(Un)tangling the Net, Tackling the Scales and Learning to Fish:
An Interdisciplinary Study in Indonesian Borneo

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Abstract

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In the face of continued environmental degradation worldwide, interdisciplinary research is needed to better understand and find practical solutions to this degradation and to better understand the complicated relationships between humans and nonhumans (the 'environment'). However, interdisciplinary research is often challenging due to problems of integrating different stakeholder concerns (e.g. government and local communities) and bridging academic disciplines. I propose a new approach – the Interdisciplinary Assemblage Approach (IAA) – which I use to study human, fish and spirit communities in the Sabangau (Indonesian Borneo), and explore relationships between these communities and 'environmental' aspects such as river depth and seasons. This case study was chosen due to the important tropical peat-swamp forest habitat in the area, the understudied nature of the fish assemblages in this habitat, and the understudied dependence of human communities on fishing around the forest and other peatlands across Sabangau. I conducted the first in-depth fish surveys in the Sabangau River and Forest, along with surveys in two human communities (Kereng Bangkirai and Taruna Jaya). Using results from these, I discuss how human-nonhuman relationships lead to Sabangau being an overfished and fire-prone area, showing both resilient and non-resilient characteristics. Taking the progressive interdisciplinary and biocultural approach to conservation, the IAA can also challenge dichotomies and hierarchies that are often imposed between different knowledge systems ('local' versus 'scientific' knowledge) and academic disciplines ('social' and 'natural' sciences). Ultimately, the project provides recommendations for future research and management actions, such as the impacts of canal damming and fish pond building on fish populations, to improve fish and fisher wellbeing and recommendations and considerations that will be useful for future peatland restoration projects. It evaluates the IAA, its use as a framework for interdisciplinary research along with its wider applicability for conserving environments that so many humans and nonhumans depend on.

I dedicate this thesis to my mother, Sonja and my father, Jeff.

Because you taught me to take risks, believe in myself, be adventurous, caring and critical.

Thank you for your endless support, I love you.

My twin sister, Jessica, this one is for you too. I am fortunate to share this path in life, and love for life, with you.

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The fish artwork on the front page was designed by Iwan Shinyo, one of the research assistants in my *Tim Ikan* (fish team) who helped to make this thesis a reality.

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IV. Abbreviations and Glossary

ANT	Actor-network Theory
AT	Assemblage Theory
BNF	Borneo Nature Foundation
BRG	Indonesian Government's Peatland Restoration Agency (*Balai Restorasi Gambut)*
CES	Cultural Ecosystem Services
CO_2	Carbon Dioxide
CPT	Community Patrol Team
CPUE	Catch-per-unit-effort
DO	Dissolved Oxygen
EA	Ecosystem Approach
ENSO	El Niño Southern Oscillation
ES	Ecosystem Services
FTL	Fractional Trophic Level
GDP	Gross Domestic Product
HCVF	High Conservation Value Forest(s)
IAA	Interdisciplinary Assemblage Approach
ITCZ	Inter-tropical Convergence Zone
IUCN	International Union for Conservation of Nature
MA	Millennium Ecosystem Assessment
MRP	Mega Rice Project
MTHG	More-than-Human Geography
NGO	Non-governmental Organisation
NLPSF	Natural Laboratory of Peat Swamp Forest

NTFP	Non-timber Forest Product(s)
OuTrop	Orangutan Tropical Peatland Programme (a programme of BNF)
SES	Socio-ecological System(s)
SL	Standard Length
TCK	Third culture kid
TI	Translator/interpreter
TPSF	Tropical Peat-swamp Forest
UPT LLG CIMTROP	Centre for the International Cooperation in Sustainable Management of Tropical Peatlands, University of Palangka Raya
WEF	Water-Energy-Food
WTP	Willingness-to-pay
WWF	World Wide Fund for Nature

GLOSSARY OF INDONESIAN TERMS USED

Adat	Traditional Dayak law, knowledge, wisdom or way of life
Beje	Fish pond
Hantu	Ghost/spiritual being
Naga	Giant snake/dragon
Pali	Sins or taboos
Pampan	formed when *rasau* (*Pandanus sp.)* becomes uprooted, floats down the river and then starts clumping together
Rasau	*Pandanus sp.* vegetation found commonly on the banks of the rivers
SDN	Elementary school
SMP	Middle school
Tampirai	Traditional box fish trap

CHAPTER 1

INTRODUCTION

"If there are no animals or plants there is no man, because all are the creation of God. We should not be arrogant by nature. All living things are the same and that makes nature more than just a place to stay" (Female participant, Kereng Bangkirai, focus group, 10/08/15)

It has long been understood that a thriving environment is not only beneficial to nonhuman species, but also to human wellbeing (Hippocrates, 400; Ulrich *et al.*, 1991; Lubchenko, 1998; Frumkin, 2001; Chiesura, 2004; Kellert, 2005; WHO, 2006). We are a part of the tangled web of the world. However, there is still significant degradation of habitats and continued extinction of fellow species. The primary driver of this continuing demise is the human species, so much so that this new era is being called the *Anthropocene* (Crutzen and Stoermer, 2000; Steffen *et al.*, 2007; Zalasiewicz *et al.*, 2010; Smith and Zeder, 2013; Dirzo *et al.*, 2014; Lewis and Maslin, 2015; Corlett, 2015; Waters *et al.*, 2016). Humans are causing not only environmental degradation but also a subsequent demise in our own quality of life. For example, air pollution has become the world's single biggest environmental health risk, linked to nearly one in every eight human deaths (WHO, 2014).

Halting this destruction and degradation of the world's ecosystems is challenging due to:

a. the complexity of human values and societies;
b. the complexity of ecosystems and global processes and
c. the complexity of 'socio-ecological systems' (SES) where human-ecosystem processes are explicitly entangled

Human motivations regarding environmental or 'resource' use, are furthermore subjective, heterogeneous and subject to local histories, beliefs and contexts (e.g. Baumeister and Leary, 1995; Ryan and Deci, 2001; Kinzig, 2001; Mayer and Frantz, 2004; Pahl-Wostl *et al.*, 2007; Crompton and Kasser, 2009; Satterfield *et al.,* 2013; Morales and Harris, 2014). This further complicates the aims of environmental conservation and improving human wellbeing.

The Ecosystem Services (ES) paradigm, one concern of this thesis, is based on the idea that greater understanding and acknowledgement of how humans depend on the environment (e.g. for food and clean water) may lead to more environmentally sustainable choices (Chee, 2004; Daily *et al.*, 2009; Constanza *et al.,* 2014). It falls under the Ecosystem Approach (EA) which according to the Convention on Biological Diversity (n.d.) is *"…a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way… It recognizes that humans, with their cultural diversity, are an integral component of ecosystems"*. It therefore includes humans, and their various cultures, in the consideration of the ecosystem. ES are part of the EA, and have been defined as the benefits that humans get from ecosystems (Mace *et al.,* 2012). In the Millennium Ecosystem Assessment these benefits, or services, can be classified into four main categories, where some ES can bridge more than one category: provisioning, regulating, cultural and supporting services (MEA, 2005). There has been a growing interest in the concept of ES and while it was originally conceived as a communication tool by most conservationists to better elucidate to decision-makers the importance of ecosystems to humans (Gómez-Baggethun *et al.*, 2010), there has been an increased emphasis towards regional and national ecosystem assessments along with developing methods to economically value ES (Mace *et al.*, 2012). As Villagómez-Cortés and del-Ángel-Pérez (2013: 282) re-iterates:

> *"The question is how to achieve conservation given that economics is more likely than ecology to inform policy and that the same ethics that justify conservation also demand that we be mindful of poverty and associated human suffering"*

With any project that considers environmental conservation, we must therefore also deal with issues of human wellbeing. However, this core concept of ES and subsequent attempts to value ES have been heavily critiqued due to the anthropocentricity of the approach and the alleged need for better integration of cultural and other non-quantifiable aspects of human-nonhuman relationships (e.g. Chee, 2004; Kumar and Kumar, 2007; Christie *et al.*, 2012; Villagómez-Cortés and del-Ángel-Pérez, 2013; Ninan and Inoue, 2013). I will explore these critiques further in Chapter 2 of this thesis.

