

SRJS Scoping Report

An initial assessment of economic valuation and ecosystem services in
Aceh, Chaco-Pantanal, Guianas and Zambezi

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This report is a final draft scoping report produced for WWF. The report contains a preliminary rapid literature assessment and is not a comprehensive index of all published and unpublished literature. The draft is a first look and we apologize if we have missed any data or reports. Any errors or inconsistencies are our own



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1 Introduction

1.1 Background

Over the years protecting ecosystem services has been promoted as a way to mainstream nature conservation (Daily *et al.*, 2009). The core idea of ecosystem services is that when we show the value of nature, this results in incentives to invest in nature and support conservation. Daily *et al.* (2009) proposed a framework that connects the science of quantifying services with valuation and policy work to devise payment schemes and management actions. The framework is presented in Figure 1. The framework is a loop, but we start at ecosystems, and biophysical sciences are the tool used to translate ecosystems into services. Social sciences, thereafter, are central to communicating the value of ecosystems and their services (Daily *et al.*, 2009). This value can clarify the impact of different decisions by revealing hidden values, externalities and long-term costs and benefits. Consequently, the value can provide useful information that can help in designing institutions concerning environmental management (Daily *et al.*, 2009). These institutions in turn provide incentives that enable decisions, which culminate in actions that impact ecosystems. Keep in mind, it is important that values are embedded in information provided to institutions, otherwise information may increase awareness but fail to change behaviours. The links between values, institutions and decisions represent the art and politics of social change, and can be informed by scientists when focused on specific topics (Daily *et al.*, 2009).

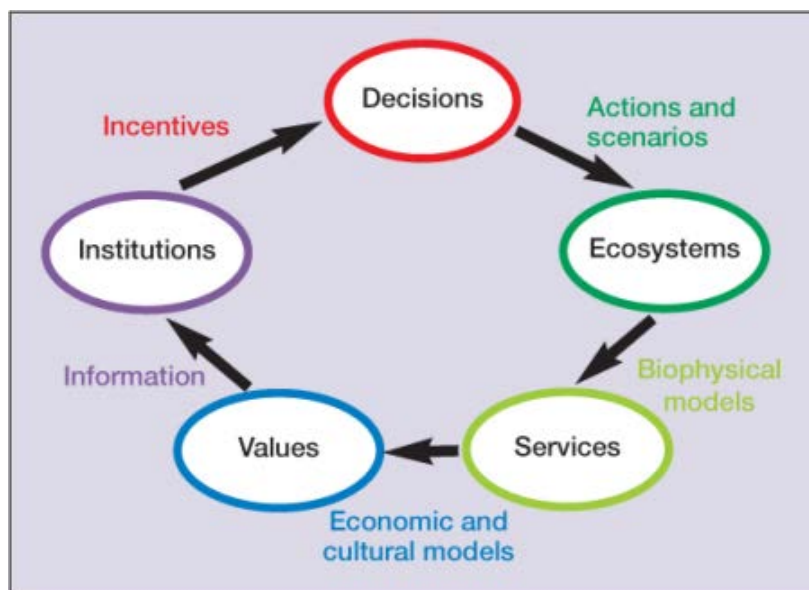


Figure 1 The science policy loop (Daily *et al.*, 2009)

In practice, reporting ecosystem services and values does not automatically result in social change. There is no magic recipe for initiating effective change, but there are factors that contribute to closing the science policy gap (seen in the Daily loop as the chain between values and institutions). To effectively inform management decisions, information should be salient, credible and legitimate (Cash *et al.*, 2003; Cook *et al.*, 2013). Saliency refers to the relevance of information to the needs of decision makers and the timing of information provision (Cash *et al.*, 2003; Cook *et al.*, 2013). This

means that the research should ask and answer the right question at the right time. Credibility means that the information is authoritative, believable and trusted, which is the result of scientific adequacy of the evidence and use of appropriate methodology (Cook *et al.*, 2013; Cash *et al.*, 2003). Legitimacy is obtained by collecting information through a process that is respectful of all involved stakeholders and their values, perspectives and beliefs (Cook *et al.*, 2013; Cash *et al.*, 2003). Integrative and participatory research is considered legitimate as it increases fairness and allows for the involvement of all stakeholders in order to fit the socio-political situation for a specific region.

1.2 Objectives

The Shared Resources, Joint Solutions (SRJS) initiative by WWF-NL is a partnership programme intending to build capacity and safeguard ecosystem services in nine global eco-regions. For this scoping report, we are focusing on four of those regions: Aceh, Guianas, Chaco-Pantanal and Zambezi in order to assess the role of scientific data, namely ecosystem service research, in influencing policy. For each region we aim to scan the literature to see what research has been done and explore what types of policies are already in place. The research is focusing on assessing relevant scientific data, and therefore did not focus on background descriptive articles nor purely qualitative studies. We will identify key ecosystem services of economic importance and gaps in the literature. Following, we explore and identify ideas for future research and how that could be used as lobby and advocacy material relevant for the area. Appendix A introduces a framework that describes how this scoping report can be used when deciding on next steps within the SRJS project. The framework clarifies the steps necessary for gathering information, conducting research and influencing policy in the SRJS context.

1.3 Methods

The primary method we use is literature research. We searched for scientific articles, reports and other types of documents on relevant topics for each region. While doing so, we created a database in which we report the following: authors, year of publication and research, organizations involved, use of primary and secondary research, use of economic valuation, exact methods used, discussion and quantification/valuation of each ecosystem service and to what sectors and goals the document might be applicable. This gives us insights into the gaps in the literature as well as in the saliency, credibility and legitimacy of each document.

In addition to literature research we have conducted interviews. The goal of the interviews was to get expert advice on the background, policy context, as well as the information needs and targets of the SRJS project per region.

1.4 Structure

The report will discuss each case study starting with Aceh in Chapter 2, then Chaco-Pantanal in Chapter 3, Guianas in Chapter 4 and finally Chapter 5, Zambezi. For each case study site, we will first discuss the focus of our research, present the inventory matrix and provide a deeper analysis of the inventory matrix. Afterwards we will shortly summarize the interviews. This will lead us to some overall lessons learned for each site and finally some recommendations for future research on the topic of ecosystem services and economic valuation. After discussing the case study sites, we will provide an overall conclusion in Chapter 6 to assess general research gaps.

2 Aceh

5 main takeaways

- High dependency on one study
- Missing data on cultural and several regulating services
- Importance of credibility and legitimacy
- Need more recent primary data
- Involve local population

2.1 Inventory matrix for Aceh

The focus of the literature search for Aceh has been on studies concerning ecosystem services related to degrading watersheds, illegal logging, land conversion of forest to timber and palm oil plantations, unsustainable forest management, human-wildlife conflicts and threatened biodiversity. During our search, we came across multiple news articles on the new spatial plan for Aceh, which will open up the nationally protected Leuser ecosystem to roads, mining, palm oil and timber concessions. Local citizens filed a lawsuit but so far the plan has been allowed to continue. This conflicted situation summarizes the threats to the forests of Aceh.

For the SRJS area in Aceh, the so-called PJT area (Pasee Peusanang, Jambo Aye and Tamiang Langsa), we have composed the inventory matrix on the next page, which summarizes the results of our literature research. Since the area in question is relatively small, but comparable to adjacent areas and Indonesian islands, we have also included a couple of studies that have been conducted in the surrounding area. This generates an overall perspective of what is going on in the region. The second column of the matrix mentions the authors and year of publication, the third column the exact location, the fourth column indicates if the study included some form of economic valuation – which can be direct market valuation, a willingness-to-pay (WTP) study, but also benefit transfer. The other columns show if a study discussed (“•”) or quantified/valued (“X”) the ecosystem service in question. We included ecosystem services that are relevant to Aceh and/or are mentioned in one or more studies.

The data presented in the table is collected and published between the year 2000 and now. The most commonly used research method in Aceh is literature research. Different universities, WWF, Fauna & Flora International (FFI), as well as other organizations have been active in the area.

2.2 Analysing the inventory matrix

2.2.1 Economic valuation

The matrix shows that quite some studies have included economic valuation. Some of these studies have been conducted outside of the SRJS area, such as in Sulawesi, Java and Kalimantan. Butler *et al.* (2008) value carbon, timber and palm oil in Sumatra using secondary research methods. The master thesis project of Amin (2014) has been conducted in the Krueng Peusangang Watershed and the study of Suharti *et al.* (2014) focuses on the mangrove area in Kota Langsa, both used primary research methods.

	Author(s)	Location	Economic valuation	Provisioning Services							Regulating Services							Supporting services	Cultural Services								
				Water	Agriculture	Palm oil	Fish	Timber	NTFP	Minerals	Carbon	Water	Landslide	Flood prevention		Erosion control	Fire prevention		Pollination	Biological control	Habitat/biodiversity	(Eco-) tourism	Education	Spiritual	Recreation	Existence	Bequest
														River	Ocean												
1	Anderson 2008	General	No			.					X	.		.					.								
2	Kasim <i>et al.</i> 2015	Sulawesi, Baubau wonco	Yes	X	.					.	.								.	.		.
3	Cochard 2017	Aceh	Yes	X	X		X	X	X		X			X					X	X							
4	Sitompul <i>et al.</i> 2011	Aceh	No																X								
5	Satriawan <i>et al.</i> 2014	Aceh	No								.		.		.												
6	Kadir 2014	Aceh, Krueng Aceh Watershed	Yes	The report in Indonesian, so besides the abstract we have not been able to read the report.																							
7	Nuva <i>et al.</i> 2009	West Java	Yes																	X							
8	Foster <i>et al.</i> 2011	South east asia	No			.													X								
9	Muis <i>et al.</i> 2016	Aceh, Krueng Aceh Watershed	No	X								X															
10	Aswandi <i>et al.</i> 2015	Aceh, Trumon and Singkil	Yes		X	X	X	X	X		X	X		.						X							
11	Legget <i>et al.</i> 2016	Aceh	Yes		X	X								X													
12	Butler <i>et al.</i> 2008	Sumatra	Yes			X		X			X																
13	Sandker <i>et al.</i> 2007	Malinau, East-Kalimantan	Yes		X			X	X	X																	
14	Cattau 2010	Borneo	No							X										X							
15	Nasution <i>et al.</i> 2013	Aceh, Krueng Peusangang watershed	No								.																
16	Wich <i>et al.</i> 2011	Sumatra	Yes					X		X	X		X			X			X								
17	Amin 2014	Aceh, Krueng Peusangang watershed	Yes	.							X		X			.											
18	Beukering <i>et al.</i> 2014	General palm oil	Yes	X	X	X	X		X		X		X			X			X								
19	Khasanah <i>et al.</i> 2010	Aceh, Krueng Peusangang watershed	No	.							X		.			.											
20	Fitri 2013	Aceh, Krueng Simpo	No													.				.							
21	Linkie <i>et al.</i> 2016	Aceh, Singkil	Yes	X	X		X	X	X		X		X			X			X			X		X			
22	Kasia <i>et al.</i> 2011	Aceh, Ulu Masen	No					X		X																	
23	Ardiansyah 2006	Indonesia	Yes		.														.								
24	Beukering <i>et al.</i> 2003	Sumatra, Leuser national park	Yes	X	X	.	X	X	X		X		X		.	X	.	.	X		X		X				
25	Beukering <i>et al.</i> 2009	Aceh	Yes	X	X	X	X	X	X		X		X			X			X		X		X				
26	Kanangaratnam <i>et al.</i> 2006	Aceh (west coast and island)	Yes			.	X	X																			
27	Suharti <i>et al.</i> 2014	Aceh, Kota Langsa	Yes	Unfortunately, we could only find the abstract of this article. It could be that the study is similar to Suharti <i>et al.</i> (2015)																							
28	Suharti <i>et al.</i> 2015	South Sulawesi, East Sinjai	Yes				X	X	X		X														X	X	

