=kurang setengah, 5=Baka ke bisi baka ke nadai, 6=Nadai)

	Resource *Sumber*	**Harvest (Y/N)** *Tuai*	**How much per week?** *Berapa kali dalam semingguu?*	**Units (kg, bags, etc.)** *unit*	**Own consump-tion(1-6)** *Guna diri empu*	**Gave to others (1-6)** *Beri agai urang bukai*	**Sold at market (1-6**) *jual ba pasar*	**Price /unit** *Rega/ unit*
1.	Fish/*Ikan*							
2.	Wild pigs/*Babi kampung*							
3.	Deer/*Kijang*							

4.	Materials for handicrafts/ *asil kampung ti kena begagaka kraf tangan*							
5.	Fuel wood/ *Kayu api*							
6.	Timber/ *Kayu balak*							
7.	Sago/ *Sagu*							
8.	Wild vegetables/ *sayur kampung/babas*							
9.	Herbs/ *Herba*							
10.	Wild fruit/ *buah kampung*							
11.	Honey/ *Madu*							
12.	Rattan/ *Rotan*							
13.	Other……/ *utai bukai*							

11. Where do you usually get your fresh water?
Dini alai nuan selalu bulih ai?

	Location *Alai*	**How much?** *Berapa mayuh*	**Units (e.g. litres/day)** *Unit*	**Do you treat it? (Y/N)** ***Bisi nuan nyaga iya?***	**If treated, how?** *Enti bisi, bakani?*
1.	Gravity feed/ *Tekat ai bukit*				
2.	Rainwater catchment *Ai ujan*				
3.	River or stream *sungai*				
4.	Other……. *Lain-lain …….*				

12. Is there a Pulau Galau in the longhouse? If yes, what is the size of the Pulau Galau? ……
Bisi Pulau Galau ba ditu?
Enti bisi, berapa pemesai Pulau Galau? ……

13. What is the condition of the Pulau Galau? ……
Nama keadaan Pulau Galau? ……

14. How have the *following* resource abundances changed in the last 10 years?
Bakani pemayuh asil tu bisi berubah dalam 10 tahun ti udah?

Resource *Sumber*		**Decrease** < - - - - - - - - - | - - - - - - - - - > *majak mimit mayuh*			**Increase** *majak*		
		Large decrease	**Some decrease**	**No Change**	**Some increase**	**Large Increase**	**Don't Know**
		1	**2**	**3**	**4**	**5**	**0**
1.	Fish/ *Ikan* (*e.g. empurau, semah, tenggadak, labang, tapah*)	☐	☐	☐	☐	☐	☐
2.	Wild pigs/ *babi kampung*	☐	☐	☐	☐	☐	☐
3.	Deer/*kijang*	☐	☐	☐	☐	☐	☐

4.	Materials for handicrafts/ *asil kampung ti kena begagaka kraf tangan*	☐	☐	☐	☐	☐	☐
5.	Fuel wood/ *kayu api*	☐	☐	☐	☐	☐	☐
6.	Timber/ *kayu balak*	☐	☐	☐	☐	☐	☐
7.	Sago/ *sagu*	☐	☐	☐	☐	☐	☐
8.	Wild vegetables/ sa*yur kampung/babas*	☐	☐	☐	☐	☐	☐
9.	Herbs/ *herba*	☐	☐	☐	☐	☐	☐
10.	Wild fruit/ *buah kampung*	☐	☐	☐	☐	☐	☐
11.	Honey/ *muda*	☐	☐	☐	☐	☐	☐
12.	Rattan/ *rotan*	☐	☐	☐	☐	☐	☐
13.	Other, pl spefcify…….	☐	☐	☐	☐	☐	☐

15. How have the following aspects of the environment changed over the past 10 years?
Bakani aspek rampa menua tu bisi berubah ari 10 tahun ti keterubah?

		Decrease < - - - - - - - - - | - - - - - - - - - > **Increase**					**Don't Know**
		Large decrease	**Some decrease**	**No Change**	**Some increase**	**Large Increase**	
		1	**2**	**3**	**4**	**5**	**0**
1.	Bird abundance *Pemayuh burung*	☐	☐	☐	☐	☐	☐
2.	Frequency of flooding *Penyuah bah*	☐	☐	☐	☐	☐	☐
3.	River sedimentation *Pemendapan sungai*	☐	☐	☐	☐	☐	☐
4.	Farm productivity *Produktiviti betanam*	☐	☐	☐	☐	☐	☐
5.	Freshwater quality *pemeresi ai*	☐	☐	☐	☐	☐	☐

16. Have you experienced **damages** to your home or property from floods within the past 10 years?
Kala rumah nuan tauka reta tengkira nuan jai ketegal banjir dalam kandang 10 taun tu?

1	Yes/ *Iya*	☐
2	No [Go to question 20]/ *Nadai*	☐

17. Please think of a specific significant flood during this time period. In which year did it occur? .....
Uji nuan ngingatka baru pasal bah/banjir ti bisi nyadi ba menua kita ditu, ni bagi taun iya nyadi?