There is also a recognised necessity in contemporary Geography to further integrate the concerns of people within the study of our dynamic physical environment through interdisciplinary research to support conservation and environmental management (e.g. Pickett *et al.*, 1999; Milner-Gulland, 2012; Pooley *et al.*, 2013). Most threats to biodiversity and all conservation interventions are ultimately human behaviours and therefore it is vital to understand how social factors such as cultural beliefs and values along with laws and policies influence human interactions with the environment (Ehrlich, 2002; Fox *et al.*, 2006; St. John *et al.*, 2010; Dallimer and Strange, 2015). Interdisciplinarity is therefore considered by some as an educational paradigm that can better meet the ecological challenges of the future (Palmer *et al.*, 2005). There have also been an increasing number of examples showing how interdisciplinary or multidisciplinary approaches (these are not the same as I expand on in Section 1.2 and see Pooley *et al.*, 2013; Beichler *et al.*, 2014) can lead to positive conservation outcomes (see Holt and Webb, 2007; Rutherford *et al.*, 2009; Margles *et al.*, 2010).

However, while it is increasingly clear that conservation projects are likely to fail if plans to preserve the remainder of vital habitats, such as tropical rainforests, do not include local communities; there still needs to be an increased collaboration not only between disciplines, but also academic and non-academic actors to allow for a greater learning and sharing of different knowledges and experiences (Anglestam, *et al.,* 2013). There is still a journey to be made to bridge worlds between stakeholders, academic disciplines, diverse ontologies, various forms of knowledges and different worldviews. In this thesis, I aim to take one step forward in this journey.

To take this step, I tackle the concepts of 'interdisciplinarity' and ES to explore the links between humans and their environment. I further develop the idea of 'interdisciplinarity' as the challenging of dichotomies and categories, including those imposed between academic disciplines, human-nonhuman relationships, various forms of knowledge and different worldviews. To do this, I take a case study of Sabangau in Indonesian Borneo. Within this case study, I focus on human and nonhuman (namely fish and spirit) communities and draw out the entanglements between these and other elements of the ecosystem at various scales. My reasons for focussing on fish are outlined in Chapter 4 which also explains the rationale to my case study location. Specifically, I'm concerned with the importance of fish and fishing to the local human communities, and I furthermore conducted the first in-depth fish and river assessments of the Sabangau River and Forest to better understand fish conservation issues in the area. To do the latter, I had to learn how to fish, which depended on local fishing knowledge and in turn challenged the 'scientific' and 'local' knowledge dichotomy. Throughout this thesis, I will return to these ideas of entanglements and untangling; scales and tackling these scales; and learning to fish in various forms and nuances and will signpost these as I go along.

This thesis therefore deals with wider philosophical issues of how I approach interdisciplinarity, dualities between sciences and knowledges, humans versus nonhumans etc. On the other hand, it also deals with more local, and perhaps less abstract topics of conservation, livelihoods, fish and fishing in Indonesia. To clarify these multiple levels, Figure 1.1 illustrates the key research question, and the main objectives and approaches of this thesis. These will be expanded on and justified in the coming chapters. Under objectives, I split the sections of fish and human communities preliminarily to allow me to illustrate through the course of this thesis how these communities are intertwined. Potentially unfamiliar terms of more-than-human geographies (MTHG) and De Landian Assemblage Theory (AT) will also be introduced and discussed in Chapter 3. In the following subchapters, I now further explore the conceptualisation of interdisciplinarity as proposed in this thesis. I will then discuss the barriers to interdisciplinary research and how I intend to tackle these.

Overall aims of the thesis:

- To develop new within-individual approaches to interdisciplinarity and assemblage theory (AT) that can challenge anthropocentric and dichotomous approaches to environmental research and policy, using a case study of fish and fishing in Sabangau (Indonesia).

Research questions

1) How do we develop an approach to interdisciplinarity that challenges biases from within and accepts different worldviews and knowledge systems?
2) Can assemblage theory provide a non-dualistic way of understanding people-environmental relations, thereby avoiding some of limitations of ecosystem service perspectives?
3) How can an interdisciplinary assemblage theory help to explain the importance of fish and fishing to local human communities in Sabangau, Indonesia?

Objectives:

1.1 <u>Use constant self-reflection and a consideration of personal as well as disciplinary positionality, through each step of the research process</u>

2.1 <u>Establish what fish species are present in the Sabangau and how the fish assemblage changes over time. This will be achieved through:</u>
- ➔ Completing the first in-depth assessments of local fish biodiversity of both TPSF standing water and blackwater river habitats.
- ➔ Using monthly environmental and fish data collected over the period of a year to form a baseline for future monitoring project and to improve our understanding of these wetland habitats

2.2 <u>Establish key characteristics of two local human communities in Sabangau and their experiences over time. This will be achieved through:</u>
- ➔ Using interviews, questionnaires and focus groups to investigate how characteristics of the communities influence education levels, occupations and identities (ethnic and religious), and to investigate experiences of environmental change and challenges.

3.1 <u>Elucidate how human and nonhuman elements are interconnected (i.e. how the assemblage is formed and how it functions). This will be assessed via:</u>
- ➔ Using interviews, questionnaires and focus groups, along with an interdisciplinary analysis supported by the IAA to evaluate how the elements of the assemblage (e.g. human, fish and spirit communities) are entangled and to identify previously unknown relationships
- ➔ Provide research and management recommendations for the Sabangau area

Figure 1.1: The overall aim, research questions and objectives of this thesis

1.1. The interdisciplinarity of challenging knowledge dichotomies

As Silitoe and Marzano (2009: 17) write:

> "*...only when all perspectives are taken together can we hope to achieve a more rounded and better understanding of the social and natural environments, and the potential for sustainable development*"

This thesis will be taking a biocultural approach to conservation as outlined by Gavin *et al.* (2015) who explain that this can support just outcomes within 'socio-ecological' contexts. The authors define biocultural approaches to conservation as "*conservation actions made in the service of sustaining the biophysical and sociocultural components of dynamic, interacting and interdependent social-ecological systems*" (Gavin *et al.*, 2015: 141). Their eighth and final principle calls for the respect and incorporation of different worldviews and knowledge systems as a critical step in conservation planning. This thesis deals with the, as I intend to illustrate, false dichotomy between local and 'scientific' knowledge, taking the stance that that these forms of knowledge may differ in specific ways but they are found on a continuum and hierarchies between them must be challenged, as I expand on in this section. In my consideration of 'local knowledge' I will follow Failing *et al.*'s (2007: 48) use of the term as an inclusive and descriptive label encompassing 'indigenous' knowledge and traditional knowledge: as "*the full variety of insights, observations and beliefs related to a particular decision that do not stem from conventional scientific expertise*". I use quotation marks for the term 'indigenous' to acknowledge a contentious term that can be seen to collectivise many distinct populations with diverse histories and experiences (see Smith, 1999).

Local knowledge systems are increasingly being recognised by development organisations, NGOs and governments as valuable to consider when discussing sustainable resource use and balanced 'development' (Niamir, 1990; Warren, 1990; Gupta and Ferguson, 1992; Failing *et al.*, 2007), vital to help design more effective management of ecosystems (Berkes *et al.,* 1995, Ohmagari and Berkes, 1997; Folke, 2004), and at times constituting the 'best available science' (Sullivan *et al*., 2006). Saying this, there are great challenges in how exactly to include and combine local and Western 'scientific' knowledge(s) such as the contentiousness of accessing and representing various forms of knowledge, the arguably more dynamic nature of local and traditional knowledge compared to Western 'scientific' knowledge which results in constantly changing knowledge and relationships, the location-specific nature of knowledges and the danger of oversimplifying traditional knowledge and local practices with the aim of fitting it into developmental frameworks (Silitoe and Marzano, 2009). With an absence of clear methods and frameworks to consider and evaluate different knowledges, any form of knowledge can often be uncritically rejected and at other times uncritically accepted (Failing *et al.*, 2007) and can face dangers of over-romanticisation (Reed *et al.*, 2007). In this thesis, I will outline how my proposed framework can support the reconciliation of different knowledges to challenge the knowledge dichotomies through an interdisciplinary approach. This includes the challenging of personal biases and worldviews, as aforementioned.

So how do we deal with the purported knowledge dichotomy? Agrawal (1995: 3) writes about the separation between 'indigenous' and Western 'scientific' knowledges:

> "*In the face of evidence that suggests contact, diversity, exchange, communication, learning and transformation among different systems of knowledge and beliefs …it is difficult to adhere to a view that separates indigenous and scientific/Western knowledge*"

Instead, multiple domains and types of knowledge can be considered, which differ in logics and epistemologies that can be found on a continuum rather than being complete binaries (Agrawal, 1995; Vermeylen *et al.,* 2008). Both 'scientific' and 'local' knowledges need to be tested rather than unquestioningly accepted (Reed *et al.*, 2007) and in combination with each other can contribute to more comprehensive understandings of complex and dynamic 'socio-ecological' systems (Reed, 2008). The duality between 'indigenous' and 'scientific' knowledge can be further softened by accepting that all knowledge is socially produced (Vermeylen *et al.*, 2008). Vermeylen *et al.* (2008: 202) indeed argue that Western European science is "*a particular, standardized form of local knowledge*" and is, like local knowledge, a social and cultural as well as a technical practice.