The study of Amin (2014) focused on water regulation and flooding. We are unsure about the focus of Suharti *et al.* (2014) since we were only able to find the abstract, but it could be comparable to Suharti *et al.* (2015) in Sulawesi.

The other economic valuation studies for the SRJS area (van Beukering *et al.*, 2009; Wich *et al.*, 2011; van Beukering *et al.*, 2014; Legget *et al.*, 2016; Linkie *et al.*, 2016; Cochard, 2017) use only or mostly the economic values generated by van Beukering *et al.* (2003). Services quantified and valued in this study are water availability, agriculture, fish, timber, non-timber forest products (NTFP), carbon sequestration, flood prevention around the river, fire prevention, biodiversity and eco-tourism. The study analyses three different scenarios: conservation, selective use and deforestation. Data collection for this study took place in 2000 and consists of a mix of primary and secondary data. For example, the values for tourism are the result of a tourist survey while the values for biodiversity come partially from literature and partially from the same tourist survey. No data has been obtained on household level for this study.

2.2.2 Provisioning services

The inventory matrix shows that all provisioning services are represented in the literature, with timber being the most common service. However, the studies for Aceh and the SRJS area are mostly based on the data from van Beukering *et al.* (2003). Van Beukering *et al.* (2003) used data from local organizations, field surveys and literature to quantify and value the services. This means that for the SRJS area there is no recent data available on water use, water availability, agricultural yields and revenues, fish catch, NTFP and mineral mining.

2.2.3 Regulating services

For the regulating services, data is missing on pollination, prevention of landslides and biological control, while data on erosion control is limited. All the information that is available on fire prevention is based on van Beukering *et al.* (2003), as is most of the data on flood prevention from the river. The only information on flood prevention from the ocean could be in the study of Suharti *et al.* (2014), and for the west coast of Aceh there is information available related to the tsunami. Carbon sequestration as well as water regulation are better represented in the literature.

Specifically for the SRJS area, recent data is available on costs of river floods and WTP for changes in water quality from Amin (2014). Khasanah *et al.* (2010) describes the changes in water regulation. Both concern the Krueng Peusangan watershed. No data has been found for the other two watersheds.

2.2.4 Habitat and biodiversity

Aceh is home to many iconic species, and multiple studies discuss the biodiversity in the region. Some of these studies quantify biodiversity by reporting the number of elephants or orangutans in specific areas. One study mentions the costs of the human-wildlife conflict in Riau (Ardiansyah, 2006), the other studies that valued biodiversity used the data from van Beukering *et al.* (2003). This also means that biodiversity has only been valued once, in spite of the fact that Aceh is a biodiversity hotspot.

2.2.5 Cultural services

Cultural ecosystem services seem to be the most understudied services in Aceh. The only known quantities and values are for eco-tourism from van Beukering *et al.* (2003)

and are again widely used in other studies. However, due to the increased stability and extraordinary biodiversity in the region, it can be expected that eco-tourism has increased in Aceh since 2000.

2.2.6 Summary of inventory matrix analysis

IPG	Key Ecosystem Service(s)	Status in literature
Water provisioning	Water provisioning	One study available, relatively older
	Water regulation	Two studies available for Krueang Peusangan watershed
	Erosion control	Understudied
Food security	Non-timber forest products	One study available, relatively older
	Agriculture	One study available, relatively older
	Fish	One study available, relatively older
	Pollination	Understudied
	Biological control	Understudied
Climate resilience	Coastal protection	Understudied
	Carbon sequestration	Multiple studies available
	Flood prevention	Two studies available for river flooding, of which one is relatively older
	Habitat / biodiversity	One study available, relatively older

The IPG of food security is understudied in Aceh. There are no studies available on pollination and biological control and the data available on the other services is relatively older. For the IPG water provisioning, there are two studies available for one of the three watersheds, but other data is missing. Carbon sequestration is studied more often in relation to climate resilience, but the other services related to this IPG are relatively understudied. For this summary we only included the key ecosystem services per IPG, which means that some indirect relevant services are left out, such as prevention of landslides or fire prevention. Another issue is that cultural services are not included, while they are heavily understudied and could serve as an important argument for SRJS goals.

2.3 Summary of interview with Hans Beukeboom

The overall level of deforestation in Aceh is limited, although there are issues with illegal logging. Other things on the current agenda are reductions in sand and gravel extraction in rivers to prevent degradation of watersheds, a biodiversity corridor, a solution for the human-wildlife conflicts with elephants and certification of palm oil plantations.

There are quite a few policies in place already, but implementation and enforcement is lacking. For example, sand and gravel extraction is regulated on paper and there is a logging moratorium in place. There are also some PES schemes in place, but these are small scale and solely based on corporate social responsibility (CSR). For palm oil, none of the plantations are certified at the moment.

It seems like studies on ecosystem services end up with policy makers and stimulate good intentions. However, Hans feels that it might be necessary to offer the policy makers more concrete tools. It might also be necessary that companies demand enforcement of laws that otherwise would impose costs on them, such as laws related to the watershed a company depends upon. Involving palm oil companies in biodiversity and ecosystem services would also be an opportunity, as is improving environmental assessments.

Takeaways from the interview

- Lack of implementation and enforcement of policies
- Focus on biodiversity, watersheds, human-wildlife conflicts and palm oil certification
- Develop concrete tools
- Involve companies

2.4 Lessons learned for Aceh

The study of van Beukering *et al.* (2003) is frequently cited over the years, indicating an interest for valuation studies. This study used primary next to secondary research methods and included perspectives from all stakeholders, increasing credibility and legitimacy of the study. It also seems that this study has influenced policy makers in Aceh, which is confirmed by a document released by TEEB (Forster and Berghofer, 2010). Namely, on behalf of the government the private companies Carbon Conservation Pty Ltd and FFI secured funding for forest conservation in the Ulu Masen Ecosystem for REDD. Next to that the former governor of Aceh, Irwandi Yusuf, also requested a similar study for all of Aceh's forests to aid the initiation of Aceh Green. Suyanto *et al.* (2005) mention that strong intermediaries and WTP studies have often stimulated the emergence of ecosystem service markets in Indonesia. A statement found online from Tri Agung (WWF-Indonesia) confirms this; the statement discusses how economic valuation played an important role in shifting policy away from logging the Rinjani forest (Lombok) towards the provision of ecosystem services. The valuation allowed for the identification of groups who would be willing to pay towards watershed protection, supported the design of mechanisms for increased income channelled into forest restoration, as well as the provision of alternative livelihoods for local communities (Tri Agung, unknown). WTP studies have also been conducted in Sulawesi and Java (Suharti *et al.*, 2015; Kasim *et al.*, 2015; Nuva *et al.*, 2009).

Since the study of van Beukering *et al.* in 2003, only a limited amount of new data has been generated for the area. There is also data missing on multiple ecosystem services and their value, such as pollination, prevention of landslides, biological control and cultural ecosystem services. This reduces the overall saliency and credibility of the data available. Besides that, there also has not been a study that reflects the perspective of local communities, their ecosystem service use and the cultural values they attach to their surrounding environment. This type of information could potentially be used to avoid land conversion or unsustainable management by revealing the value the land currently has and the effects on that value of different land use decisions. At the same time, for issues related to watershed degradation, this information could reveal who should be compensated, how and how much they should be compensated, and what people are willing to do or pay in return. Including local communities' perspectives could also reveal some of the costs and benefits of human-wildlife conflicts and biodiversity corridors. Due to the lack of information on local

perspectives, resulting in low legitimacy, decisions that are currently made may fail to accurately reflect local population needs and disempower them. Looking at the study of van Beukering *et al.* (2003) and its influence, it could be that showing the long-term benefits and costs influences the decision makers to make more environmental decisions, and that high legitimacy increases the influence of a study.

2.5 Recommendations for future research in Aceh

Looking at the current and future threats as well as the literature that is already available, some recommendations can be made on future research in the field of ecosystem services and economic valuation in Aceh. One recommendation would be an update of the study conducted by van Beukering *et al.* in 2003, covering all of Aceh. There is a clear interest in such a study, it is currently the leading piece of science on the region, and it has had influence on policy makers. However, it is likely that things have changed since the year 2000. For example, the value of eco-tourism is likely to have increased while values of water availability and carbon sequestration might have decreased due to logging activities. In other words, it is seen as a credible and legitimate study but currently lacks saliency due to the date of publication.