18. What was damaged due to this flood? *Nama utai jai ketegal banjir nya?*

1.	Walls/ *Dinding*	☐
2.	Floor/ *Lantai*	☐
3.	Roof/ *Atap*	☐
4.	Household furniture/ *Perabot rumah*	☐
5.	Household appliances/ *Peralatan rumah*	☐
6.	Car/ *Kerita*	☐
7.	Boat/ *Perau*	☐
8.	Water storage tanks/ *tong kena nyimpan ai*	☐
9.	Crops/ *utai tanam*	☐
10.	Livestock/ *Jelu tupi*	☐
11.	Roads / paths/ *Jalai*	☐
12.	Other ...../*Lain-lain*	☐

19. What was the total cost of the damage of the flood (e.g. to repair the house)? RM .....
Berapa ungkos utai ke jai ketegal bah? (Chunto: ngatur rumah)?

20. How important do you consider the following threats for your community?
Bakani runding nuan pasal ancaman tu ngagai bala kita?

		Not Very Important Important < - - - - - - - - - - - - - - >					**Don't know**
		1	**2**	**3**	**4**	**5**	**0**
1.	Overfishing/ *Mayuh nangkap ikan*	☐	☐	☐	☐	☐	☐
2.	Overhunting/ *Mayuh ngasu/begiga jelu*	☐	☐	☐	☐	☐	☐
3.	Sedimentation of the river/ *Pemendapan*	☐	☐	☐	☐	☐	☐
4.	Loss of biodiversity/ *Lenyau biodiversity*	☐	☐	☐	☐	☐	☐
5.	Sewage / *Kumbahan*	☐	☐	☐	☐	☐	☐
6.	Solid waste (e.g. plastics, glass bottles)/ *Sisa*	☐	☐	☐	☐	☐	☐
7.	Deforestation/ *Nebang kayu*	☐	☐	☐	☐	☐	☐

8.	Invasive species	☐	☐	☐	☐	☐	☐
9.	Climate change/ *Iklim berubah*	☐	☐	☐	☐	☐	☐
10.	Other, pl specify	☐	☐	☐	☐	☐	☐

Choice Experiment

IMPORTANT: FILL VERSION NUMBER!!!

21. Choice Experiment

- Introduction: explain the "attributes" of each choice option. Explain what the images for each "attribute level" mean. You can only pick one option per card. Pick the option that is best for your household. Keep in mind that any income from farming that you give up is money that you cannot spend on other things (e.g. food, transportation, education etc.)

Pengenalan: terangka "atribut" bagi tiap pilihan jawapan. Terangka reti gambar bagi tiap "tahap atribut". Nuan semina ulih ngaga siti pilihan bagi tiap kad. Ambi pilihan ti pemadu manah ngagai bala nuan. Ingat, nama-nama penatai pemisi ari betanam ti diberi ia nya duit ti nuan enda ulih belanja ba utai bukai (utai empa, pengangkutan, pendidikan dll).

- Are there any questions?

bisi utai bukai deka ditanya?

[Record the respondent's answers to each choice question in the table below]

[Catat jawapan responden ba tiap pilihan saut tanya dalam jadual]

<show choice cards here>

Choice Card ***Pilihan kad***	**Option A** ***Pilih A***	**Option B** ***Pilih B***	**Refused** ***Enggai***
1.	☐	☐	☐
2.	☐	☐	☐
3.	☐	☐	☐
4.	☐	☐	☐
5.	☐	☐	☐
6.	☐	☐	☐
7.	☐	☐	☐
8.	☐	☐	☐

22. How certain were you about the choices made?

Berapa pasti nuan enggau pilihan ti udah digaga?

Very Very Certain	**Uncertain**	**Neutral**

< - >

Enda pasti ***Amat pasti***				
1	**2**	**3**	**4**	**5**
☐	☐	☐	☐	☐

23. How did you make your choices?
[*Do not show the list just ask and record response - check only one]*
Bakani nuan milih saut nuan?

1.	Considered all the items at the same time *Ngerunding semua item dalam masa yang sama*	☐
2.	Considered only a few items *Ngerunding sekeda item*	☐
3.	Considered only one item *Ngerunding siti item*	☐
4.	Used intuition *Ngena ati*	☐
5.	Made a random choice *Ngaga pilihan rawak*	☐
6.	Don't know *Enda nemu*	☐
7.	Other, specify	☐

24. In making your choices, how important were the following items to you? Please **rank** with **1 being most important** and **5 being least important**.
*Dalam nuan ngaga pilihan, betapa penting item tu bagi nuan? Uji rank ari **1 pemadu penting enggau 5 kurang penting.***

		Rank
1.	Availability of bush meat and fish for food *jelu enggau ikan bisi ungkup ke pemakai*	
2.	Able to use usual /traditional hunting grounds *Ulih begiga jelungena chara biasa/tradisional*	
3.	Clean water availability for drinking, cooking and washing *ai ti beresi bisi diirup, kena nyumai tauka bebasu*	
4.	Access to road *Akses ke jalai alun*	