In this thesis, I will highlight how the local knowledge of my research assistants was *vital* for the collection of my 'scientific' data. Without one, there would be no other. I do not think this is a unique experience with the number of conservation organisations worldwide that depend on local research assistants and their skills. I do think, however, that this symbiosis of knowledges is not expressed explicitly enough, while it is such a clear example of how the knowledge dichotomy shatters the moment you step into the real-world.

Tackling this knowledge dichotomy can be supported by interdisciplinary approaches to research. I also argue that tackling knowledge dichotomies can be part of an interdisciplinary approach itself. Thereby, the concept of interdisciplinarity becomes more than merely crossing disciplinary boundaries: it is challenging false dichotomies and hierarchies whether these are between academic disciplines, or between 'local' and 'scientific' knowledge. This conception of interdisciplinarity can be even further developed with another aspect: the personal approach to interdisciplinarity. For, through dealing with cross-cultural research, and various worldviews, problematising distinctions between the academic disciplines I find myself in: I argue for a *within-individual* element to interdisciplinarity. I discuss this further in the following section.

1.2. Personal dimensions of 'interdisciplinarity': (Academic) identity and cultural marginalisation

> *"Where am I from? and Where do I belong?" are basic questions of human identity. Because global nomads have been crossing boundaries and borders of personal, national and cultural identity since childhood, it is no wonder … that we never completely fit in anywhere."* (Global Nomads Washington Area, 2007)

I find the personal journey through interdisciplinary research a particularly interesting one, especially through my own experience of coming into this PhD with a BSc in Ecological Science (Conservation and Ecological Management) and hence with a more 'natural' science background.

When discussing her experience in conducting interdisciplinary research, Donovan *et al.* (2011) writes about the difficulty of losing her sense of, what we could call, 'academic identity' as she felt that she knew who she was before undertaking the interdisciplinary geography/geology PhD and fondly remembered how she fitted comfortably within the categories of the geological science discipline. Donovan's experience is an illustration of how the search for interdisciplinarity is not only an academic, but also a personal journey, where one must accept a path of insecurity and of 'intellectual homelessness' (Mewburn, 2013). This made me reflect on my own personal approach to interdisciplinarity, and made me question why, in many ways, I was comfortable with this sense of 'intellectual homelessness'. The journey of interdisciplinarity in this project was like that of learning a new culture and language, travelling to a completely new country and having to 'fit in'. I did this both theoretically in trying to engage more with 'social' sciences, as well as literally by living for a year and a half in Indonesia, needing to navigate through Indonesian culture and picking up a new language.

For me though, this constant change and adapting to the unknown is what I am used to and in fact is a very defining element of my identity. Unlike people who grew up in one country and one culture, I am a second-generation third culture kid (TCK) which Pollock (1988) defines as *“an individual who, having spent a significant part of the developmental years in a culture other than the parents’ culture, develops a sense of relationship to all of the cultures while not having full ownership in any”*. My background has an even greater complexity, with my mother being a TCK as well. A part of my identity is that I am a foreigner in all countries: I hold multiple nationalities yet belong to none. While often causing a feeling of rootlessness (see Walters and Auton-Cuff, 2009), this state of ‘in-betweenness’ can enable TCKs to overcome ‘*the politics of polarity*’ with ever-changing and hybridising forms of identity (Grimshaw and Sears, 2008). I have always been an ‘outsider’, or as Lam and Selmer (2003) describe it, a *‘cultural marginal’*.

While coming from a TCK background certainly has its own challenges (see Walters and Auton-Cuff, 2009), it comes with one advantage: that being an ‘outsider’ is familiar and to a certain extent normalised. This was beneficial in my quest for interdisciplinarity, where I was in many ways an outsider trying to dive into the world of ‘social’ science. My background training has been mostly ecological and I have therefore had to try to adapt to the language, culture and way of thinking of the ‘social’ sciences, and while this has in no means been easy (and arguably there is no end-point to this personal development), my comfort with being an outsider has perhaps allowed me to be less intimidated by this task. Lastly, drawing from this experience, in our increasingly globalised and multicultural world the idea of crossing not only cultures, but also disciplines, should therefore become less problematic.

As part of the contribution to the literature dealing with interdisciplinarity, I thereby take one further step and argue that interdisciplinary approaches can also come from within an individual. This within-individual interdisciplinarity involves actively challenging your own worldview, perspectives and biases, along with accepting different worldviews and knowledge systems all with the aim of decentring hierarchical and in many cases oppressive attitudes. Of course, not only TCKs, but anyone who is open to the aforementioned is capable of taking this within-individual interdisciplinary approach. I argue that more traditional understandings of interdisciplinarity count as well, but that a within-individual perspective of interdisciplinarity can support a more progressive understanding of interdisciplinarity. Many papers dealing with interdisciplinary research deal with scientists from different disciplines working together (e.g. Sievanen *et al.*, 2011; Bridle *et al.,* 2013), rather than researchers trained in both 'natural' and 'social' science techniques. This is 'multidisciplinary' rather than 'interdisciplinary' (Pooley *et al.,* 2013; Beichler *et al.*, 2014). In multidisciplinary research, where each researcher sticks to the discipline that they are comfortable in, this self-critique and self-challenging will not exist to the same extent and therefore fails at the more progressive understanding of interdisciplinarity that this thesis argues for.

In this sense, it is still possible to have an interdisciplinary team if this within-individual experience is encountered by each team-member. Furthermore, while most literature dealing with personal dimensions of fieldwork mainly discusses aspects of gender (e.g. Gurney, 2003; Bracken and Mawdsley, 2004; Sharp and Kramer, 2006; Burek and Kölbl-Ebert, 2007), there is this other dimension of familiarity of being the outsider and how this links with interdisciplinarity that has previously been overlooked. This is another unique contribution of this thesis: the explicit negotiation of interdisciplinarity within oneself. In the conclusion of this thesis I will also reflect on how a TCK background can provide personal experiences that better positions a researcher to deal with interdisciplinary difficulties, such as 'intellectual homelessness'.

1.3. Barriers to interdisciplinary research: A mythical chimera?

I have now outlined the need for interdisciplinary research and why I am taking this approach in this thesis. I am (as are many others) still left with the gaping hole of exactly *how* to conduct interdisciplinary research, with issues including integrating the concern of various stakeholders, different knowledges and practicalities in bridging disciplines (Pickett *et al.*, 1999; Lyall and Meagher, 2012; Delibes-Mateos, 2017). Interdisciplinary research approaches are certainly not new, with one of the earliest reported mentions of the need for greater interdisciplinarity in science being in 1929 (Balsiger, 2004). However, there remains a need to tackle the disciplinary divides of academia, along with engaging various stakeholders effectively and fairly, be they governments or local communities. Thereby, realising interdisciplinarity in practice continues to be a challenging but necessary goal in conservation research (Agarwala *et al.,* 2014; Corlett, 2015; Bennett *et al.*, 2017; Delibes-Mateos, 2017). As Bennett *et al.* (2017) write, when doing interdisciplinary research 'interdisciplinarity' has to permeate every research step, from planning and conducting the research, to the synthesis and writing of the final thesis. I will return specifically to this last point in Section 1.3.1 of this chapter.

The need for area-specific experts will always be there, such as taxonomists, animal behaviour scientists or experts on greenhouse gas emissions from peatlands to maintain and build the foundations which interdisciplinary science is then based on (Kinzig, 2001). I therefore do not see my focus on interdisciplinary approaches as a dispute against the importance of area-specific experts. But there is also a need, as outlined in Section 1.1., for an integrated view of human-environment systems to better understand requirements for environmental conservation. To do this, generalist interdisciplinary researchers need to be trained in both 'natural' and 'social' science methods, as Adams (2007: 276) writes:

> "*...our challenge is not to take biologists and equip them with the skills to get by in social surveys. Our real task is to create conservationists for*

> *whom these skills are innate, for whom the disciplinary boundaries so beloved of academic researchers are no constraint*”

By training what is arguably ‘true conservation scientists’, this would allow a greater awareness of the assumptions and limitations of each of the academic ‘worlds’, in turn allowing researchers to make a better choice of methods, approaches and ways of presenting their research. Collaboration is not enough, and in agreement with sentiments of Adams (2007), what is needed is a novel way of training the new interdisciplinary academic and practitioner. To do so, the structural barriers enforced by our academic institutions will doubtlessly need to be dissolved.