Another recommendation relates to the perspectives of the local people that have been left out so far. To include their perspectives, it is recommended to conduct household surveys in different ecosystem service dependent communities with varying characteristics. These could be communities living in sub ecosystems, practicing different livelihoods, under diverse threats, and so on. These surveys can measure and value their ecosystem service use, including cultural services, as well as to explore future policies by asking for their preferences and WTP. These studies could potentially serve as a strong message in favour of the local communities, based on primary data, and therefore legitimate and credible in a way that seems to match the context of Aceh.

Combining an update of the study by van Beukering *et al.* (2003) for all of Aceh with some detailed studies on the local level could be used by the CSOs to stimulate implementation and enforcement of policies on provincial level, voice the interests of local populations, test and design local policies, and eventually involve companies.

2.6 Overview of main ideas for Aceh

SRJS research recommendation	Rationale	Policy context
Update of the study of van Beukering <i>et al.</i> (2003) for all of Aceh	Currently implementation and enforcement of regional policies is lacking. Previously, the study of van Beukering <i>et al.</i> (2003) has influenced policy makers to develop sustainable plans and until today it is the leading piece of science for the region. However, data collection took place in 2000 and it is likely that things have changed since then. For example, eco-tourism might have increased due to the increased stability and extraordinary biodiversity in the region, while water services could have decreased due to logging. An update could be a valuable tool for the SRJS project and many more years to come.	Updating the study would increase saliency and show the current value of all the ecosystems. The study will also reveal long-term costs and benefits of different management decisions, such as sustainable management and deforestation, and how different stakeholders are impacted by each decision. This information could be used by CSOs to lobby for enforcement of forest protection and so reduce illegal logging; enforcement of regulations on sand and gravel extraction and so protect watersheds; and serve as motivation to protect biodiversity. Since a similar study has been conducted before, comparing both results will also show the impact of past policies. The study could also motivate companies to get involved by revealing the impact on ecosystem services they depend upon.
Local valuation studies in different communities	The results indicate that credibility and legitimacy play an important role in context of Aceh. Currently there is no primary data available on household level, while this could be a powerful tool due to high credibility and legitimacy. These studies could reveal the current use, value and importance of ecosystems for people's livelihoods. This information can be used to measure the impacts of different local decisions and to design future policies. At the same time, these local studies add to the overall study by providing more insights on the household level and for specific areas.	Information on ecosystem service use, including cultural services, by local communities could serve as an argument for forest protection while also empowering the local population. In communities where human-wildlife conflicts exist, information could be gathered on the current costs and future benefits of eradicating the conflict. The survey could also include willingness-to-pay and preference questions which can be used to test and design local policies, such as PES schemes, that are in line with local interests. These results could in turn be used to involve companies in issues related to ecosystem services.

3 Chaco-Pantanal

5 main takeaways

- Lack of data from Paraguay and Bolivia
- Involvement of populations to tap into local pride
- Focus on sustainable use and value of natural systems
- Increase legitimacy
- Need for more recent primary data

3.1 Inventory matrix for Chaco-Pantanal

The Gran Chaco and Pantanal region in South America is a large eco-region that faces a variety of environmental pressures. The SRJS project is focusing on two countries within the region, Paraguay and Bolivia, however the ecosystem expands beyond country borders. The Gran Chaco is a dry forest that spans Bolivia, Paraguay and Argentina and the Pantanal, the largest wetland in the world, is mainly located in Brazil though it extends into Bolivia and Paraguay as well. The biome is affected by deforestation and conversion to croplands, namely soy, as well as grazing pasture. The Pantanal, as a wetland, is further suffering from erosion, hydropower dams and biodiversity reduction. Both the Pantanal and Gran Chaco are facing threats of climate change and increasing development within the region.

Although the two ecosystems are functionally unique, one being a desert while the other a wetland, they are linked ecologically, politically and socially via shared hydrology, national borders, conservation and development initiatives (Viglizzo & Frank, 2006). The inventory matrix below gives an overview of literature and research that has been conducted in the Chaco-Pantanal region, though many studies were not undertaken in the SRJS sites. These studies were necessary to include due to the limited amount of ecosystem service research that has been conducted in Bolivia and Paraguay.

The main organizations active in the area include WWF, Conservation International and local non-profits Fundacion Naturaa and Asociacion Guyra. Funding for scientific research has been found to come from national universities in Brazil and Argentina, as well as from international organizations such as WWF and government associated programmes like the US National Science Foundation.

3.2 Analysing the inventory matrix

3.2.1 Economic valuation

As seen in the inventory matrix, there are limited economic valuation studies for ecosystem services in the Chaco-Pantanal region. The most frequently cited Pantanal study was conducted by Seidl and Moraes in 2000, which valued a specific area in the Brazilian Pantanal using value transfer formulas from Costanza *et al.* (1997) and satellite data. The values from this study have been used in other valuation studies, such as the more recent 2009 application for the entire Pantanal region by Morae *et al.* (2009).

However, this study was a literature analysis and did not involve any primary research. Shrestha *et al.* (2002) conducted primary research to value recreational fishing in Brazilian Pantanal, but the data they used was gathered in 1994. There is evidently a lack of current economic valuations in the Pantanal, and none were found to be conducted in Paraguay or Bolivia.

The Chaco region of Argentina has been studied numerous times in order to assess the changes that occur during land conversion from dry forest to cropland or cattle pastures (Killeen *et al.*, 2007; Lambin *et al.*, 2013; Mastrangelo and Littera, 2015; Viglizzo and Frank, 2006; Volante, 2012; Baldi *et al.* 2015). Less research exists on land conversion in the Pantanal, which is heavily driven by agribusiness (Viglizzo and Frank, 2006; Palacios Nieto, 2016). These land conversion studies provide quantification or value the inherent trade-offs that exist in land use change, and describe differences in ecosystem services provided. Studies of this type are useful to decision makers as they show the potential impact of development scenarios, but they do not provide the full economic value of ecosystem services. There have been some interesting studies highlighting the benefits of sustainable agribusiness, for example rotational or intermediate-intensity cattle permits native foliage to regrow, or promoting hyacinth harvesting for biomass (Mastrangelo and Littera, 2015; Bergier *et al.*, 2012).

Caceres *et al.* (2015) published an innovative stakeholder analysis of ecosystem services for the Argentinian Gran Chaco region, including provisioning services. The researchers conducted interviews and focus groups with stakeholders to determine which ecosystem services were considered valuable, and which they depended upon. The study refrained from providing an economic valuation, but nevertheless could show policy makers what the local populations valued in terms of conservation and threats. Besides this qualitative study, there have been no valuation studies in the region using localized survey data to quantify services from the perspective of local populations and ecosystem users.

3.2.2 Provisioning services

The most commonly studied and discussed provisioning services in the Chaco-Pantanal are commercialized activities such as agriculture and livestock. These activities often involve deforestation to clear the land which could otherwise be providing timber and other non-timber forest products. The Pantanal is an important water source for the extensive agriculture in the region, and also supports fisheries for both recreation and food source for local populations (Seidl and Moraes, 2000; Morae *et al.*, 2009; Palacios Nieto 2016).

The research gaps that exist are studies in the country contexts of Paraguay and Bolivia, as mentioned earlier, most research was conducted in Brazil and Argentina, and in order to fully understand local stakeholders and policies, national studies should be conducted in the SRJS locations. Additionally, most values of resources are taken directly from the Seidl and Moraes (2000) study, and taking into account the amount of land conversion over the past 16 years, it is likely that these values are less applicable to present situations.

3.2.3 Regulating services

The regulating services in the Chaco-Pantanal are critical, however, these services are not as visible or appealing to policy makers and local populations who can capitalize on provisioning services. There is a notable lack of quantified studies of regulating

services in the area. Both biomes have large carbon storage capacity and regulate water in the region. The Pantanal, as a wetland, can act as a sponge absorbing water during heavy rains and slowly draining to regulate water flows far beyond its borders. This phenomenon helps with flood mitigation and erosion control for not only the wetland area but also surrounding agricultural zones (Seidl and Moraes, 2000). In the Pantanal, Palacios Neito (2016) used satellite data to model and value erosion control and water yield capacity services. Hamilton (2002) summarizes the ecological structure and function of the Pantanal, however the findings may need to be updated.

The semiarid Chaco, when converted to croplands or pasture, loses some ability to manage ecohydrologic risks, as was found by Gimenez *et al.* (2013). Arnstein (2013) conducted research on the carbon storage potential in the Bolivian Chaco, providing estimates for the amount of carbon stored per hectare in order to support PES schemes for Fundacion Natura. The carbon study was evidently requested by the organization in order to support a policy tool used for conservation of natural landscapes. Arnstein is not the only carbon researcher in the region, however valuations or regional quantifications have not been published (Conti and Diaz, 2013; Conti *et al.*, 2014). Gonzalez *et al.* (2015) found that native landscapes bordering soybean fields provided regulating services in the form of biological control. This study makes the case to favour heterogeneous crop fields with nearby Chaco forest.

3.2.4 Habitat and biodiversity

Though the habitat and biodiversity of the Gran Chaco and Pantanal are conservation hot spots, research has mostly described biodiversity qualitatively. Few studies have tried to measure or value these services, though there may be utility in pursuing research in this area. Campos-Krauer and Wisely (2011) investigated the dispersal of Capybara through the Gran Chaco due to increasing fragmentation. Additionally, Periago *et al.* (2014) discussed trends in mammalian populations in the Chaco. Unfortunately, the study was qualitative and highlighted a further need to accurately document the exact population numbers and assess the functional roles played by mammals and other animals. Furthermore, Torres *et al.* (2013) used models to estimate the species richness of flora and fauna in the Argentinian Chaco, but this study did not attempt to value these patterns nor discuss implications for policy and management. During the search, no quantifications or valuations of biodiversity in the Paraguayan or Bolivian Pantanal were found, but Junk *et al.* (2005) published an assessment in Brazil.

3.2.5 Cultural services

Eco-tourism has been the focus of a few studies, most notably the study by Shrestha *et al.* (2002) which looked at the recreational value of fishing in the Brazilian Pantanal. Other researchers have qualitatively described the potential values that can be captured via tourism, however primary research is lacking in the region (Periago *et al.*, 2015; Viglizzo and Frank, 2006; Caceres, *et al.* 2016). Other cultural services are encompassed in the valuations by Seidl and Moraes (2000) and Moraes *et al.* (2009) but these values come from the Brazilian Pantanal and are not localized for the SRJS regions.