5.	Income from agriculture *Pemisi ari betanam*	

25. Statements on community
Kenyataan untuk komuniti

		Strongly Disagree < - - - - - - - - - - - - > **Strongly Agree**					**Don't know**
		1	**2**	**3**	**4**	**5**	**0**
1.	The community is very united *Komuniti besatu*	☐	☐	☐	☐	☐	☐
2.	There are often conflicts in the community *Selalu bisi konflik dalam komuniti*	☐	☐	☐	☐	☐	☐
3.	There are serious conflicts in the community *Serius konflik dalam komuniti*	☐	☐	☐	☐	☐	☐
4.	Members of my family participate in community meetings *Bala ku bisi enggau meeting komuniti*	☐	☐	☐	☐	☐	☐
5.	Members of my family often participate in community activities *Bala ku selalu enggau atur komuniti*	☐	☐	☐	☐	☐	☐
6.	I am confident that in a time of need the community will help me *Aku yakin maya aku pelu, komuniti bisi nulung*	☐	☐	☐	☐	☐	☐
7.	I am more likely to participate to forest restoration activities if other members of the community also participate *Aku deka enggau nyaga kampung enti komuniti lain bisi enggau*	☐	☐	☐	☐	☐	☐

26. Are you interested in developing tourism in your community?
Nuan bisi minat ngatur dagang temuai dalam komuniti?

1.	Yes	☐
2.	No [skip to question 28]	☐

27. If YES, what type of tourist activities would you like to develop?
Enti YA, ngatur dagang temuai deka digaga nuan?

1.	Homestay	☐
2.	Forest trekking *bejalai ba kampung*	☐
3.	Cultural heritage *Warisan adat*	☐
4.	Bird watching *Meda burung*	☐
5.	River rafting *Kayak ba sungai*	☐
6.	Other ….	☐

28. Have you ever considered moving from your longhouse? Perhaps to Kapit town, Sibu or another town. [*If the respondent has already moved from their longhouse, ask questions in past tense]*
Bisi enda nuan kala berunding deka pindah keluar ari rumah panjai? Ke pasar kapit, Sibu tauka endur bukai?

1.	Yes	☐
2.	No [Skip to 31]	☐

29. If YES, where would you move to? ……
Enti YA, kini nuan deka pindah? ……

30. If YES, when would you want to move?
Enti ya, kemaya

1.	Within the next year	☐
2.	1-2 years	☐
3.	2-5 years	☐
4.	5-8 years	☐
5.	8+ years	☐
6.	Other ……	☐

31. If you are considering moving, please can you tell us the reasons why?
[Do not show the list, ask the question and let them respond. Check all that apply]
Enti nuan bisi runding deka pindah, ulih nuan madah nama kebuah?

1] To earn more income *Deka ngiga mayuh agi duit belanja*	☐
2] To get more education *Deka nyambung pelajar*	☐
3] To join family *Nitihka bala*	☐
4] Shortage of resources in the community *Kurang sumber dalam komuniti*	☐
5] Loss of community or culture *Lenyau adat*	☐
6] Other ..... *Utai bukai .....*	☐

Thank respondents for their time!

Appendix 3. General public questionnaire

GENERAL PUBIC QUESTIONNAIRE
17 NOV 2017

I. Name interviewer		
II. Date of interview		
III. Location of interview		**Respondent Number:**
(Start/end time of Interview)	**IV. Start:**	**V. End:**

Introduction
Hello my name is ……. We are conducting a study on behalf of WWF-Malaysia to determine how Sarawakians value the environment, and specifically to measure their interest in conservation of the Baleh watershed. For this we would like to ask a few questions about how you view environmental conservation. There are no right or wrong answers to the questions – we only want to know your honest opinions. Everything that you tell us will be kept strictly confidential.
The interview will take about 20 minutes. Would you be willing to participate?

Pengenalan
Hai, nama saya ialah …….. Kami, mewakili WWF-Malaysia menjalankan kajian untuk mengenalpasti bagaimana masyarakat Sarawak menghargai alam sekitar khususnya mengukur minat mereka dalam memulihara das Baleh. Untuk itu, kami mahu bertanya beberapa soalan tentang pandangan anda terhadap pemuliharaan alam sekitar. Tiada jawapan betul atau salah bagi soalan yang ditanya. Kami cumalah mahukan pendapat yang jujur. Segala pandangan dari pihak anda adalah sulit dan tidak akan didedahkan kepada umum.
Temu bual ini mengambil masa 20 minit. Sanggup kah anda mengambil bahagian?

Part I. Background

1. Where do you live? .....
Di manakah asal/tempat tinggal anda? .....

2. Where did you grow up? .....
Membesar di mana? .....

3. Have you ever visited the Baleh area?/ *Pernahkah anda melawat kawasan Baleh?*

1.	Yes/ *Ya*	□
2.	No [go to question 5] *Tidak [sila jawab soalan 5]*	□

4. If YES, what was the purpose of your visit?/ Jika YA, apakah tujuan lawatan anda?

1.	Work *Urusan kerja*	□
2.	Visiting family or friends *Melawat keluarga atau kawan*	□
3.	Hunting *Memburu*	□
4.	Fishing *Memancing*	□
5.	Tourism *Pelancongan*	□
6.	From Baleh *Dari Baleh*	□
7.	Other, specify: Lain-lain, nyatakan	□

5. If NO, have you/ Jika TIDAK, adakah anda:

1.	Heard of the Baleh watershed? *Mengetahui tentang tempat kawasan tadahan air Baleh?*	YES	NO
2.	Know where the Baleh watershed is? *Mengetahui tentang tempat kawasan tadahan air Baleh?*	YES	NO