Lastly, it should not be expected that interdisciplinary studies are able to convert all environmental conflicts into win-win situations (Fry, 2001) and while there is a wide recognition that interdisciplinary research is needed, this approach faces several structural and conceptual challenges and barriers. There are challenges associated with funding, degree granting, publishing as well as the cultural and historical differences (e.g. different theories of knowledge) between the ‘natural’ and ‘social’ sciences (see Wear, 1999; Pickett *et al.*, 1999; Boulton *et al.*, 2005; MacMynowski, 2007; Pooley *et al.*, 2013). There is still a persisting hierarchical inequality between the ‘social’ and ‘natural’ sciences, which despite calls to integrate ‘social’ sciences into research and management of ‘social-environmental’ systems, ‘natural’ scientists still seem to retain their authority as “*mediators of truth and knowledge on environmental matters*” (Pooley *et al.*, 2013: 27). There are difficulties with definitions, vocabulary or ‘language’ (see MacMynowski, 2007; Donovan *et al.*, 2011) and a lack of clear frameworks for integrating the ‘social’ and ‘natural’ sciences (Sievanen *et al.*, 2011). This thesis therefore proposes a new framework to begin this journey of interdisciplinarity. I begin to outline this in the following section.

1.3.1. The missing framework: beginning to envision the Interdisciplinary Assemblage Approach

One key issue faced when attempting to write an interdisciplinary thesis is how to structure the thesis itself. While this may seem a specific issue, I see it instead as a foundational one: without a structure or framework to support interdisciplinary writing the aims of interdisciplinarity itself are unachievable. There is very little literature to support how to actually write and structure an interdisciplinary PhD thesis (Lyall and Meagher, 2012, do give some general tips), and this left me in the blatant dilemma that indeed any thesis that splits the disciplines of 'social' and 'natural' science into different chapters, fails to be interdisciplinary. It was therefore necessary to purposively find, or devise, a new framework.

Taking the stance that to understand 'socio-ecological systems' (SES) there is a need to identify and analyse relationships among multiple levels and between different human and nonhuman (biotic and abiotic) component parts, I agree with Ostrom (2005: 420):

> "*We must learn how to dissect and harness complexity, rather than eliminate it from such systems*"

To do this, frameworks that support interdisciplinary approaches through the whole scientific process need to be further developed (Sievanen *et al.*, 2011; Ostrom, 2005). Frameworks such as SES do exist and have been extensively used in geographical and conservation literature (e.g. Anderies *et al.*, 2004; Ostrom, 2009, Collins *et al.*, 2011; Laterra *et al.*, 2016). This thesis does refer to SES, yet in its aim to challenge the nature-culture dichotomy which arguably SES actively perpetuates (Widgren, 2012); there is a need to search beyond SES framing. As the coming chapters will more thoroughly outline, I look instead towards theories of 'assemblages' in ecology, More-than-Human Geographies (MTHG) and Assemblage Theory (AT).

As a brief introduction, Assemblage Theory (AT) is a social philosophy theory originally proposed by Deleuze and Gautarri (1980), with this thesis adopting the approach as further developed by Manuel DeLanda (2006; 2011; 2016). In this thesis, I take a novel approach by drawing upon the parallel use of 'assemblage' in ecology and AT as a 'bridging concept' to connect and integrate approaches and perspectives (Beichler *et al.*, 2014) and thereby support my interdisciplinary aims. I use a framework based on AT to challenge the nature-culture dichotomy and to foster interdisciplinarity by allowing me to deal with human and nonhuman elements and the interrelationships between these. This is also done to manage the differential power and authority associated with 'local' and 'scientific' knowledges. A 'peering across' from my ecological and 'natural' science background towards MTHG and AT also allows me to deal with some of the main criticisms of ES, which is central to this thesis. I take my 'starting point' to be the ES concept. However, through the course of the thesis I will distance myself from the ES concept for multiple reasons such as the anthropocentricity of the ES paradigm (this will be more fully dealt with in Chapter 2). I do this by, again, drawing on AT and MTHG, as I will outline in Chapter 3.

Therefore, I take a novel approach to interdisciplinarity and environmental conservation research, calling upon Assemblage Theory (AT) as understood within Human Geography, and marrying this with the ecological concept of 'assemblages' to construct and analyse the case study area through, what I term, an Interdisciplinary Assemblage Approach (IAA). The IAA is structured as outlined in Figure 1.2. This includes three main 'steps' to explore the Sabangau area, which map onto the three analysis chapters of this thesis. This is done to provide an interdisciplinary analysis throughout. Figure 1.2 includes the main questions posed by each chapter, and the methods (red, underlined) used to answer these questions and complete each step of the IAA framework analysis. The data collected in this study will 'populate' or 'flesh out' the assemblage, how it is formed and how it functions. This IAA framework will be further elucidated in Chapters 2 and 3. I will then introduce the case study location in Chapter 4.

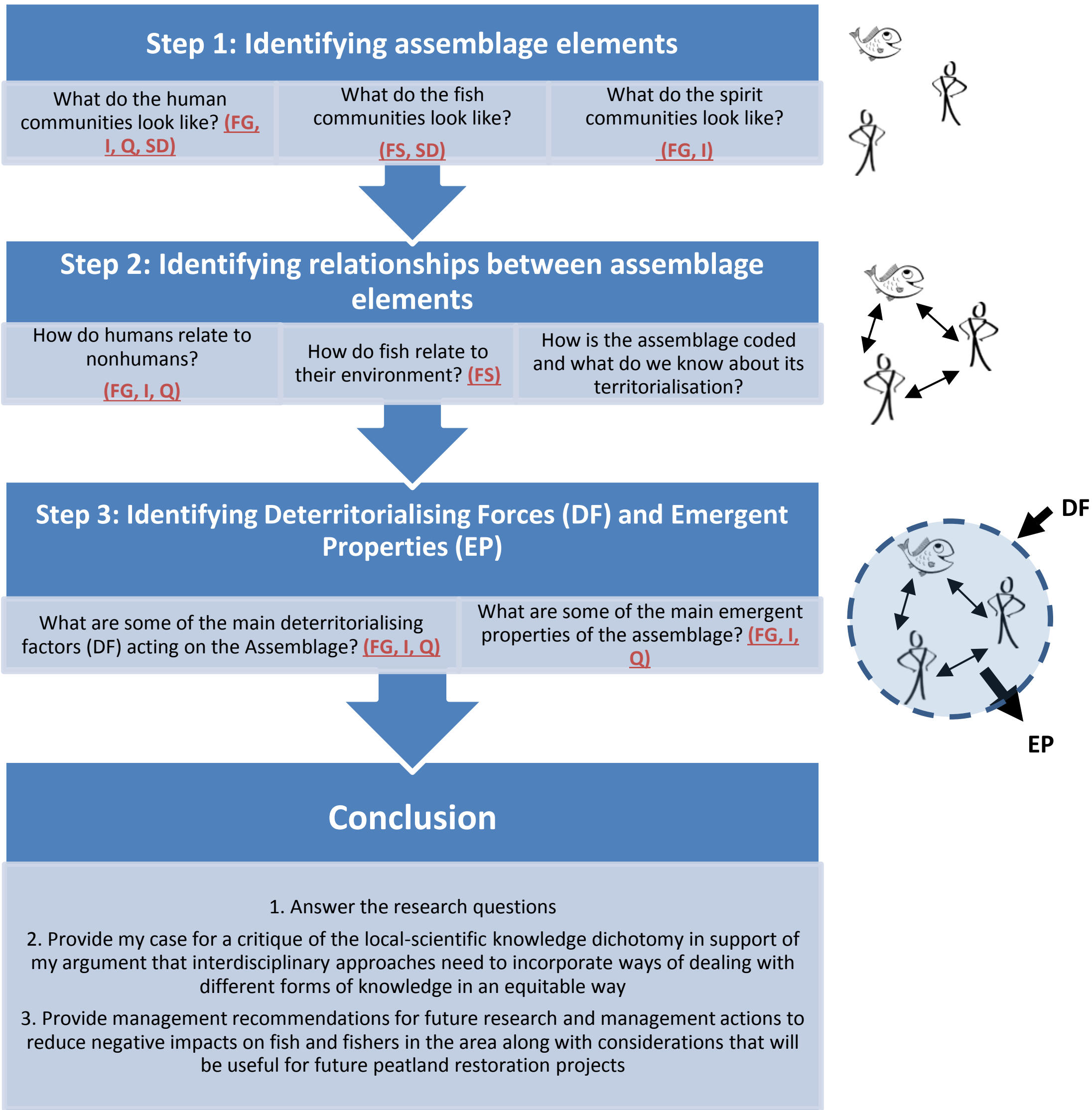


Figure 1.2: Structure of the IAA framework, and the thesis' analysis chapters. Indicating the methods used at each step of this process (in red and underlined). FG = 'Focus Groups', I='Interviews', Q='Questionnaires', SD= 'Secondary Data', FS='Fish Surveys'.