3.2.6 Summary of inventory matrix analysis

IPG	Key Ecosystem Service(s)	Status in literature
Water provisioning	Water provisioning	Understudied
	Water regulation	Multiple regional studies, none in Bolivia or Paraguay
Food security	Non-timber forest products	Some studies, but limited in scope
	Agriculture	Multiple regional studies
	Fish	Two studies, relatively older
	Pollination	Only one study available
	Biological control	Only one study available
Climate resilience	Habitat / biodiversity	Multiple studies
	Carbon sequestration	Few studies
	Flood prevention	Multiple studies, none in Bolivia or Paraguay

The IPG of water provisioning is understudied in the region, though water is often taken for granted as being abundant in Pantanal. The Pantanal is critical for regulation of rainwater and flooding, yet there is limited research on the economic effects of reduced water storage capacity and impacts of increased runoff or floods. Food security is studied in terms of agriculture, where it is often analysed in relation to land conversion, but currently there are no studies in Bolivia or Paraguay. Cattle grazing is cited as being economically feasible in both regions, and fishing has been studied as food source and source of income, though these findings are outdated. Research has shown that the presence of natural habitats increases pollination and biological control, which is beneficial for agribusiness. Biodiversity and habitat are mentioned in some studies, yet the topic is complicated, and no research has focused on biodiversity in relation to climate change or climate resilience. Carbon sequestration has had limited analysis, though there is need for this data for REDD+ or certain PES schemes.

3.3 Summary of interview with Daphne Willems

Daphne discussed her main concern for the region, which in her opinion is land conversion of the Pantanal and Gran Chaco into soy fields or cattle pastures. This development is happening at a staggering rate, and there is a special concern for the Gran Chaco, which has been left relatively undisturbed and uninhabited, if drought-resistant soy is developed. Additionally, there are no valuations that can be used as evidence to favour conservation of the Chaco-Pantanal in Bolivia and Paraguay in order to make the case for protection of important ecosystem services. There is potential to work with smallholders and businesses in order to promote best practices in farming and cattle ranching in order to appease both development and conservation goals. Other sustainable development options include tourism, sustainable harvesting of timber and non-timber forest products or through international arrangements such as REDD+.

In Paraguay, the Chaco has very limited protection legally and deforestation is rampant. There is an effort to map illegal deforestation in Paraguay, but although satellite images are published, serious preventative action has yet to be taken. In the

Paraguayan Pantanal, there is hope for PES and REDD+ schemes, however presently there are limited initiatives within the country. In the Bolivian Pantanal, officially half of the area is legally protected, but unfortunately there is little enforcement on illegal logging and mining. The Bolivian government and people are outspokenly 'green' and value protecting their natural landscapes, however this mentality can be challenged when foreign developers move into the country or policies are not implemented. In both locations, there is concern about the ability of foreign investors or banks to easily purchase and alter the natural environments. If power and ownership can be granted to indigenous tribes or local communities, Daphne thinks they will have better luck in conservation.

Takeaways from interview

- Chaco may face severe threats from drought resistant crops
- Working with landowners and understanding land tenure is key – especially if land is sold to foreign developers
- Few studies have been conducted in the SRJS countries and there is a need for more scientific data and valuations

3.4 Lessons learned for Chaco-Pantanal

The Chaco-Pantanal region in Paraguay and Bolivia is currently understudied in terms of ecosystem services and economic valuations. The main ecosystem service studies in the area are trade-off analyses that compare natural landscapes to commercialized landscapes. Though this research is useful for decision makers, it can leave out many critical ecosystem services that are not immediately visible, such as supporting, regulating and cultural services. This limits the salience and legitimacy of the data. Besides the study conducted by Seidl and Moraes (2000), which was done in Brazil, there are hardly any scientific studies that assess the total economic value of these threatened biomes. Additionally, the region is occupied by various stakeholder groups such as indigenous tribes, resource-dependent communities and foreign developers. Each of these groups have different opinions on managing the land and more scientific effort needs to be spent on increasing legitimacy. It is critical to understand how these groups value the Chaco-Pantanal and how this value can be capitalized on, be it with sustainable use, strategic development or PES and REDD+ schemes.

The water related services provided by the Pantanal have yet to be studied in economic terms in a way that can be communicated to the surrounding landowners and governments. The Pantanal has remained relatively protected, however in the face of increasing deforestation, dam development and agricultural water use, the hydrology needs to be better understood as these issues become more salient.

In Chaco-Pantanal, land conversion studies have been used to advise landowners on the best use of land in the long term, considering all costs and benefits. If this type of information can be included in government legislation, and actually enforced, then perhaps the region will see a sustainable land management system in the near future.

3.5 Recommendations for future research in Chaco-Pantanal

Landownership is critical in the Chaco-Pantanal region, and Argentina and Brazil have enacted laws to limit land ownership by foreigners. If local landowners are less interested in converting native habitat to highly mechanized agriculture, regulations imposed on foreigners could slow conversion while allowing for sustainable development (Caceres *et al.*, 2015). Authors have suggested the impending threat of drought-resistant crops that would open previously inhospitable areas of the Gran Chaco for cultivation (Lambin *et al.*, 2013). Efforts should be made to communicate the value of the Chaco beyond agricultural purposes to landowners now, again this could be supported via PES schemes or other legislation, to protect the area from the potential crop takeover. This tension is exemplified in Bolivia, where oil and gas companies began developing on traditionally indigenous lands, and later had to make a major payment to the tribes due to the damages from the extractive industry (Bebbington 2013).

Local stakeholder valuation studies could be useful in the Chaco-Pantanal context as they tap into the pride for the unique habitats while also promoting economic development and engaging the relevant populations. Ecosystem valuations that focus on the SRJS countries and that provide up to date quantifications for understudied services, especially regulating, supporting and cultural, would add economic incentive to reducing land conversion.

Some policies are ineffective at the ground level, as was found by Killeen *et al.* (2007), who suggest that conservation policies were functionally ineffective at slowing deforestation in Bolivia, and Marinaro *et al.* (2014) found that protected areas in the Argentinian Chaco actually had reduced biodiversity levels. Perhaps choosing a more engaged economic approach would benefit policy makers and CSOs. If non-commercialized value can be communicated to local landowners, this may be more powerful than descriptive studies that highlight the staggering rates of ecosystem degradation without drawing attention to the potential benefits accrued from the ecosystems (Killeen *et al.*, 2007). Robertson and Wunder (2005) have shown that PES schemes can be successful in Bolivia, and there is great potential to increase these types of policies if there is adequate scientific data to support them. If studies can continue to test and understand the ways in which populations can sustainably harvest from these South American ecosystems, this may provide a buffer to the trend seen in Brazil and Argentina of intense deforestation and monoculture conversion.

3.6 Overview of main ideas for Chaco-Pantanal

SRJS research recommendation	Rationale	Policy context
Implementation of localized valuations	The lack of any economic valuations conducted in Bolivia and Paraguay suggest this is a powerful first move to draw attention to the value that exists in these ecosystems. The study by Seidl and Moraes (2000) has been heavily cited for the Brazilian Pantanal, but being able to cite values for Bolivia and Paraguay will increase the legitimacy of findings.	Economic values can be used by CSOs and governments alike to understand and make a case for conservation. CSOs can lobby for regulation of land use and protection of hot spots. Governments can use this data to fully understand costs and benefits of their policies and development projects. Localized valuation requires cooperation by local CSOs and researchers and can strengthen the legitimacy and credibility of conservation advocates.
Engage local communities in research	Communities have been responsive in the past to conservation, in terms of being stewards of protected areas or citizen scientists. Tapping into the social and human capital of local populations can increase impact.	Citizen scientists have participated in wildlife mapping and indigenous tribes in Paraguay manage protected areas. Working directly with villages and tribes allows for action if governments are lagging. If landowners and resource users are engaged, then SRJS can work from the ground up to promote sustainable land use.
Quantify hidden services	Research has remained limited in breadth, focusing mainly on surface level benefits of agribusiness vs natural habitats, more effort should be spent highlighting (economic) value of underlying services: carbon sequestration, water regulation, habitat and biodiversity. These hidden ecosystem services are necessary especially in the face of climate change. For example, as rain patterns change and potentially get more extreme, the ability of Pantanal to absorb excess water during storms and flood events is critical.	Quantifying underlying services will increase the saliency of research in the region, and can be combined with projects to adapt and mitigate climate change. PES schemes have been initiated successfully in Bolivia that involve protecting upstream forest for downstream water quality, this can be expanded. REDD+ has great potential due to carbon storage in Pantanal, and even Chaco.

4 Guianas

5 main takeaways

- Lack of information in general
- Focus on fresh water, coastal area, cultural services and valuation of biodiversity
- Reveal long-term costs and benefits
- Importance of human factor
- Overall approach needed

4.1 Inventory matrix for Guianas

For Guianas, specifically Guyana and Suriname, the focus of the literature search has been on studies concerning ecosystem services related to gold mining, land conversion, oil and gas exploration, overfishing and climate change threatening the coastal areas. The direct threats resulting from these activities are mercury pollution and health risks, loss of water and forest resources, decreasing fish stocks and reduced coastal protection.

The inventory matrix on the next page summarizes the results of the literature search. Most studies focus on Guyana and Suriname, but we also included a few studies that cover French Guiana, the Guiana Shield or the Amazon. The ecosystem services included (“•” discussed by study, “X” quantified/valued by study) are relevant to both countries and/or are mentioned in one or more studies. WWF and Conservation International together with universities in Utrecht, Guyana and Suriname are mainly responsible for studies in the area. The studies have been conducted between the year 1997 and now and the most popular research method has been literature research, while some studies also used mapping or interviews and/or focus group discussions. The least used methods are surveys and modelling. It also appears that a lot more studies have been conducted in Guyana compared to Suriname and that many studies only discuss services or quantify only one service.