Part II: Environmental Awareness/ *Bahagian II: Kesedaran Alam Sekitar*

6. How concerned are you about the following environmental issues in Sarawak? (*1 being not important and 5 being very important*)
Apakah tahap kebimbangan anda terhadap isu-isu alam sekitar di Sarawak? (*1 tidak penting dan 5 menjadi sangat penting)*

		Not important				**Very important**
1.	Lack of green areas in towns/ *Kekurangan kawasan hijau di bandar*	1	2	3	4	5
2.	Air pollution/ *Pencemaran udara*	1	2	3	4	5
3.	Deforestation/ *Penebangan hutan*	1	2	3	4	5
4.	Forest fires/ *Kebakaran hutan*	1	2	3	4	5
5.	Water pollution/ *Pencemaran air*	1	2	3	4	5
6.	Litter and waste/ *Pembuangan sampah*	1	2	3	4	5
7.	Flooding/ *Banjir*	1	2	3	4	5
8.	Loss of biodiversity/ *Kehilangan kepelbagaian-bio*	1	2	3	4	5
9.	River sedimentation/ *Pemendapan sungai*	1	2	3	4	5
10.	Over fishing/ *Terlebihan penangkapan ikan*	1	2	3	4	5
11.	Climate change/ *Perubahan klimaks*	1	2	3	4	5
12.	Other, specify/ Lain-lain, nyatakan_____	1	2	3	4	5

7. Have you donated any money or time towards an environmental cause in the last 12 months; and if yes, how much time/money did you donate?
Pernahkah anda menderma dari segi kewangan atau masa untuk tujuan alam sekitar dalam tempoh 12 bulan yang lalu; jika YA, berapa banyak masa/duit yang anda telah derma?

1.	Yes/*Ya*	□	_____**RM**	_____**Days/hari**
2.	No/*Tidak*	□	If no, go to Q8	

8. Are you in principle willing to pay a small additional fee through your water bill, which would be used to improve the Sarawak environment?
Adakah anda sanggup membayar caj tambahan kecil melalui bil air anda yang akan digunakan untuk memperbaiki persekitaran Sarawak?

1.	Yes/ *Ya*	□
2.	No / *Tidak*	□

<u>Part III: Choice Experiment/ *Bahagian III: Eksperimen Pilihan*</u>
IMPORTANT: FILL VERSION NUMBER!!!

9. Choice Experiment/ *Eksperimen Pilihan*
    - Step 1: Introduction: explain the **"attributes**" of each choice option.
    - Step 2: Explain what the images for each "**attribute level**" mean.
    - Step 3: You can only **pick one option** per card. Pick the option that is **best for your household**.
    - *Step 4: Keep in mind that any income that you give up is **money that you cannot spend on other things (e.g. food, transportation, education etc.)**

    - Step 1: *Pengenalan: terangkan **"atribut"** setiap pilihan jawapan.*
    - Step 2: *Terangkan makna gambar bagi setiap "**tahap atribut**".*
    - Step 3: *Anda hanya boleh **membuat satu pilihan** bagi setiap kad.*
    - Step 4: *Ambil **pilihan yang terbaik untuk isi rumah anda**.*
    - Step 5: *Ingat, apa-apa pendapatan yang **diserahkan ialah duit yang tidak akan anda belanja terhadap benda lain** (makanan, pengangkutan, pendidikan dll).*

    - Are there any questions?/ *Ada sebarang pertanyaan?*

[Record the respondent's answers to each choice question in the table below]
[Catat jawapan responden bagi setiap pilihan soalan dalam jadual di bawah]

<show choice cards here>/ <*Tunjuk pilihan kad-kad di sini*>

Choice Set *Set pilihan*	**Option A** *Pilihan A*	**Option B** *Pilihan B*	**Do Nothing** *Tiada*	**Refused** *Menolak*
1.	□	□	□	□
2.	□	□	□	□
3.	□	□	□	□
4.	□	□	□	□
5.	□	□	□	□
6.	□	□	□	□
7.	□	□	□	□
8.	□	□	□	□

[ONLY ASK THE FOLLOWING QUESTION IF THE RESPONDENT HAS CHOSEN OPTION "**DO NOTHING**" (OPTION 3) EACH TIME OR **REFUSED** TO MAKE A CHOICE, OTHERWISE SKIP TO NEXT QUESTION]

*[HANYA TANYA SOALAN YANG BERKAITAN JIKA RESPONDEN SETIAP KALI TELAH MEMILIH UNTUK "**TIDAK MELAKUKAN APA-APA**" (PILIHAN KE-3) ATAU **MENOLAK** UNTUK MEMBUAT PILIHAN, JIKA TIDAK LANGKAU SOALAN SETERUSNYA]*

10. You have chosen the **'Do Nothing'** in each card or refused to make a choice. Can you explain why?
Anda telah memilih untuk "Tidak melakukan apa-apa" dalam setiap kad atau menolak untuk membuat pilihan. Sila jelaskan kenapa?