I will use the IAA to build a bridge and attempt 'big' interdisciplinarity. I propose this by no means as an 'answer to all', as *the* solution to the environmental and social difficulties that we are facing from environmental degradation and the loss of environmental 'resources'. I instead make this attempt to explore whether the IAA can effectively support interdisciplinary research at multiple scales of this issue: from structuring the thesis itself (which is key to a truly interdisciplinary piece of work and thereby has much wider ambitions and implications), to the larger scale of challenging multiple false dichotomies as this chapter presented. I make this attempt at interdisciplinarity to further explore in more general terms its challenges. Using the IAA, this thesis highlights that the 'natural' and 'social' sciences, however different they may be, can foster their similarities in common concepts and approaches, such as 'assemblages'. As Phillips *et al.* (2008: 54) writes, and as this thesis further aims to elucidate; "*the social and natural sciences are not as distinctly divided philosophically and methodologically as is often assumed*".

This thesis uses the terms 'interdisciplinary *approaches*' to refer to, not only the use of different research methods (that originate from different academic disciplines), but also the use of concepts that originate from different disciplines and the intention of writing and reporting in a way that balances effort and consideration of various methods and views equally (following Bennett *et al.*, 2017).

1.4. Chapter interpretation

This thesis proposes an Interdisciplinary Assemblage Approach (IAA) and explores its use for understanding complex human-nonhuman systems to a) support environmental conservation, b) provide a framework for interdisciplinary research, c) address critiques of the ES paradigm and d) challenge dichotomies and hierarchies that are often imposed between different knowledge systems ('local' versus 'scientific' knowledge) and between academic disciplines ('social' and 'natural' sciences). Specifically, this thesis is based upon the following premises:

1. To understand human motivations to support environmental conservation, we need to make use of both human and physical geography approaches. This requires **interdisciplinary approaches** to research.

2. **Interdisciplinary approaches** can be fostered through understanding parallel and supportive concepts that are found in both the 'natural' and 'social' sciences: such as the concept of '**assemblages**'. I will marry the two uses of 'assemblage' in ecology and De Landian social philosophy (Assemblage Theory [**AT**]) to form my own approach that I will call an **Interdisciplinary Assemblage Approach (IAA)**.

3. The **Ecosystem Service Approach** has serious critiques that I will be balancing with my use of **More-than-Human Geographical (MTHG)** approaches. I will clarify this in the coming chapters.

4. My **IAA** can 'catch two fish with one hook': **AT** is a **MTHG** approach, and therefore my dealing with the critiques of the **EA** and my attempt **at interdisciplinarity** (in the marriage of the assemblage approaches) can be performed using the **IAA** as a framework**.**

5. People relate to their environment in many ways. We can study these relationships using both **MTHG** and **ES** approaches, but this is not enough. On top of this, I argue in support of a biocultural approach to conservation which challenges **knowledge** dichotomies with a respect for and incorporation of different worldviews and knowledge systems, and thereby a more progressive understanding of ‘interdisciplinarity’.

CHAPTER 2

Ecosystem Services: Values, Contradictions and a Starting Point

As outlined in Chapter 1, the Ecosystem Approach (EA) and Ecosystem Services (ES) concept/approach have been subject to serious critiques. I will attempt to respond to some of these through the use of More-than-Human Geographical (MTHG) approaches. Furthermore, people relate to their environment in many ways. These relationships can be studied using both MTHG and ES approaches. To take this further, I argue in support of a biocultural approach to conservation which challenges knowledge dichotomies with a respect for and incorporation of different worldviews and knowledge systems, and thereby a more progressive understanding of 'interdisciplinarity'. To clarify approaches that are central to the thesis, this chapter discusses some of the complexities of the ES concept including its critiques, the concept of 'values', and different meanings of 'value'. This includes discussing cultural ES (CES) and the concept of 'wellbeing'. This will then be built upon in Chapter 3 when I will clarify how I intend to use MTHG approaches to balance some of the main critiques of the ES concept that are outlined in this chapter. Chapter 4 then focuses on the rationale of the case study and the focus on fish and fishing in Indonesia.

2.1. The Ecosystem Service Approach

In the Anthropocene, the consensus view is that the environment is best understood and studied as a 'socio-ecological' system (SES) which integrates humans within the 'ecological' (Liu *et al.*, 2007; Collins *et al.*, 2011). One attempt to do so, is the study of how ES benefit society, which was at the core of the Millennium Ecosystem Assessment (MA) (MA, 2005). Collins *et al.* (2011: 351) describes this as "*the first interdisciplinary global assessment of Earth's ecosystems conducted at the behest of world leaders*". For the interdisciplinary aims of this thesis, ES therefore seems a good starting point. This chapter further explores the ES concept and will focus on key critiques and contradictions of the concept that need to be addressed.

2.1.1. Ecosystem Services: Critiques and toward alternatives

The MA argues that decision-making processes often ignore or underestimate the value of ES, and this leads to decisions being made that ultimately have net disbenefits for human wellbeing (MA, 2005). Therefore, the issue is framed as being how to effectively show the 'true value' of ES and better include these in decision-making. Valuing ES can take many forms, considering both utilitarian and non-utilitarian paradigms (see MA, 2005). In practice though, this has led to a predominant focus on economic values for many reasons, including that these are simply more easily quantifiable than non-utilitarian values (see Igoe and Brockington, 2007; Büscher *et al.*, 2012; Martin *et al.*, 2013). Most research on valuing biodiversity, which is supported by ES and also is a source of ES (MA, 2005), focuses on economic benefits where value is usually measured monetarily (Christie *et al.*, 2012). Within the discussions of conservation, increased emphasis is placed on 'investment', 'profit', '(natural) capital' and 'growth', and so, the values that are quickly permeating conservation are those of neoliberal capitalism (Büscher *et al.*, 2012). I therefore focus on this economic valuation of ES as this seems to be according to some the consensus solution to contemporary conservation problems and in doing so has engendered many critiques (Büscher *et al.*, 2012).

Büscher *et al.* (2012) criticise and explain how the 'safe road' of doing conservation today is widely represented as that which feeds in to marketised exchanges of ecotourism, trophy hunting, payments for ecosystem services, biodiversity offset schemes, etc. Economic valuation of ES has already permeated through many levels of decision-making and governments, as the UK government's current White Paper on the environment writes:

> *Economic growth and the natural environment are mutually compatible. Sustainable economic growth relies on services provided by the natural environment, often referred to as "ecosystem services"... Too many of the benefits we derive from nature are not properly valued. The value of natural capital is not fully captured in the prices consumers pay, in the operations of our markets or in the accounts of government or business"* (DEFRA, 2011: 4)

As Sullivan (2012) criticises, there is a systemic embrace of 'green growth' and neoliberal conservation to mediate, mitigate and govern environmental damage. If done successfully, it is argued that economic valuation can deliver benefits, such as improving our understanding of problems and trade-offs relating to natural resource management and different land use options by illustrating the distribution of benefits, which can inform decision making processes dealing with ecosystem management (Chee, 2004). It has also been argued that economic valuation can increase awareness of the importance of ecosystems, and can therefore support decision-making with regards to land use changes and policies (Constanza *et al.*, 2014).

On the other hand, whether economic valuation is the most effective way to ensure conservation of 'natural resources' and ecosystems is highly debatable and comes with many critiques: by Büscher *et al.* (2012) and Sullivan (2012) it is seen as an anthropocentric, commoditised view of 'nature', where 'nature' is in service to humanity and has an economic value only if people consider it desirable and are willing to pay for it (Chee, 2004; Villagómez-Cortés and del-Ángel-Pérez, 2013). Further complications that I will expand on include the following:

1. Values are difficult to categorise
2. Values are subjective
3. Values are difficult to determine (e.g. they change with time and scarcity)
4. An individual's perception of wellbeing is not the same as the value of an ecosystem as a whole
5. There is a difference between individual and shared values
6. Economic valuation is based on an assumption of human rationality

Firstly, values are difficult to categorise. There are many different types of values and benefits, and these are categorised by different people in many different ways. The MA (2005) and TEEB (2010) distinguish between economic, social and ecological benefits of biodiversity. Kumar and Kumar (2007) give further examples of the various meanings of the word 'value', such as 'intrinsic value' (the value of something that may have a use value but no market value), 'existence value' (the value attached to e.g. knowing a species exists, even if there is no contemplation of ever actively using or interacting with the species) and 'market value' (e.g. the price of a commodity or service in the open market), which are also all dependent on context.