4.2 Analysing the inventory matrix

4.2.1 Economic valuation

Most of the economic valuation studies are conducted in Guyana, but we also found three economic valuation studies for Suriname. Of these studies, Burke and Ding (2016) value coastal protection in Suriname using secondary research methods. Bhairo-Marhe *et al.* (2009) use literature and interviews to present some overall economic values related to changes in agriculture, timber, non-timber forest products (NTFP) and eco-tourism due to land-use decisions. The third study concerned the Bigi Pan area and has been conducted by Parahoe and Soetosenio in 2008. However, we have not been able to find all the files of this study and we are therefore unsure which methods they use and what services they value.

For Guyana, most studies use secondary research methods for the valuation, and a few studies use primary research. The valuation studies often focus on carbon, timber, NTFP and minerals (Osborne and Kiker, 2005; Unknown, 2010; Butts and Sukhdeo-Singh, 2010; EIS, 2013; van Andel, 2000; Thomas, 2009; Bynou, Souza and Agard, 2011; Republic of Guyana, 2008; Pearce and Bello, 1998; Sullivan, 1997; van Beukering and van Heeren, 2003). Two studies also focus to some extent on ocean floods (Republic of Guyana, 2008; Williams and Johnson-Bhola, 2009), two on river fish (Sullivan, 1997; van Beukering and van Heeren, 2003), and only one on agriculture, eco-tourism, biodiversity and education (van Beukering and van Heeren, 2003). The most used economic valuation method is direct market valuation. A few studies used benefit transfer, one study did non-market valuation and one indirect market valuation.

4.2.2 Provisioning services

Strikingly, we did not come across studies on coastal fisheries, and barely found any studies that focus on fresh water use. From the interviews with Harko Koster and Preeya Rampersaud we do know that some research has taken place on the coastal fisheries. For fresh water, there are a few studies that quantify water in terms of water availability per capita, number of people dependent on the watershed, renewable water resources and amount of water extracted by a company. None of the studies uses primary research methods or discusses actual water use by households. There is one study conducted between 2003 and 2006 on river fish consumption in two communities in Suriname (Ouboter *et al.*, 2007) and two studies in Guyana (Sullivan, 1997; van Beukering and van Heeren, 2003). Plouvier *et al.* (2012) mentions total fish consumption per capita in Guyana and Suriname in 2003. This means that all data on fish consumption is more than 10 years old. Agriculture is studied twice in Guyana (Sullivan, 1997; van Heeren and van Beukering, 2003) and Bhairo-Marhe *et al.* (2009) mention a value related to agriculture in land-use decisions. Information on timber and NTFP, especially for Guyana, is more extensive, but the primary data on NTFP in Guyana stems from before the year 2003.

4.2.3 Regulating services

Carbon sequestration is the most studied regulating service in the area, especially for Guyana. Erosion control, river flood prevention, fire prevention and pollination have not been quantified or valued for either of the countries. There is one study on coastal protection in Suriname using secondary research methods (Burke and Ding, 2016) and one that mentions water discharge in a watershed in South Suriname (Moredjo *et al.*, 2013), but none for both services in Guyana. Two studies focused on coastal flooding in Guyana, one using secondary research methods (Republic of Guyana, 2008) and one using a household survey to ask people about losses they made during a flood in 2005 (Williams and Johnson-Bhola, 2009).

4.2.4 Habitat and biodiversity

For Guyana, there is a study that mentions the number of different species in Guyana in general and specifically for Rupununi (Goslee *et al.*, 2013) and one study that values biodiversity in Iwokrama Forest Reserve (van Beukering and van Heeren, 2003). Plouvier *et al.* (2012) lists the number of species per country in the Guianas. Little is mentioned about differences in number of species across landscapes and biodiversity has only been valued once, more than 10 years ago, in spite of the fact that Guianas is a biodiversity hotspot.

4.2.5 Cultural services

Eco-tourism is the only cultural service that has been quantified in Guyana and a study in Suriname mentions a value related to land-use decisions (Bhairo-Marhe *et al.*, 2009; van Beukering and van Heeren, 2003). The study of van Beukering and van Heeren (2003) in Guyana also valued education in Iwokrama Forest Reserve. Besides that, cultural values are understudied in the region, while it can be expected that indigenous people attach a high spiritual and bequest value to their environment.

4.2.6 Summary of inventory matrix analysis

IPG	Key Ecosystem Service(s)	Status in literature
Water provisioning	Water provisioning	Understudied
	Water regulation	Understudied
Food security	Non-timber forest products	Studies available, but primary data is relatively older
	Agriculture	Few studies available, relatively older for Guyana and indirect values for Suriname
	Fish	Few studies available, relatively older
	Pollination	Understudied
	Biological control	Understudied
Climate resilience	Coastal protection	One study available, secondary data
	Carbon sequestration	Multiple studies
	Flood prevention	Two studies available
	Habitat / biodiversity	One study available, relatively older

For the IPG water provisioning, studies on water use and water quality are lacking in the region. For food security studies are older or lacking, while for climate resilience it differs per ecosystem service. Especially for carbon sequestration, there are more studies available, while for biodiversity only one study has been conducted more than 10 years ago. This summary only includes key ecosystem services for each IPG, while there are also services that are indirectly related to the IPG's. One can think of erosion control for water security, for example. Another thing to be aware of is that cultural services are left out of scope while they are heavily understudied and have the potential to serve as a strong message in favour of SRJS goals.

4.3 Summary of interview with Harko Koster

WWF mainly focuses on ecosystem services related to fisheries, fresh water, carbon, and coastal protection by mangroves close to cities. Most research so far has focused on REDD+, mainly in Guyana and to a lesser extent in Suriname. In general, there is a lack of studies in the region. Marine environment and coastal protection services are understudied, while most of the population lives in the coastal area. Marine protected areas are lacking, wetlands threatened and maladaptation is become more common. Suriname still has an intact mangrove population, but Guyana does not. For gold mining, the true costs are unknown, and Suriname has not signed the Minamata convention. Local communities are struggling with reducing illegal gold mining activities and looking for compensation for safeguarding forests and lands. Future threats are posed by oil and gas exploration, roads and an increase in mining concessions.

Different policies are already in place in the two countries. Generally, Guyana has more environmental laws compared to Suriname. Currently Guyana is revising its protected area policy and is about to ratify the Ramsar convention. Suriname has a strong forest policy on paper, although enforcement is low. In both countries, there are struggles within the government in terms of corruption and the government structure. Communication often goes from local to national, which can be difficult.

Looking at the relation between science and policy, some studies seem to have influenced the policy makers. The REDD+ studies, for example, enabled the Norway agreement. The studies on fisheries have stimulated MSC in Suriname and the wetland assessments hopefully enable Ramsar. Harko also mentioned that studies that show the long-term benefits and costs of different scenarios are effective. The human factor, such as health and water and food security, is also a strong argument. Local CSOs mentioned that they are looking for valuation of fresh water, as well as of biodiversity and how to monitor this.

4.4 Summary of interview with Preeya Rampersaud

Research so far has focused on carbon because of REDD+, but besides that there is a lack of studies. However, in Guyana they are working on examining other ecosystem services. They would like to have a better understanding of services and integrate them in the Monitoring Reporting and Verification (MRV) system that was developed to assess and monitor carbon. The services that they prioritized are fresh water, biodiversity and eco-tourism. There are some mangrove regeneration projects at the coast, as a lot of mangrove area has been lost, but there is also a focus on hard structures. For the wider marine environment, a fish survey has just been completed, but the information is not available yet. Questions still remain on illegal fishing and bycatches, and they would like to promote sustainable fisheries, MSC certification and a marine protected area.

The studies on carbon reached the policy level and enabled the Norway agreement. It seems like the current government might want to make fresh water a priority. Therefore, it would be great to have as much information as possible on fresh water, because currently there is none. They need to know how much water there is and where, what kind of issues there are around watersheds, how much water is used and from which source. For biodiversity they focus on conservation and protection, and are currently not working on putting an economic value on biodiversity, although this could be of use during a future holistic discussion.

Takeaways from interviews

- Past focus on carbon because of REDD+
- Lack of studies on other ecosystem services
- Focus on fresh water, coastal area, eco-tourism and valuation of biodiversity
- Reveal long-term benefits and costs and include human factor

4.5 Lessons learned for Guianas

In general, data availability seems to be low, especially for Suriname and on topics other than carbon sequestration and timber. Data on ecosystem services is often obtained through secondary research methods and data on important ecosystem services such as fresh water, coastal protection, biodiversity and eco-tourism is lacking

or older. Even more understudied are the cultural ecosystem services such recreation, spiritual and bequest values. The problem with secondary research is that it might not correctly reflect the actual quantity or value of a service, especially for situations where there is a higher level of subsistence or if markets are missing, and reduces credibility as well as legitimacy of a study.

Studies that reveal the long-term benefits and costs of different scenarios and incorporate a human factor seem to be successful in influencing policies in the region. In that case, the current lack of data on fresh water and its value is a barrier to effectively ban or reduce mercury use and other water polluting activities. This data could reveal the long-term benefits and costs of protecting water resources, accompanied by a message concerning water security and health effects. Information on usage and changes in ecosystem services provided by the marine environment and mangroves would reveal food security and safety issues, and support useful lobby and advocacy material for sustainable coastal protection and marine protected areas. Cultural ecosystem services could potentially play an important role in all topics. On the one hand because they might reveal high values, and on the other hand because it adds an extra human factor.

4.6 Recommendations for future research in Guianas

Although the situation is somewhat different per country, overall there mainly is a lack of studies. Therefore, we would recommend an overall approach for future research on ecosystem services and economic valuation. This could include a range of studies with different targets that in the end strengthen each other and provide a holistic perspective.

A household survey focusing on multiple ecosystem services conducted in different ecosystem service-dependent communities, in different areas and ecosystems, is a way to gain a holistic perspective. This survey could include topics that are relevant across all communities, such as fresh water and fish. It could also include WTP for changes in water quality and other relevant services. More specifically for each community this survey could be complemented with use of inland forest ecosystem services, marine and mangrove ecosystem services, flood and erosion impacts, and relevant cultural ecosystem services. By adjusting the survey per location while also including some topics across all studies, multiple goals can be reached while the studies also strengthen each other. These surveys can be combined with market research, focus group discussions and interviews with relevant companies. Not only would these studies provide a lot of information on the current status of the ecosystems and their services and provide as a baseline for the future, they could also show the true costs of gold mining and health risks across the entire region, result in arguments for marine protected areas or indigenous land rights, and potentials for PES schemes or other policies. A survey conducted with tourists can reveal WTP for biodiversity and eco-tourism facilities. This survey could also serve as a baseline for further monitoring of biodiversity value.