1	I am not responsible for damage to the environment *Saya tidak bertanggungjawab terhadap kerosakan alam sekitar*	□
2	I cannot afford to give up any income/ *Saya tidak mampu untuk member pendapatan*	□
3	I do not believe there are serious environmental threats to my livelihood/ *Saya tidak percaya terdapat ancaman alam sekitar yang serius terhadap kehidupan saya*	□
4	I am not confident that any actions we take will be effective *Saya tidak yakin mana-mana tindakan yang diambil anak berkesan*	□
5	The issues are more complex than the choices suggest *Isu-isu lebih kompleks daripada pilihan yang ditawarkan*	□
6	I couldn't understand the questions, they were too hard *Saya tidak dapat memahami soalan-soalan tersebut kerana sangat susah.*	□
7	Other, specify/ *Lain-lain, nyatakan.....................*	□
8	Don't know / refused/ *Tidak tahu /menolak*	□

11. How certain were you about the choices made? Please select the level of certainty on a scale between 1 (very uncertain) and 5 (very certain).
Seberapa pasti anda tentang pilihan yang telah dibuat? Sila pilih tahap kepastian anda antara skala 1 (tidak pasti) dan 5 (sangat pasti).

Very **Very Certain** ***/Sangat pasti*** ***Sangat tidak pasti*** **- - >**	**Uncertain**	**Neutral** < -		
1	**2**	**3**	**4**	**5**
□	□	□	□	□

12. How did you make your choices?
(*Do not show the list just ask and record response - check only one*)
Bagaimana anda membuat pilihan?

(Jangan tunjuk senarai tersebut, tanya dan catat tindak balas – tandakan hanya satu)

1.	Considered all the items at the same time/ *Pertimbangkan semua perkara dalam masa yang sama*	□
2.	Considered only a few items/ *Pertimbangkan hanya beberapa perkara*	□
3.	Considered only one item/ *Pertimbangkan hanya satu perkara*	□
4.	Used intuition/ *Mengunakan gerak hati*	□
5.	Made a random choice/ *Membuat pilihan rawak*	□
6.	Don't know/ *Tidak tahu*	□
7.	Other, specify/ *Lain-lain, nyatakan*	□

13. In making your choices, how important were the following items to you? *(*Please rank with *1 being most important and 5 being least important)*
Dalam membuat pilihan, bertapa pentingnya perkara tersebut untuk anda? (Sila tetapkan dengan tahap 1 yang paling penting dan 5 yang paling tidak penting)

	Importance/Kepentingan	**Rank**
1.	Rare and endangered species (e.g. hornbills, clouded leopards) *Jarang dan terancam spesis (e.g. burung kenyalang, kucing liar)*	
2.	Clean and clear rivers *Sungai bersih dan jernih*	
3.	Frequency and severity of floods *Kekerapan dan keterukan banjir*	
4.	Intact and healthy forests/ *Hutan and utuh dan sihat*	
5.	Increase in monthly water bill *Peningkatan dalam bil air bulanan*	

Part IV: Demographics (*The following questions are for statistical purposes only)*
Bahagian IV: Demografi (*Soalan berkenaan untuk tujuan statistic sahaja)*
14. What is your age?/ *Berapakah umur anda?*

1.	15 – 24	□
2.	25 – 44	□
3.	45 – 64	□
4.	65+	□

15. Gender/*Jantina*

1.	Male/*Lelaki*	□
2.	Female / *Perempuan*	□

16. How many family members in your household? – number of adults and children at home?
Berapakah ahli keluarga dalam isi rumah anda? – bilangan ahli dewasa dan kanak-kanak di rumah?

1.	Adults (of working age)/ *Dewasa (bekerja)*	
2.	Adults (retired)/ *Dewasa (pencen)*	
3.	Children/ *Kanak-kanak*	

17. What is your ethnic background? I consider myself:
Latar belakang ektnik anda? Saya menganggap diri saya:

1.	Iban	□
2.	Bidayuh	□
3.	Melanau	□
4.	Malay/ *Melayu*	□
5.	Other Bumiputera/ *Other Bumiputera*	□
6.	Chinese/ *Cina*	□
7.	Indian/ *India*	□
8.	Other, specify/ *Lain-lain, sila nyatakan*.....	□

18. What is the highest level of education you have completed?
Tahap pendidikan yang tertinggi?

1.	None *Tiada*	□
2.	Primary school *Sekolah rendah*	□
3.	Secondary school *Sekolah menengah rendah*	□
4.	High School *Sekolah menengah atas*	□
5.	Technical/ Vocational/ Diploma/ *Teknik/ Vokasional/ Diploma*	□
6.	University degree *Ijazah Universiti*	□
7.	Don't know/refused *Tidak tahu/Menolak*	□

19. What is your total household monthly income **(before tax)**?
*Berapakah pendapatan bulanan isi rumah anda **(sebelum cukai)**?*

1.	Less than RM 200/ *Kurang dari RM200*	□
2.	RM 200 – 499	□
3.	RM 500 – 799	□
4.	RM 800 - 1,199	□
5.	RM 1,200 - 1,599	□
6.	RM 1,600 - 1,999	□
7.	RM 2,000 - 2,999	□
8.	RM 3,000 - 4,999	□
9.	RM 5,000 – 7,999	□
10.	RM8,000 – RM9,999	□
11.	RM10,000 and above	□
12.	Other, specify/ *Lain-lain, sila nyatakan .....*	□
13.	Refused/ *Menolak*	□