Secondly, values are subjective (Kumar and Kumar, 2007; Kenter, 2016b). As values differ between people, issues of 'whose values count' are introduced when making resource management and conservation decisions, with it also being vital that policies for ecosystem conservation are appropriate to local contexts and perspectives (Ninan and Inoue, 2013). For example, in any human community with strong cultural and/or spiritual values related to biodiversity, it may be difficult for non-local researchers to fully understand and deal with these in their research, leading to them being frequently discounted (Christie *et al.*, 2012).

Values are difficult to determine as they are dependent on individual and societal preferences that constantly change with time and are influenced not only by current local economy, but also social interactions, cultural practices and political landscapes (Kumar and Kumar, 2007, Kenter, 2016b, Reed *et al*., 2017). Human preferences, and hence economic values assigned to an ES, can change with time and scarcity; i.e. the scarcer a resource, the greater its economic value, with changes in markets also dependent on changing preferences that are themselves dynamic (Chee, 2004; Kumar and Kumar, 2007; Farley, 2012). Furthermore, when attempting to value an ES, through methods such as willingness-to-pay (WTP); economic values which people relate to a good or service may not properly reflect the true value to their wellbeing in situations where incomes are low and people heavily rely on biodiversity for their livelihoods (Hearne, 1996; Abaza and Rietbergen-McCracken, 1998). This is certainly an issue where fishing is both a subsistence activity and one of the main sources of income for local communities. Lastly, Chan *et al.* (2012) write that some values are such central elements of worldviews (e.g. religious/spiritual values) that it is unlikely that people are able (and willing) to put a monetary value on these. Values can therefore be very challenging to determine.

The concept of 'value' in economics is a measure of the contribution of something to human (economic) welfare (Villagómez-Cortés and del-Ángel-Pérez, 2013). This type of value is determined by "*an individual's own perception of wellbeing…and is therefore not the same thing as the value of an ecosystem and its services*" (Villagómez-Cortés and del-Ángel-Pérez, 2013: 280). Economic valuation therefore introduces issues of justice and equity (see Martin *et al.*, 2013) and as Farley (2012) writes: a system that weights preferences by purchasing power will generally allocate resources towards the wealthiest individuals in a society, which has obvious moral implications. An individual's perception of wellbeing is therefore not the same as the value of an ecosystem as a whole.

Thirdly, there is a distinction to be made between individual and shared values (Kenter, 2016a). The latter result from systemic learning and a broader set of transcendental values that include broader social concerns. They are the values "*we hold in common, as communities, cultures and societies, formed through a long-term process of socialisation, or over a shorter period of time through shared social and deliberative processes*" (Kenter, 2016b: 175). Conventional economic analysis, which focuses on the individual's perception of welfare therefore may not fully account for shared values of ecosystem services (Irvine *et al.*, 2016).

Lastly, the assumption of human rationality (i.e. that the choices we make are all based on rational decision-making processes) is central to mainstream neo-classical economics (Kumar and Kumar, 2007; Stanovich, 2013; Parks and Gowdy, 2013). Humans tend to be less rational than we like to believe (Stanovich, 2013). When considering 'values' this also assumes that a) people have accurate and sufficient knowledge of values and costs of various things and b) that they will make rational choices based on these. However, human decision making is more complex than this: having irrational aspects to it such as tendencies for people to make choices based on social, environmental, psychological context and emotions rather than purely based on objective rationale (Stanovich, 2013). A move towards 'biocultural' conservation research thereby needs to move away from the rational choice model and consider norms and morals along with cultural, memory and linguistic variables when evaluating ES, their effects on human health, their aesthetic contributions and their significance for future generations (Kumar and Kumar, 2007; Pooley *et al.,* 2013). This would better reflect the dynamic and complex nature of human-ecosystem interactions.

2.1.2. Should we use economic valuation?

Whether economic valuation should be attempted is therefore a question for debate. As Ecology 101 teaches students that "*everything hangs together with everything else*" (Büscher *et al.*, 2012: 8), only by embracing this complexity, which is at the heart of ecology and environmental conservation, can conservation have any chance of succeeding. As Büscher *et al.* (2012: 8) write:

> *"To further bring conservation into capitalism, then, is to lay bare the various ecosystemic threads and linkages so that they can be further subjected to separation, marketization, and alienation, albeit in the service of conservation rhetoric."*

With my aims of exploring, untangling and re-tangling the SES, this separation and alienation as Büscher *et al.* describe above introduces a clear tension.

Thereby, conservationists have also found themselves in a new paradigm fraught with contradictions. Neoliberal approaches may provide benefits, but they do not automatically benefit local human communities and the environment (see Igoe and Brockington, 2007). As Büscher *et al.* (2012) and Igoe and Brockington (2007) write, conservationists should keep in mind that neoliberalism is about facilitating the spread of free-markets, and any (dis)benefits to humans and the environment are only side-effects. Ehrenfeld (2008: 1092) convincingly writes:

> *"Trusting to market forces and the laws of supply and demand to correct inequities and restore healthy equilibria does not work in economics and certainly does not work in conservation"*

So, why are some conservationists clinging on to the ES paradigm with a focus on economic valuation? Indeed, there may be practical reasons with all the "*appealing promises*" of neoliberal conservation (Igoe and Brockington, 2007: 434; Martin *et al.*, 2013). Perhaps conservationists are feeling that they have to assimilate to capitalists approaches in order to try to save what they love; as Martin *et al.* (2013: 169) write, even global NGOs feel that they have to assimilate to this "*dominant way of thinking*". This however means that any challenges to the neoliberal ascent in conservation will never gain momentum if alternatives are not proposed, or at least a constructive action is suggested to build upon.

2.1.3. Towards alternatives: Cultural Ecosystem Services as a starting point

This thesis argues that rather than just discarding the ES construct altogether, it needs to be adapted and to learn from other approaches: ultimately moulded into something new that builds on what has been learnt from the ES concept. In line with other authors, this thesis argues that there needs to be a re-focus away from economic valuation, with a greater consideration of social values such as mental wellbeing, religious, spiritual and cultural values (Christie *et al.,* 2012). Within the ES paradigm, these social values are usually considered under the category of ‘cultural ecosystem services’ (CES). CES can be defined as: “*ecosystems’ contributions to the non-material benefits (e.g., capabilities and experiences) that arise from human–ecosystem relationships*” (Chan *et al.*, 2012: 9). In humans, identity is culturally and socially produced and is influenced by the local environment (van Berkel and Verburg, 2014). Cultures, family histories and sense of self are connected to and strengthened through interactions with our landscapes (see Reed *et al.*, 2017). In turn, these landscapes are themselves created out of our understanding and engagement with the world around us (Bender, 2002). Landscapes and the interaction with our landscapes, as well as the meanings attached to different landscapes are therefore not static, but ever-changing (Bender, 2002). This problematises the assessment of CES, as each individual’s experience and history with a landscape will be different, and therefore the overall connection between people and their surrounding environment can be challenging to assess. However, this also illustrates how CES can begin to introduce the complexity that this thesis calls for within the ES framework itself and therefore seems like a productive step.

As there are many ES that are rarely, or cannot be, traded directly or expressed in economic terms (Kenter *et al*, 2011) and it is generally difficult as well as ethically problematic to assign economic values to all CES, these services tend to lack appreciation and attention in policy-making. This weakens the appreciation of the complex role which ecosystems play in maintaining livelihoods and human wellbeing (Kenter *et al.*, 2011; Chan *et al.*, 2012). It will always remain meaningless to attempt to ascribe economic valuation to certain CES (such as cultural identity) as these values will differ between individuals over time and space (van Berkel and Verburg, 2014). While CES may not be responsible for the clean water and sufficient food needed for our basic survival, they are what sustain our psychological needs: our sense of wonder, our inspiration, our (religious) beliefs and our sense of self and identity which are all necessary to make human life worth living and to achieve 'wellbeing' (Frumkin, 2001; Klain and Chan, 2012). Even in the current world, where the number of people in urban areas has surpassed those in rural (Beatley, 2011) there is still an inherent human biophilia that makes 'nature' *essential* for human wellbeing (see Ulrich, *et al.,* 1991; Beatley, 2011). By failing to adequately consider these vital 'services' in ES assessments, it will not be possible to understand the true and complete links between people and their environment leading to inaccurate and unworkable assessments and findings, and potentially unworkable conservation policies. It is furthermore often these intangible benefits, not economic ones that motivate people to protect and restore ecosystems (Daniel *et al.*, 2012).