Together these studies can support the SRJS goals of water security, climate resilience and food security, while simultaneously empowering the local population by incorporating their perspectives and preferences.

4.7 Overview of main ideas for Guianas

SRJS research recommendation	Rationale	Policy context
Local valuation studies in inland communities	Currently little is known about the quantity and value of multiple ecosystem services. Revealing the value of ecosystem services can provide information on the use and importance of the ecosystems for people's livelihoods. This is valuable information and can be used to analyse the long-term costs and benefits related to specific decisions by determining changes in existing values. Human factors related to these studies are health, food and water security, and safety in the coastal areas. Success of REDD+ studies confirms that quantification and valuation can be a powerful tool in Guianas.	Economic values and information on the use of fresh water, state of the resource, and willingness-to-pay for changes in water quality can be used by CSOs to gain insights and argue on issues related to water polluting activities, such as mercury pollution. Information on other forest ecosystem service use, including cultural services such as spiritual and bequest, can provide insights and lobby material related to indigenous land rights and forest protection.
Local valuation studies in coastal communities		Including the same fresh water questions in both the inland and coastal studies would result in information on fresh water across the entire region and so the studies would strengthen each other. The result would be credible, legitimate and more comprehensive lobby material for CSOs. Information on mangrove ecosystem service use, impacts of floods and erosion and future preferences can provide insights and arguments on sustainable coastal protection. The same information on ecosystem service use from the marine environment, in combination with coastal protection issues, can be used by CSOs to argue on marine protected areas.
Tourist survey	The Guianas have large potential for eco-tourism, but development of this sector is lacking. At the same time the local CSOs would like to monitor, protect and value biodiversity.	Information from the tourist survey would reveal the current value that is generated by eco-tourism, what tourist (future) preferences are, potential future values, and willingness-to-pay for biodiversity. This could be used to stimulate eco-tourism development in a way that is favoured by tourists and serves as an extra argument for ecosystem protection. The same accounts for the value on biodiversity, which can also be used as a baseline for future monitoring.

5 Zambezi

5 main takeaways

- Integration of ecosystem services within hydrology studies
- Kafue Flats valuation is absent from the literature
- Should focus on downstream and upstream dynamics – potential for PES
- Limited legitimacy
- Absence of primary research in recent years

5.1 Inventory matrix for Zambezi

The Zambezi River basin is a large biome in Southern Africa encompassed by eight different countries, and the SRJS project is focusing on the Kafue Flats in Zambia and the Lower Zambezi delta region in Mozambique. These ecosystems face some of the same threats, such as hydropower dams, overfishing, mining, adequate water management, erosion and flooding. The area is characterized by tensions between economic development and environmental management, and these issues are exacerbated by regional politics between the eight nations (Beck and Bernaur, 2011). The most relevant ecosystem services in the river basin involve fresh water provision, carbon sequestration, water regulation, fisheries, agriculture and timber. Studies in the region are sponsored by WWF, Unesco-IHE, various universities and hydrology institutes. The studies involve both primary and secondary research, and the methodologies used range from literature reviews to surveys, and there are numerous studies that favour flood modelling.

5.2 Analysing the inventory matrix

5.2.1 Economic valuation

Fanaian *et al.* (2015) conducted an economic scenario assessment that looked at hydropower dams in relation to agriculture, fisheries, tourism and flood regulation. Though not a total economic value analysis, the study considered some of the most relevant services and then provided predictions for changes in the values of those services based on different dam and flow regimes (Fanaian *et al.*, 2015). Chimba and Musaka (2014) conducted a household survey to analyse the economic impact of a closed fishing season policy that was adopted in Kafue fisheries. The study could determine the economic losses associated with the closure, but it was beyond the scope for the authors to consider the potential economic gains of fishery recovery. Fishing was also economically analysed by Deines *et al.* (2013) who interestingly compared the provisioning service of fishing with the hydropower gained from upstream dams.

The first comprehensive economic analysis was implemented by Turpie *et al.* (1999) and involved four wetlands in the Zambezi region. This study quantified almost every single ecosystem service, and is cited heavily in literature and government and NGO documents. The large number of citations suggest that this report was useful to policy makers and has encouraged valuation of the wetlands beyond provisioning services. Seyam *et al.* (2001) conducted another valuation of wetlands in Zambezi, but used a rapid appraisal model that used only secondary data.

	Author(s)	Location	Economic valuation	Provisioning services							Regulating services							Supporting services	Cultural services							
				Water	Agriculture	Fish	Timber	NTFP	Minerals	Carbon	Water	Coastal protection	Flood prevention		Erosion control	Fire prevention	Pollination		Biological control	Habitat / biodiversity	(Eco-) tourism	Education	Spiritual	Recreation	Existence	Bequest
													River	Ocean												
1	Chimba & Musaka., 2014	Kafue Flats	Yes			X																				
2	Mumba & Thompson, 2005	Kafue Flats	No	X							X	X														
3	Deines <i>et al.</i> , 2011	Kafue Flats	Yes	X		X						.														
4	Beilfuss & Brown., 2006	Lower Zambezi	No	.	.	.						.					
5	Beilfuss <i>et al.</i> , 2010	Lower Zambezi	No														X	.			.					
6	Fanaian <i>et al.</i> , 2015	Lower Zambezi	Yes	.	X	X						X		X								X				
7	Guveya & Sukume, 2008	Lower Zambezi	Yes	X	X	X	X	X		X							X	X				X				
8	Shapiro <i>et al.</i> , 2015	Lower Zambezi	No				X			X																
9	Stringer, <i>et al.</i> , 2014	Lower Zambezi	No				X			X																
10	Turpie, <i>et al.</i> , 1999	Lower Zambezi	Yes	X	X	X	X	X		X	X	X	X	X				X					X	X		
11	van der Kroon & Brouwer, 2015	Lower Zambezi	Yes		X	X	X		X	X			X				X									
12	Jaarsveld, <i>et al.</i> , 2005	Southern Africa	No		.	.	X											.	.	.	.	
13	Scholes & Blggs	Southern Africa	No		X	X	X												X							
14	Hoekstra, <i>et al.</i> , 2001	Zambezi Basin	Yes		X						X	X														
15	Mccartney <i>et al.</i> , 2013	Zambezi Basin	No	.	X							X		.												
16	Tilmant <i>et al.</i> , 2010	Zambezi Basin	No	.							X	X														
17	Tilmant <i>et al.</i> , 2012	Zambezi Basin	Yes	.	X							.		.												
18	Timberlake, 2000	Zambezi Basin	No				.	.	.																	
19	Seyam, <i>et al.</i> , 2001	Zambezi Basin	Yes		X	X		X	X								X	X								
20	Beck & Bernauer, 2011	Zambezi Rasin	No	X						X		X														

Guveya and Sukume contributed another valuation study to the literature in 2008, which was advanced by van der Kroon and Bouwer in 2015, however only the former involved primary data, while the second used literature already published. Additionally, we found no explicit valuation of the Kafue Flats region, and literature is disproportionately based in Lower Zambezi delta region

5.2.2 Provisioning services

Shapiro *et al.* (2015) used satellite imagery to assess mangrove forests in the delta region, and also gives insight on the amount of timber in the area and rates of deforestation. Timber was additionally studied by the large valuation studies (Turpie *et al.*, 1999; Seyam *et al.*, 2001; van der Kroon & Bouwer, 2015). Fishing in the Kafue river has been studied relatively frequently, and is a key concern for the region both as a widespread livelihood source and as a source of protein (Deines *et al.*, 2013, Chimba and Musaka, 2014; Turpie *et al.*, 1999; Seyam *et al.*, 2001). Flood plain agriculture is a major economic activity in the Zambezi, and values have been studied in terms of large-scale plots and subsistence farming (Seyam *et al.*, 2001; Turpie *et al.*, 1999; van der Kroon & Bouwer, 2015; Tilmant *et al.* 2012). The hydrology of the region is studied in environmental flow studies, however less attention is paid to the provisioning service and more towards the value of the water flows in the many dams in the Zambezi (Tilmant *et al.*, 2010; Tilmant *et al.*, 2012). Water is a critical input to agriculture and general sustenance of life, and this aspect of the system has not been adequately studied.

Beck and Bernauer (2011) conducted scenario analysis for water provisioning until 2050 and predict water stress will increase exponentially with water flows being reduced up to 77% in some of the river basin. A few regional studies have been conducted in Southern Africa that provide data per country on services such as agriculture and timber, but this data is national and values are not attributed to the Zambezi area specifically (Jaarsveld *et al.*, 2005; Scholes and Biggs, 2004).

5.2.3 Regulating services

Shapiro *et al.* (2015) and Stringer *et al.* (2012) conducted a mangrove forest analysis in the Zambezi delta, which they then modelled to determine the carbon storage capacity, which is a necessary prerequisite to form a REDD+ project. Numerous studies have been conducted that focus on the hydrology of the Zambezi river basin and the cascading effects that various flow regimes have on ecosystems and livelihoods (Beilfuss and Brown, 2006; Fanaian *et al.*, 2015; Hoekstra *et al.*, 2001; Tilmant *et al.*, 2010; Tilmant *et al.*, 2012). Hydrology studies are critical as the Zambezi has a few major dams, and more planned for the future, which significantly alter the traditional water regulation services provided by floodplains and wetlands in the basin (Mumba and Thompson, 2005). No data was found on fire prevention, pollination or biological control.

5.2.4 Habitat and biodiversity

Beilfuss *et al.* (2010) conducted a large scale study on the distribution of herbivores which serves as a useful baseline of species diversity. Turpie *et al.* (1999) also analysed large animal quantities, however they did not study biodiversity or habitat provisioning as a service or attach a value. Scholes and Biggs (2004) their ecosystem service assessment also commented on biodiversity, but this data was descriptive and did not mention trends or values.