20. In which sector are you employed? **(Check only one)**
Di manakah sector anda bekerja? ***(Tandakan hanya satu)***

1.	Agriculture, forestry and fishing/ *Pertanian, perhutanan dan menangkap ikan*	□
2.	Mining and quarrying/ *Perlombongan dan kuari*	□
3.	Manufacturing/ *Industri Pembuatan*	□
4.	Electricity and gas/ *Electrik dan gas*	□
5.	Water supply, sewage and waste management / *Bekalan air, pengurusan sisa kumbahan*	□
6.	Construction/ *Pembinaan*	□
7.	Wholesale and retail trades/ *Perdagangan borong dan runcit*	□
8.	Transportation / Storage// *Pengangkutan/Penyimpanan*	□
9.	Restaurant / Café// *Restauran / Cafe*	□
10.	Hotel / Accommodation// *Hotel / Penginapan*	□
11.	Information / Communications// Informasi / Komunikasi	□
12.	Banking / Insurance// *Perbankan / Insurans*	□
13.	Real estate services// *Perkhidmatan hartanah*	□
14.	Professional / Scientific / Technical// *Professional/Sains/Teknikal*	□
15.	Public administration/ *Pentadbiran awam*	□

16.	Education/ *Pendidikan*	□
17.	Health / Social work// *Kesihatan/Kerja sosial*	□
18.	Arts / Entertainment / Recreation// *Seni/hiburan/Rekreasi*	□
19.	Housework/*Suri rumah tangga*	□
20.	Retired / Unemployed// *Pencen/Menganggur*	□
21.	Other, specify/ *Lain-lain, sila nyatakan*	□
22.	Refused/ *Menolak*	□

THANK THE RESPONDENT FOR HIS/HER TIME!
PLEASE GIVE THE TOKEN OF APPRECIATION
TERIMA KASIH!

Appendix 4. Tourist questionnaire

TOURIST QUESTIONNAIRE

I. Name interviewer		
II. Date of interview		
III. Location of interview		
IV. Respondent Number		
(Start/end time of Interview)	**V. Start:**	**VI. End:**

Introduction

Hello my name is……. We are conducting a study on behalf of WWF-Malaysia to find out how visitors to Sarawak see the importance of the environment especially related to the Baleh Watershed in the Kapit District.
For this we would like to ask a few questions about your visit here.
There are no right or wrong answers to the questions – we only want to know your honest opinions. Everything that you tell us will be kept strictly confidential.
The interview will take about 15 minutes. Would you be willing to participate?

Part 1. Background

1. Are you a resident of Sarawak?

3.	Yes	□ Thank and end interview
4.	No	□

2. What is the main purpose of your visit?

1.	Tourism	□
2.	Business	□ Thank and end interview
3.	Visiting friends or family	□ Thank and end interview

3. Where do you live?

1.	Peninsular Malaysia	□
2.	Sabah	□
3.	Brunei	□
4.	Europe	□
5.	Australia	□
6.	North America	□
7.	ASEAN country, specify …….	□
8.	China	□
9.	Other, specify …….	□

10.	Refused	□

Part 2. Your visit to Sarawak

4. How many times have you visited Sarawak (including your current visit)?

1.	Once	□
2.	Twice	□
3.	3-5 times	□
4.	6-10 times	□
5.	More than 10 times	□

5. How did you travel to Sarawak for your current visit? (tick more than one if relevant)

1.	Aeroplane	□
2.	Car	□
3.	Bus	□
4.	Other, specify ……	□

6. How many days will you stay in Sarawak?

1. \	2-3 days	□
2.	3-5 days	□
3.	5-7 days	□
4.	1-2 weeks	□
5.	2-4 weeks	□
6.	More than 4 weeks	□

7. How many people are you here with (including yourself)?

1.	Adults	
2.	Children	

8. What activities did you do (or would you consider) during your visit?

1.	Visiting historic and cultural sights	□
2.	Visiting national parks	□
3.	Visiting wildlife refuges	□
4.	Boat trip on the river	□
5.	Beach	□
6.	Bird watching	□
7.	Shopping for handicrafts	□
8.	Other, specify ……	□

9. How much did/will you spend on the following items during your visit (a rough estimation is sufficient)? Please indicate the currency and whether the amount is *per person* or *per household/group.*

		RM	US$	Person/Household
1.	Hotel / guesthouse			
2.	Food and drinks			
3.	Tours			
4.	Transportation			
5.	Shopping			
6.	Other, specify_____			

Part 3: Environmental awareness

10. How concerned are you about the following environmental issues in Sarawak? (*1 being not important and 5 being very important*)

		Not important				Very important
1.	Lack of green areas in towns	1	2	3	4	5
2.	Deforestation					
3.	Air pollution	1	2	3	4	5
4.	Water pollution	1	2	3	4	5
5.	Litter and waste	1	2	3	4	5
6.	Flooding	1	2	3	4	5
7.	Loss of biodiversity	1	2	3	4	5
8.	River sedimentation	1	2	3	4	5
9.	Other, specify	1	2	3	4	5

Part 4. Baleh watershed

11. A National Park has been established in the Baleh watershed. Have you heard about it?

1.	Yes	□
2.	No	□

[Please read out the background information] Baleh National Park

The proposed Baleh National Park is located at the headwaters of the Baleh Water Catchment in the Heart of Borneo and would cover an area of approximately 66,000 hectares. This is a remote forested area next to the border with Indonesia and at least a full day's journey from Sibu. A scientific expedition carried out in 2015 showed that the area is rich with important plant and wildlife diversity including hornbills, Semah fish, sun bears and clouded leopards.