2.2. Chapter conclusion

Considering values of ES, environmental degradation and how to manage our environments and ecosystems more sustainably (in all senses of the word), demands an understanding of human behaviour and attitudes (Clayton and Opotow, 2003), and how we decide what is important and translate this into actions. It is also clear that the social and cultural values of ecosystems and their resources cannot be calculated as a sum of their economic values to individuals in society (Kumar and Kumar, 2007). Economic valuation methods furthermore do not fully address the complexities related to human attitudes, motivations and behaviour. As Kinzig (2001: 709) writes;

> *"Solving today's environmental problems requires an understanding of the complex ways in which nature and society interact to make a whole that is different from the sum of its parts"*

The moral and ethical issues in pricing 'nature' are abundant, and often argued to be counterproductive to conservation. This thesis therefore does not make an attempt at economic ES valuation. It does however argue for the need to further highlight and integrate the complex CESs within the ES framework.

However, there are still some main critiques of the ES framework that need to be explicitly dealt with: such as the anthropocentricity of the approach. As I introduced in Chapter 1, I use MTHG to balance this critique of ES. This is the next 'step' that I take in this thesis as further explained in the following chapter, and will slowly see me veering away from ES vocabulary.

CHAPTER 3

Assemblages: Common ground and bridging concepts?

In previous chapters the Ecosystem Service (ES) and interdisciplinary approaches used in this thesis were introduced. Here, I clarify the use of Assemblage Theory (AT) and how this supports the Interdisciplinary Assemblage Approach (IAA) by providing a framework for analysis. AT also belongs under the More-than-Human Geographical (MTHG) approach that this thesis takes to balance some of the main critiques and shortfalls of the ES paradigm highlighted in Chapter 2. The IAA will be used to untangle and re-tangle the intricate net of a 'socio-ecological' system (SES). SES are complex and dynamic; they are composed of multiple interacting and relating components and they experience potentially large and diverse uncertainties (Nuno *et al.,* 2014). This 'unruly complexity' leads to generalisations being difficult, along with a need for constant engagement and adaptive management with the system and the situation (Taylor, 2010). Using AT and MTHG, I further intend to unsettle the idea of nonhumans as 'other' that is perpetuated by the ES paradigm.

I build the IAA framework based on DeLanda's (2006; 2011; 2016) approach to AT. In the analysis chapters of this thesis I will illustrate the agency and ability of assemblages and their components to affect eachother, taking the fish and spirit communities as an example of how this can be extended to nonhumans. The fish, spirits and humans are acting and being acted upon by each other and these relations are what shape and determine the assemblage. I therefore consider the complexity of human-nonhuman relationships, discuss the performative and agentive aspects of the assemblage (what it does and how it functions), consider associations and relations as basic elements of analysis, and aspects of territorialisation and deterritorialisation in the form and function of an assemblage.

In this chapter I will first explain the theoretical background to using this AT approach, comparing the use of 'assemblage' in both ecological literature and theory, and social philosophies and MTHG. I will then demonstrate that the parallel vocabulary and language, along with concepts and approaches of both 'ecological' and 'social' assemblages, can be innovatively used to bridge disciplines and support the interdisciplinary approach of this thesis. I argue that assemblage-thinking along with the interdisciplinary approaches it can foster allow a more holistic view of conservation decisions and management options, and further can be used to reflect on historical experiences to inform current and future actions. Thereby, to support biocultural approaches to conservation. I intend to illustrate this through the analysis chapters (Chapter 6, 7 and 8). I also use MTHG approaches to resist the tendency of capitalist values to 'flatten' and 'deaden' non-human natures into "*abstract and conveniently incommunicative and inanimate objects, primed for commodity capture*" (Büscher *et al.*, 2012: 23). This is done by discussing the agency of nonhuman beings, to not render these mute (Curry, 2008; Sullivan 2012) and to embrace a world that is much 'messier' than the neoliberal ideal suggests (Igoe and Brockington, 2007).

3.1. More-than-Human Geographies as a balance to the Ecosystem Service Approach

In MTHG, geographers approach the nonhuman and material with the aim of deviating from an anthropocentric understanding of the world and challenging the privileging of human beings in the concern of environmental change (Lorimer, 2012). This also involves attempting to better understand the world through the relationships between human and nonhuman beings (Gibbs, 2009). It does this by focusing on the agency of nonhumans, relationality, power, hybridity, vitality and emotion (Gibbs, 2009). With its focus on decentralising and de-powering a human-centred view of the world, I use MTHG to tackle the inherently anthropocentric approach of ES. This furthermore allows me to move away from the rational choice model of ES economic valuation, with a consideration of more social values such as spiritual and cultural values, the dynamic nature of these subjective non-economic values and centralising a more holistic approach to wellbeing (which is not equated to economic income/values). I therefore have a starting point very much within ES framing in terms of literature from the cultural ES (CES) (e.g. non-economic valuations), however I take the further step of considering the ES paradigm critically, with its embedded and problematic anthropocentric framing, through the use of MTHG. During the course of the thesis, the ES vocabulary will disappear, instead leaving a stage for the IAA approach and its language. However, in the analysis chapters the parallels between the ES approach and that of the IAA will remain evident, particularly in my consideration of fish as food, as a source of livelihood, and the spiritual/cultural links to fish and fishing, to name a few.

In this first section of Chapter 3, I outline the rationale behind using AT as the framework for the thesis. The reasons for using AT are multiple: it provides certain tools and opportunities which actor-network theory (ANT) and nexus thinking do not, as will be discussed in coming sections. With the language having a certain familiarity, writers on AT drew me in to their work through using examples that were familiar from my 'natural' science and ecological background, using terminology that may have meant slightly different things, but was familiar nonetheless. Drawing on Anderson and McFarlane (2011: 126) the use of assemblage as an ethos resonates with me personally as an engagement with the world that "*experiments with methodological and presentational practices in order to attend to a lively world of differences*". In this way, work that utilises AT experiments, opens the researcher up to risks, embraces uncertainty and aims to express "*something of the fragility of composition*" of the world (Anderson and McFarlane, 2011: 126). The following paragraphs will further clarify my approach and choice of AT over ANT and nexus thinking, further elaborating on the main differences between these approaches as illustrated in Table 3.1 below.

Table 3.1: Some of the main differences identified between Assemblage Theory (AT), Actor-network Theory (ANT) and nexus thinking (Nexus)

	AT	ANT	Nexus
Deals with **heterogeneous** 'groupings'	✓	✓	✓
Considers **change**	✓	✓	✓
Takes a **relational** approach to the world	✓	✓	✓
Relations are **contingently obligatory**	✓	×	?
Emphasises **emergence**	✓	✓	×
Considers **humans and nonhumans**, and places these on an **equal footing**	✓	✓	×
Deals with **capacities** and **unpredictable** potentials	✓	×	×
Provides a space to consider **desire/emotion** as creating and sustaining relations in the system	✓	×	×

3.1.1. Why Assemblage Theory over Actor-Network Theory?

Actor-Network Theory (ANT) was an important development for sociology in the 1990s and uses the concept of the network as a unit of analysis to describe heterogeneous assemblages. As Müller (2015: 30) writes, ANT is sometimes thought of as the "*empirical sister-in-arms*" of the more "*philosophical*" AT. Like assemblage thinking, ANT is also concerned with how entities are ordered, socially and materially, with this ordering being provisional and constantly undergoing change (Müller, 2015). ANT and AT approaches share productive similarities (see Müller and Schurr, 2016), with both placing all entities on an equal ontological footing to begin with and both focusing on how the social and the material (physical aspects of the world) undergo processes and interactions (Müller, 2015). Both view the world relationally, emphasise emergence, and the associations between human and nonhuman elements (Müller and Schurr, 2016).

While ANT and AT resonate in many ways with each other, there are still some key differences between these approaches. ANT originally considered the network as a 'seamless whole' that fully assimilates its component parts (Anderson *et al.,* 2012): "*if the unity and consistency of the entity-environment relationship were interrupted at some point, the existence of the entity would be imperilled*" (Stamou, 2012: 73). This contrasts with AT where relations are viewed as *contingently obligatory:* entities are affected by relations and by the other terms they are related to, but they are not fully determined by those relations/terms (DeLanda, 2006: 11). One can therefore detach an entity and re-plug it to become a part of a new assemblage, as will be further discussed in Section 3.2.1. When considering ecosystems, the superorganism concept, comparable to the seamless whole of ANT, would work as an appropriate representation of reality if ecosystems were "*fully integrated units subject to pure group selection*" (Loreau, 2010: 254). However, as Loreau (2010) writes, most ecosystems are not so fully integrated and localised to be free of individual selection, and with the usual combination of individual as well as group selection the seamless whole, and thereby ANT, is not appropriate to apply to ecosystems.