5.2.5 Cultural services

Cultural services, with the exception of tourism and recreation, have been almost entirely left out of scope of research in the Zambezi. One of the only references to non-tourism cultural services is in the prominent valuation study Turpie *et al.* (1999). Turpie *et al.* (1999) assessed existence and option value. However, they only conducted household surveys in the Barotse wetland, which is quite different than Kafue Flats and Zambezi delta and so the data may be difficult to translate across the region. Guveya and Sukeme (2008) calculated existence values for wildlife and bird habitat using a combination of primary and secondary data, but focused more on the tourism aspect of these habitats. There are evidently limits to the studies on cultural services in the Zambezi region.

5.2.6 Summary of inventory matrix analysis

IPG	Key Ecosystem Service(s)	Status in literature
Water provisioning	Water provisioning	Few studies
	Water regulation	Multiple studies relating to water flows and dam effects
Food security	Non-timber forest products	Understudied
	Agriculture	Few studies but limited in Kafue Flats
	Fish	Multiple studies
	Pollination	No studies
	Biological control	No studies
Climate resilience	Coastal protection	Understudied in the Delta region
	Carbon sequestration	Few studies
	Flood prevention	Multiple studies
	Habitat / biodiversity	Few studies

The IPG of water provisioning is understudied for the Zambezi region, as mentioned earlier, water is generally researched in regards to hydropower and more attention needs to be paid to water as a public good. In researching dams and flows, research has looked at water regulation, flood prevention and to a lesser extent coastal protection. Food security is poorly studied, besides fishing for which there is relatively more data. Pollination and biological control both have not been studied at all in the region. The services related to the IPG of climate resilience, namely coastal protection, carbon sequestration and biodiversity, are understudied. Climate resilience is critical in Zambezi as the region is heavily populated and the population continues to grow.

5.3 Summary of interview with Bart Geenen

The main areas of research and scientific attention in the Zambezi river basin involve environmental flows and water management. These projects are large scale and include the entire river system due to its interconnectedness and distributional issues between upper and lower river users. The river provides water used for small and large scale floodplain agriculture but is also being harnessed by large dams that restrict water flows and harm wetland environments. For these reasons, water allocation and water rights are often the focus of government and NGO policies, and there could be

utility in further discussing the ecosystem services in the region beyond commercialized provisioning services.

In the Kafue Flats in Zambia, WWF is interested in restoration since the area is highly developed with many economic activities. Some conservation and agriculture programmes have been applied in the Kafue Flats area, but they would like to upscale these projects to larger areas in Zambia. In the Mozambique delta, the focus is more on preservation and conservation as many development projects are in the works. The goal would be to try and preserve the environment and promote sustainable use through ecosystem studies and environmental impact assessments. In both regions, there is a need to work with private companies and communities to demonstrate the importance of the natural environment, since the governments work slowly and development is occurring quickly.

Bart mentioned that a big issue for the Zambezi basin is that the system is poorly understood as an ecological system. Due to the limited understanding of the ecosystem and its services, a comprehensive analysis answering questions such as: how does the ecosystem work? What kind of ecosystem services are there? Would be beneficial to have answers to these general questions, to provide a framework to model more specific economic valuation studies after.

Takeaways from interview

- Need to establish baseline data for the region
- Kafue Flats needs restoration, while lower delta requires conservation
- Ecosystem and services are not well understood yet
- Focus so far has been on understanding hydrology of river system

5.4 Lessons learned for Zambezi

Scientific research has been conducted in the region mostly in terms of large-scale environmental changes, such as dams, but there is evident need for more research and more engagement in the area. There have been numerous economic valuations in the Lower Zambezi delta region, four to date, which have used a combination of primary and secondary research (Turpie *et al.*, 1999; Seyam *et al.*, 2001; Guveya and Sukeme, 2008; van der Kroon and Brouwer, 2015). Though there are many valuations, none have attempted a total economic valuation and they all focus on a select number of services. Economic development is a critical issue in the Zambezi research, and this is evident by prevalence of studies that focus on provisioning services and other economic activities such as eco-tourism and hydropower. Little research has focused specifically on the Kafue Flats, though the area is threatened by overfishing, land conversion and altered hydrology due to dam construction.

There is an abundance of hydrology studies for the Zambezi river basin, but these are often specific to measuring water flows. It seems the region is popular for scientists to try and understand and model the downstream effects of changing a water regime. A benefit from this research has been the successful modification to dam discharges after research promoted environmental flows. This is most evident in the decision to use environmental flows (e-flows) at the Itezhi-Tezhi dam in 2004, which was changed to mirror a more natural flood regime (Forslund *et al.* 2009; Schelle and Pittock, 2005). In Zambezi, the hydrology of the river impacts communities and businesses from the Kafue Flats to the delta, but an integrated approach to water management has yet to

be developed. If less visible services can be monetized in valuations, or compensation guaranteed in PES schemes, then fair water allocation can be realized for the basin.

5.5 Recommendations for future research in Zambezi

The most pressing research gap for the Zambezi region is the lack of valuation studies conducted in the Kafue Flats. The region is severely understudied in terms of economic valuation, especially in contrast to the Lower Zambezi delta. The lack of research could be related to the fact that most of the Kafue Flats have already been degraded and the area is mainly used for economic purposes in terms of water use, agriculture and hydropower. There could be utility in showing the economic benefits of a restored environment, or at least an effort to show the benefits of preserving what natural landscapes are left. As mentioned by Bart Geenen and cited in WWF literature, the river basin has a dire need for ecosystem service research that is currently limited. This research can serve as a baseline to first understand the relationship between the environment and communities and businesses in the region. A baseline study would provide scientific direction for NGOs, CSOs, researchers and governments to focus efforts on the most critical services (WWF, 2016; Beck & Bernaur, 2011). Developing this frame of reference is critical for the Mozambique delta region as the area is still quite pristine.

For the region as a whole, the issues with downstream users depending on actions upstream could warrant the implementation of a PES scheme. Though the Zambezi delta is large and spans numerous countries, if PES schemes are successful at community or national scales, this might pave the way for a more unified water management system of the river basin (Bohensky and Lyman, 2005). Additionally, the focus of many studies has been on hydrological implications, but there is need to tie this hard science approach with social science to value and demonstrate the local implications of altered hydrology and secure fair water allocation (Beck and Bernaur, 2011). This socio-economic perspective is lacking from the environmental flow discussion, even though large populations have been impacted directly (through forced migration) and indirectly (loss of food security) by changing water patterns (Arnell, 2013; Brown and Watson, 2007). If research can analyse how ecosystem services are currently allocated among different stakeholders, they can then predict who wins or loses from certain developments. This analysis can be done for water resources, but also agriculture, fisheries and even regulating and cultural services.

Food security is an issue in the region, and with fish stocks dwindling and agriculture threatened, research can be used to support sustainable resource use and safeguarding food supplies. There should be an effort to show to private companies and governments that degraded landscapes and overfished rivers do more than harm the environment, they also cause humanitarian problems (Welcomme, 2003). Efforts could also be made to assess specifically how altered water flows affect downstream fisheries, because even though fisheries have been studied, their relation to water flows is poorly understood (Chabwela and Haller, 2010)

In order to improve legitimacy of scientific research, more efforts should be made to include communities as sources of data and they should be included in decision making processes. Community based research has been conducted in Zambezi in Namibia, and in Tanzania and has enabled researchers to propose targeted actions to empower local populations alongside environmental gains (Teweldemedhin *et al.*, 2015; Rebelo *et al.*, 2009). There is significant opportunity in localized research to

raise awareness while also gathering legitimate data that can be included in ecosystem service assessments and valuations.

5.6 Overview of main ideas for Zambezi

SRJS research recommendation	Rationale	Policy context
Develop baseline ecosystem service assessment	As Bart mentioned, there is critical need for a baseline assessment of ecosystem services in the region. There are no recent quantifications and valuations in Kafue Flats, and without a baseline understanding it will be hard for SRJS to create targeted strategies for conservation and development.	The SRJS project has little background to orient strategic projects around. A solid scientific baseline would allow WWF to see exactly where there are conservation, restoration and development needs are, and then tailor project goals accordingly. Though CSOs and governments have an understanding of the threats in the area, quantifications can be used to limit certain activities or protect critical areas and resources like wetlands or threatened habitats.
Research water services beyond hydropower	Hydropower and environmental flow regimes are often the topic of scientific research in the area, however it is becoming evident that other water related services need more attention. These services include fishing, agriculture, water provisioning, carbon sequestration and erosion control.	There are various water regulatory institutions that range from community level to transnational which would have a vested interest in understanding the regional water system. These institutions again mostly focus on water flows, and providing data to show the hydrological effects beyond flows would be a useful to the SRJS project. The institutions are also beneficial to engage as they already bring water stakeholders together.
Determine sustainable use of regional resources	Development is a key concern in the area, and there needs to be legitimate studies that support sustainable use of resources such as water, fish and timber. Trade-off studies can assess the costs and benefits of pursuing various development initiatives, like mining or agriculture while understanding the environmental impact as well.	It is unrealistic to imagine the Zambezi region pursuing conservation goals over development goals. However, if businesses can be shown the economic benefits of sustainable use, and governments implement and enforce regulations, there is potential to reduce negative impacts. CSOs can also promote sustainable use by local resource users, for example fishermen, to preserve long term use of natural resources and promote resilience.

6 Conclusion

This scoping study aimed to provide a useful baseline on what research exists on ecosystem services and economic valuation in four case study sites which are involved in the WWF-NL SRJS project, namely Aceh, Guianas, Chaco-Pantanal and Zambezi. By interviewing key informants with intimate knowledge of the four case study sites, we hoped to enhance the legitimacy of this literature review by focusing our efforts on certain issues and ecosystem services that were determined to be most critical for each region. The goal was to identify gaps, explore already existing policies and identify ideas for future research that could be used as lobby and advocacy material for each of the case study sites.

As Daily *et al.* (2009) presented in their framework, ecosystems, their services and values, are linked to institutions through scientific information. This in turn can provide incentives for behaviour changes and result in effects on the ecosystems. By looking at research gaps, we analysed if the loop had been completed for different parts of the ecosystem and led to desired changes. By looking at the policies already in place and the effect of studies, we analysed what contributes to effective translation of science into policy. Cash *et al.* (2003) and Cook *et al.* (2013) describe saliency, credibility and legitimacy as factors influencing this translation.