12. Would you be interested in visiting the Baleh National Park?

1.	Yes – on current trip	☐
2.	Yes – on future trip	☐
3.	No [skip to question 15]	☐

13. If YES to question 12: What activities would you be interested in during a visit to the Baleh National Park? (select all that apply)

1.	Forest trekking	☐
2.	Bird watching	☐
3.	Viewing wildlife and plants	☐
4.	Fishing	☐
5.	Photography	☐
6.	River rafting	☐
7.	Cultural events	☐
8.	Homestay in longhouse	☐
9.	Other, specify	☐

14. If YES to questions 12: What is the maximum that you would be willing to pay for a 5 day tour to the Baleh national park (including accommodation, guide, food, water and the activities you indicated)?

Amount	Currency (specify RM, US$ etc.)

15. If NO to 12: What is the reason you are not interested in visiting the Baleh National Park? **[Do not show the list, just ask and record response; check all that apply]**

1.	I don't have time	☐
2.	It is too far away	☐
3.	I am not interested in visiting forests	☐
4.	I do not like to go on tours	☐
5.	It would be uncomfortable	☐
6.	There are better things to see	☐
7.	Other, specify ……	☐

Part 5. Choice experiment

IMPORTANT: FILL VERSION NUMBER!!!

16. Choice Experiment
    - Introduction: explain the "attributes" of each choice option. Explain what the images for each "attribute level" mean. You can only pick one option per card. Pick the option that is best for you. Keep in mind that any money you spend on environmental conservation is money that you cannot spend on other things (e.g. food, transportation, tours etc.)
    - Are there any questions?

[Record the respondent's answers to each choice question in the table below]

<show choice cards here>

Choice Set	Option A	Option B	Do Nothing	Refused
1.	□	□	□	□
2.	□	□	□	□
3.	□	□	□	□
4.	□	□	□	□
5.	□	□	□	□
6.	□	□	□	□
7.	□	□	□	□
8.	□	□	□	□

[ONLY ASK THE FOLLOWING QUESTION IF THE RESPONDENT HAS CHOSEN OPTION "DO NOTHING" (OPTION 3) EACH TIME OR REFUSED TO MAKE A CHOICE, OTHERWISE SKIP TO NEXT QUESTION]

17. You have chosen the 'Do Nothing' in each card or refused to make a choice. Can you explain why?

1..	I am not responsible for damage to the environment	□
2.	I cannot afford to spend money on environmental conservation	□
3.	I do not believe there are serious environmental problems in	□
4.	I am not confident that any actions we take will be effective	□

5.	The issues are more complex than the choices suggest	☐
6.	I couldn't understand the questions, they were too hard	☐
7.	Other, specify …………………	☐
8.	Don't know / refused	☐

18. How certain were you about the choices you made? Please select the level of certainty on a scale between 1 (very uncertain) and 5 (very certain).

Very Very Certain	**Uncertain**	**Neutral**		
< - >				
1	**2**	**3**	**4**	**5**
☐	☐	☐	☐	☐

19. How did you make your choices? **[Do not show the list, just ask and record response; check only one]**

1.	Considered all the items at the same time	☐
2.	Considered only a few items	☐
3.	Considered only one item	☐
4.	Used intuition	☐
5.	Made a random choice	☐
6.	Don't know	☐
7.	Other, specify ……………………	☐

20. In making your choices, how important were the following items to you? *(*Please rank with *1 being most important and 5 being least important)*

		Rank
1.	Rare and endangered species (e.g. hornbills, clouded leopards)	
2.	Intact and healthy forests	
3.	Clean and clear rivers	
4.	Frequency and severity of floods	
5.	Tourist green fee	

Part 6. Demographics *The following questions are for statistical purposes only*

21. What is your age?

1.	15 – 24	□
2.	25 – 44	□
3.	45 – 64	□
4.	65+	□

22. Gender

1.	Male	□
2.	Female	□

23. How many family members in your household? – number of adults and children at home?

1.	Adults (of working age)	
2.	Adults (retired)	
3.	Children	

24. What is the highest level of education you have completed?

1.	None	□
2.	Primary school	□
3.	Secondary school	□
4.	High School	□
5.	Technical/ Vocational/ Diploma	□
6.	University degree	□
7.	Don't know/refused	□

25. Which employment category applies to you?

1.	Employed	□
2.	Self-employed	□
3.	Unemployed/seeking work	□
4.	Student	□
5.	Retired	□
6.	Not working	□

26. Please indicate (approximately) your **monthly household income** (after tax) in USD. We kindly remind that the survey is anonymous.

1.	Less than US$ 400	□
2.	$400 – $600	□
3.	$600 – $800	□
4.	$800 – $1000	□

5.	$1000 – $1500	☐
6.	$1500 – $2000	☐
7.	$2000 – $3000	☐
8.	$4000 – $6000	☐
9.	More than $6000	☐
10.	Other, specify	☐
11.	Refused	☐

THANK THE RESPONDENT FOR HIS/HER TIME!