During our literature research it became evident that there are limitations to each case study site in terms of available data. It is commonly seen that commercialized products, such as timber, agriculture and palm oil, are better represented compared to other provisioning services. Information on regulating services in general is less extensive for each site, and across sites especially for pollination and biological control. For Zambezi there is more information on hydrology, and in Aceh and Guianas there has been a focus on carbon sequestration. Information on habitat and biodiversity is mainly qualitative and rarely valued, while all of these regions are well known for their biodiversity with high prevalence of endangered and endemic species. Cultural ecosystem services are understudied in all the areas, while these could provide valuable information in relation to the SRJS goals. As mentioned for the Chaco-Pantanal region, for example, there are local populations that have immense pride in their natural environments, but this value has been left uncalculated. One can also think of the spiritual and bequest values of indigenous tribes in the inland forest of Guianas.

Additionally, extensive primary research valuation studies are absent or older, although these studies are seen as credible and legitimate and the results prove to be useful for a long time. Two very good examples of this are the reports of Turpie *et al.* (1999) in Zambezi and van Beukering *et al.* (2003) in Aceh, who both continue to be cited until today, and the report in Aceh has proven to have had an effect on policies. These comprehensive valuations using primary research methods clearly have the potential to become the backbone for economic valuation in a region and influence policy makers. For Guianas and Chaco-Pantanal, such a comprehensive study is not available and primary research is mostly lacking. The lack of localized primary research that includes the perspectives of the local population and other local stakeholders can be seen across all case study sites. This research, in combination with non-market valuation studies, could also reveal values for regulating services and biodiversity, other information that is limited in all sites. Conducting such research generates credible and legitimate results and can, in all cases, serve as strong advocacy and lobby material for the SRJS project goals.

6.1 IPGs and ecosystem services

When researching the current state of knowledge of ecosystem services in relation to the SRJS project, we noticed a few disparities between the concepts of international public goods (IPGs) and ecosystem services. Most notably, the absence of cultural services from the IPG descriptions. Water provisioning, food security and climate resilience are pressing issues for all the case sites, though some sites have different priorities. However, across all the sites, there is a need to include cultural services such as recreational, spiritual and educational value of ecosystems. There is also no mentioning of bequest and existence values, which refer to the cultural desire for the ecosystem to be safeguarded for future generations. These services are not as visible as direct economical services like fishing or agriculture, however they are culturally important and should not be ignored. Since the focus of the SRJS project is to build local capacity, there should also be an emphasis on strengthening cultural ties to the ecosystems beyond economic use. The ecosystem service approach recognizes the invisible values that humans attribute to the environment, and these benefits go beyond food security or water provisioning (Costanza, *et al.* 1997)

We also noticed that the IPG of climate resilience is understudied across all case study sites. Carbon sequestration by natural environments has the potential to benefit each site through internationally or nationally funded schemes. There is opportunity to fulfil conservation goals while also promoting development if payments can be sponsored by international community or within countries by NGOs or governments to protect critical carbon reservoirs. Additionally, flood protection and water regulation will become critical buffers for ecosystems and infrastructure as weather patterns and storms change and become more severe. The climate resilience IPG involves numerous underlying services that may not be apparent to most people, if these services are quantified and this information communicated clearly, then the need to safeguard these services will become more apparent.

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Appendix A Guide and framework for using the Scoping Report

This appendix introduces an overall framework, of which the scoping study is the first step, and can be used by programme and regional managers to orient this scoping report within the SRJS project and timeline. The SRJS project goal is to support sustainable management of landscapes in nine eco-regions. The accompanying “theory of change” of the SRJS project focuses on increased capacity for lobby and advocacy in target areas. For the Theory of Change approach to be successful, good quality information is crucial in feeding complex decision making processes. Information generated by studies that is salient, credible and legitimate can strengthen conservation arguments and empower communities and local organizations.

The framework can be easily understood by comparing the steps to the act of making a puzzle (see second column in Figure 2 next page). Imagine the economic context of each case study site as a new puzzle. The first step in constructing the puzzle would be to gather all the pieces and define the types of pieces. Next, you would organize the pieces, fitting them together slowly and methodically. At this point, you may realize you have missing pieces or even large holes in the puzzle. This is as far as this scoping report goes. The logical next step may be to attempt to fill these holes, by finding the missing pieces or creating new ones (see method 2 surveys & mapping below). Finally, the completed information/puzzle allows us to see the bigger picture which allows for coherent communication and stakeholder engagement (see method 3 in Figure 2 on the next page).

Our framework follows this trajectory, starting by searching the literature to assess the information, and type of information, that exists for each site. After analysing the state of knowledge, it is then possible to assess the research gaps that exist, while also noting where there is sufficient data. The scoping report is the result of this process. For example, this report revealed missing puzzle pieces for cultural services across all sites, big holes in the puzzle in general for Guianas, and lack of pieces on water services beyond hydrology in Zambezi.

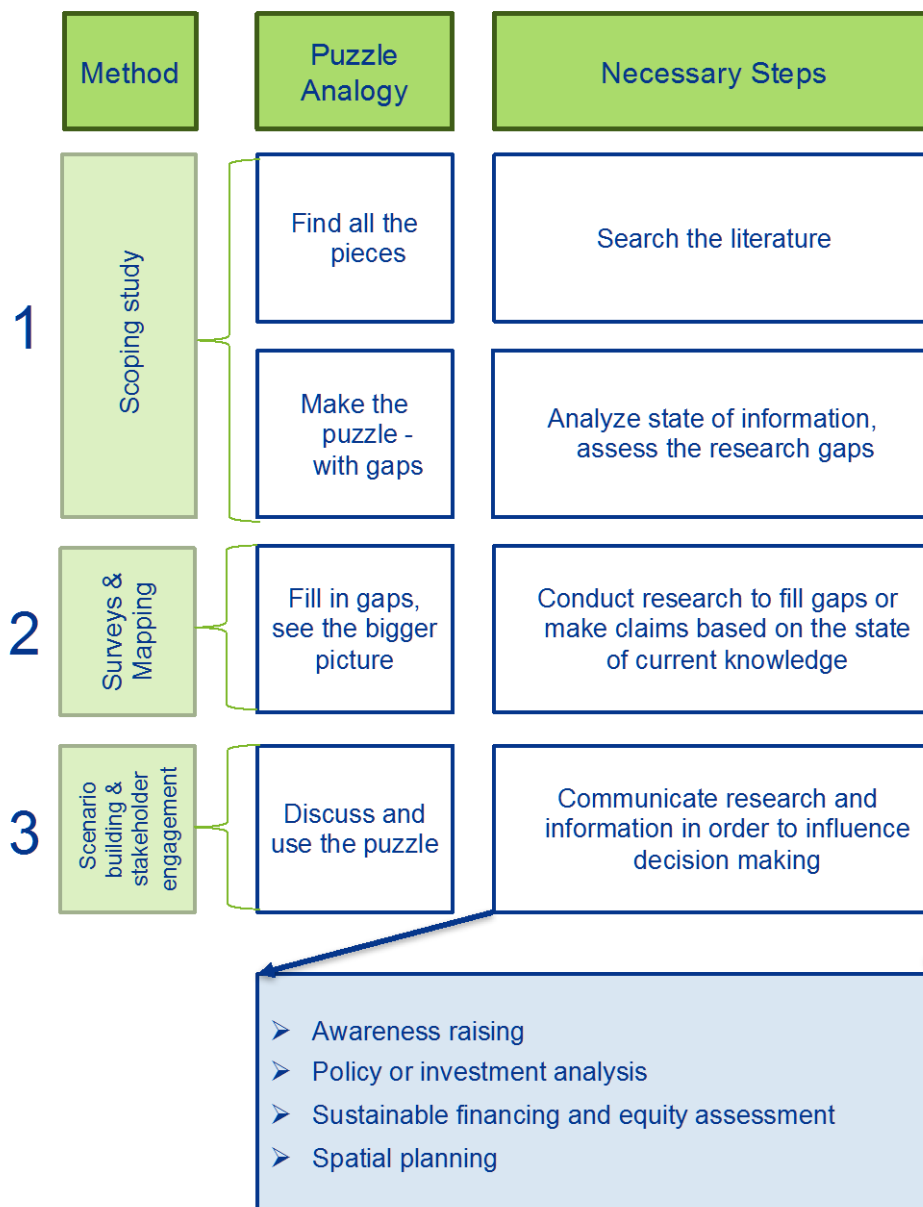


Figure 2 Framework for SRJS Project

The next step for the SRJS project would be to decide if and which holes in the puzzle are to be filled, by sponsoring more data gathering to support the local CSOs in their lobby and advocacy efforts. Surveying and mapping methods provide good quality data that can be used for different topics and situations, and can be designed so the research supports certain goals. The scoping report includes basic recommendations per site on what this step could look like. Such as local studies in Aceh to fill in the gap of the household perspective, and quantification of hidden services in Chaco-Pantanal.

The final step is to engage with stakeholders and communicate the results of the research in an effective way, with the ultimate goal to influence decision making. This can happen on several scales, such as local and regional, in a variety of contexts, such as governmental and business, and in many different ways. One way the scientific information can be used is to raise awareness. This could be raising awareness on the

current value of an ecosystem as well as on the severity of a threatening issue. Awareness can stimulate stakeholders to demand action, be it from their government or from other relevant parties. Scientific information can also be used to inform policies and investments by revealing the costs and benefits of different scenarios. A scenario analysis reveals trade-offs between different management practices, such as deforestation, sustainable management and conservation. Regarding equity assessments, information can shed light on the winners and losers within landscapes due to management decisions. This could be the impact on different stakeholders at a regional scale, or data quantifying effects such as downstream farmers' negative experiences due to upstream pollution. Finally, spatial planning can benefit from generated scientific information by creating value maps to highlight key areas for conservation, and delineate the most economically feasible areas for development.

Our scoping report went as far as the first step in the overall framework and identified opportunities for future research and policy targets, nested in step 2 and 3 of the framework, that have the potential to make a great impact. The scoping report can therefore be used as a guiding document showing where information exists, what the gaps are, and what possible next steps for the SRJS project could be.