Appendix 5. Non-spatial parameters used in the ecosystem service models

Seasonal Water Yield

Month	alpha	rainy days
January	0.091	24
February	0.077	22
March	0.085	23
April	0.091	21
May	0.085	22
June	0.064	15
July	0.059	18
August	0.071	19
September	0.085	21
October	0.098	24
November	0.097	27
December	0.096	26

Land use type	CN_A	CN_B	CN_C	CN_D	Kc_1	Kc_2	Kc_3	Kc_4	Kc_5	Kc_6	Kc_7	Kc_8	Kc_9	Kc_10	Kc_11	Kc_12
Cropland, rainfed	45	66	77	83	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Herbaceous cover	43	65	76	82	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Tree or shrub cover	43	65	76	82	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Cropland, irrigated or post-flooding	60	72	80	84	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	43	65	76	82	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	36	60	73	79	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Tree cover, broadleaved, evergreen, closed to open (>15%)	36	60	73	79	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sparse vegetation (tree, shrub,	30	58	72	80	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

herbaceous cover) (<15%)																
Tree cover aquatic or regularly flooded in fresh or brakish water	50	50	50	50	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Tree cover aquatic or regularly flooded in salt or brakish water, Mangroves	50	50	50	50	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Urban areas	68	79	86	89	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water bodies	50	50	50	50	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Existing and Proposed TPA	36	60	73	79	1	1	1	1	1	1	1	1	1	1	1	1
Baleh dam innundation (WWF)	50	50	50	50	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
WWF Priority Conservation Areas	36	60	73	79	1	1	1	1	1	1	1	1	1	1	1	1
IWRM Off-take 8km buffers	36	60	73	79	1	1	1	1	1	1	1	1	1	1	1	1
Oil palm (Current, S1)	30	58	72	80	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Licenced planted forest (Current, S1)	36	60	73	79	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Oil palm (S2, S3)	30	58	72	80	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Licenced planted forest (S2, S3)	36	60	73	79	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95

Sediment Delivery Ratio

Land use type	C Factor	P factor
Cropland, rainfed	0.5	0.4
Herbaceous cover	0.02	0.25
Tree or shrub cover	0.01	0.2
Cropland, irrigated or post-flooding	0.5	0.4
Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	0.3	0.4
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	0.3	0.4
Tree cover, broadleaved, evergreen, closed to open (>15%)	0.1	0.3
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	0.01	0.4
Tree cover aquatic or regularly flooded in fresh or brakish water	0.001	1.0
Tree cover aquatic or regularly flooded in salt or brakish water, Mangroves	0.001	1.0
Urban areas	0.001	1.0
Water bodies	0.001	1.0
Existing and Proposed TPA	0.003	0.2
Baleh dam inundation	0.001	1.0
IWRM Off-take 8km buffers	0.003	0.2
Oil palm (Current, S1)	0.3	0.4
Licensed planted forest (Current, S1)	0.2	0.3
Oil Palm (S2, S3)	0.15	0.4
Licensed planted forest (S2, S3)	0.1	0.3

Carbon sequestration

Land use type	Aboveground carbon (t/ha)	Soil carbon (t/ha)
Cropland, rainfed	55	215
Herbaceous cover	87	192
Tree or shrub cover	99	166
Cropland, irrigated or post-flooding	42	241
Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	66	228
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	80	236
Tree cover, broadleaved, evergreen, closed to open (>15%)	136	167
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	133	174
Tree cover aquatic or regularly flooded in fresh or brackish water	127	195
Tree cover aquatic or regularly flooded in salt or brackish water, Mangroves	68	267
Urban areas	0	291
Water bodies	0	235
Oil palm (Current, S1)	100	217
Licensed planted forest (Current, S1)	148	154
Oil palm (S2, S3)	120	217
Licensed planted forest (S2, S3)	158	154
Baleh dam inundation (WWF)	0	160
Existing and proposed TPA	158	168
WWF Priority Conservation Areas	158	168
IWRM Off-take 8km buffers	158	168

Biodiversity habitat

Land use type	Current	S1	S2	S3
Cropland, rainfed	0.1	0.1	0.1	0.1
Herbaceous cover	1	1	1	1
Tree or shrub cover	1	1	1	1
Cropland, irrigated or post-flooding	0.1	0.1	0.1	0.1
Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	0.33	0.33	0.33	0.33
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	0.66	0.66	0.66	0.66
Tree cover, broadleaved, evergreen, closed to open (>15%)	1	1	1	1
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	1	1	1	1
Tree cover aquatic or regularly flooded in fresh or brackish water	1	1	1	1
Tree cover aquatic or regularly flooded in salt or brackish water, Mangroves	1	1	1	1
Urban areas	0.1	0.1	0.1	0.1
Water bodies	0	0	0	0
Oil palm	0.2	0.2	0.66	0.66
Licensed planted forest	0.5	0.5	0.66	0.66
TPA	1	1	1	1
Baleh dam inundation	0	0	0	0
IWRM 8km offtake buffers	1	1	1	1
WWF Priority Conservation Areas	1	1	1	1