AT and ANT have moved towards each other, particularly in the 1990s when authors dealing with ANT began embracing fluidities (Müller and Schurr, 2016). This suggests that relations can change gradually without the actor falling apart, which is a development from the seamless whole conceptualisation (Müller and Schurr, 2016). This moves ANT closer towards the approaches so integral to AT such as "*blurred boundaries and shifting topologies*" (Müller and Schurr, 2016: 22).

However, Müller and Shurr (2016) write that there are still some main differences relevant to this thesis. The first revolves around capacities and the still unknown. ANT deals with the unknown and unpredictable potentials in a system through, for example, Latour's invocation of a "*strange figure of plasma*" to stand for "*that which is not yet formatted, not yet engaged in metrological chains and not yet covered, surveyed, mobilized or subjectified*" (Latour, 2005: 50 note 48). Instead of using this very abstract approach, AT uses a distinction between assemblage element properties and capacities:

> "*where properties are given and known, while capacities are open and unpredictable*" (Anderson *et al.*, 2012: 179)

With its approach of seeing the world through associations and not considering the unpredictable capacities of entities, ANT has been criticised for "*being blind to what remains outside associations but may shape them nevertheless*" (Müller, 2015: 31). AT therefore offers "*a greater conceptual openness to the unexpected*" and pays more attention to impermanence and change compared to ANT (McFarlane, 2011: 654; Müller and Schurr, 2016).

Müller and Schurr (2016) go on to discuss desire/wish as the link between the actual and the virtual, and the usefulness of this approach within AT of conceptualising the formation and breaking-down of assemblages. It takes a central role in AT, with Deleuze and Guattari (1987: 399) writing:

> *"Assemblages are passional, they are compositions of desire.... The rationality, the efficiency, of an assemblage does not exist without the passions the assemblage brings into play, without the desires that constitute it as much as it constitutes them".*

For example, a wish for economic profit will lead people to act in certain ways, and a wish to go to a certain school can lead to people moving to another area. This aspect of desire is important to consider when looking at how assemblages form or dissipate. This is another contrast to ANT, as in assemblages desire would result *from* the assemblage as a more passive consequence, "*and bodies would learn to desire through the assemblage*" (Müller and Schurr, 2016: 226) while AT deals with how desire acts to *create* and *sustain* an assemblage. By considering desires and wishes, I draw parallels to the concept of values in CES as coming from relationships between assemblage elements and thereby from the assemblage itself (i.e., how it forms, functions and changes). A person's desires, needs and values can all significantly influence the outcomes of conservation projects (Gould *et al.*, 2015). Both desires and values can generate reasons for acting, and values can influence desires (Hubin, 2003). As Hubin (2003) and Smith (2009) illustrate, the relationships between desires and values are complex, and go far beyond the realms of this thesis (and apparently involve another duality between value-based and desire-based theories which I look forward to tackling in the future!). The point I will make here, though, is that there are parallels to be drawn and at least primarily engaged with between desires, values and the formation of the assemblage. I explore this further in the analysis chapters (6, 7 and 8).

AT, therefore, avoids totalisation and the seamless whole of historical notions of ANT (Anderson *et al.,* 2012; DeLanda, 2016). AT allows the autonomy and agency of component parts which permits us to deal with and analyse the importance and use of these separately as well as in relation to other components of the assemblage and the assemblage itself. AT is more open to the unpredictable events that rupture assemblages (Müller and Schurr, 2016) and allows this thesis to better deal with unpredictable forces and relationships. AT allows the concept of desires to be considered as key to assemblage formation and dissipation, taking an active rather than a passive role in the system. It furthermore resonates very much with ecological approaches to assemblages, both in terms of vocabulary used and concepts of resilience, change and communities. This will be further explored in Chapter 3.2.

3.1.2. Why Assemblage Theory over Nexus thinking?

Another approach that involves a similar consideration of 'systems' and that has also become popular in Geography is 'Nexus thinking'. From the late 2000s, the water-energy-food (WEF) nexus has been increasingly promoted as a global concept and research agenda, and an emerging development and environmental management paradigm (Leck *et al.*, 2015; Al-Saidi and Elagib, 2017). It was first conceived by the World Economic Forum (2011) to emphasise the inseparable links in resource use to provide food, water and energy security (World Economic Forum, 2011; Biggs *et al.,* 2015), and to tackle the mismanagement of these resources and deal with increasing resource scarcity (Leck *et al.*, 2015; Howarth and Monasterolo, 2016; Al-Saidi and Elagib, 2017). It also calls for a holistic approach to analysis of complex adaptive systems and to understanding the (un)intended consequences of policies, technologies and practices (Howarth and Monasterolo, 2016). An example of the WEF nexus can be seen in the close relationship between biofuels, food and water security, where biofuel production can have both positive and negative effects on food and water security (Leck *et al.,* 2015). There can also be unintended effects of subsidised biofuels by generating increased competition for land and water (see Leck *et al.*, 2015 for further examples). The nexus can have stressors such as climate change, which has implications for water availability, agricultural production and some parts of energy production and demand (Leck *et al.*, 2015).

Nexus thinking is therefore meant to encourage 'socio-ecological' perspectives and a systems approach to planning and decision-making (Davis, 2014). However, this holistic systems approach has not always been fully applied, with nexus research facing a challenge in developing effective analytical frameworks to support interdisciplinarity (Leck *et al.*, 2015). There are a multitude of ways to frame the nexus, from some studies based upon a security framing which tends to focus on supply chain concerns (and neglects impacts on biodiversity and land-use change), to others such as 'foot printing studies' concentrating on environmental impacts (and underplaying economical and societal consequences) (Keairns *et al.*, 2016). Lastly, political and economic considerations tend to be under-represented in nexus research and there is a need for more emphasis on bottom up ways of interpreting the relationship between water, food and energy (Leck *et al.*, 2015). Nexus approaches are centred on 'resource use', 'supply of commodities' and the interconnectedness of 'systems' or 'commodities' (see Hulley, 2015; Keairns *et al.,* 2016). Keairns *et al.* (2016) focus strongly on the nexus as a consideration for the analysis of supply chains and the distribution of products. Therefore, while being described as a holistic approach, there is evidence that it is taking a very anthropocentric and market-centric view of the world, which only furthers the issues that arise from strictly economic approaches to 'wellbeing' and the commodification of the environment and environmental 'resources'. It therefore provides no tools for this thesis to balance the critiques of the ES approach.

There are critical differences between nexus approaches and AT, with the nexus approach not allowing for dealing with nonhuman agency, relations of exteriority or virtualities such as desire and emotion. Nexus thinking is also more involved in understanding between-system complexity (e.g. between the food system, water system and energy system), rather than within-system complexity as AT does. This underpins the choice of using the AT approach instead of the nexus approach in this thesis to better balance the critiques of the ES approach (already an anthropocentric approach).

3.2. Comparing Assemblage Theory and ecological concepts of assemblages: Towards my Interdisciplinary Assemblage Approach

I have outlined my reasons for taking an AT approach, in contrast to ANT and nexus approaches. This section highlights some differences between the variants of AT (that of Deleuze and Gautarri and that of DeLanda), how AT and ecological ideas of assemblages overlap and differ, shortfalls of DeLandian AT and how these are all reconciled to form the Interdisciplinary Assemblage Approach (IAA) on which I base this thesis.

In the following paragraphs, I build on the previous discussion of AT, and further expand on and compare the various definitions and characteristics of 'assemblages' in ecological and social-science settings. This includes notions of emergence and relations of exteriority, stability and change, coding and how this relates to ideas of capacity and capability, and lastly, issues of space and time. Importantly, the following paragraphs highlight how not only the concepts of assemblages in the ecological and the 'social' sciences are strikingly similar, but also the language. In Chapter 1, I explained the importance of language in tackling interdisciplinary research, and so these similarities in ecological and social philosophical language are pertinent; even if the intended meanings of 'assemblage' have some key differences, they still resonate with each other. Many of these terms that I discuss below, including assemblage, resilience, coding, emergence etc., already had a sense of familiarity to me, even if I had to broaden my understanding of them. The leap between the 'social' and 'natural' sciences therefore felt less daunting. I then deal with and explain the determining characteristics of assemblages to clarify the lens of analysis and the vocabulary that will be used in Chapters 6, 7 and 8.

3.2.1. Definition of assemblages in Levinsian ecology and DeLandian social philosophy

This thesis adopts the perspective of assemblage theory as outlined by DeLanda (2006; 2016). DeLanda's (2006; 2016) approach to assemblages differs slightly from Deleuze's and Gautarri's (1987) original approach. Firstly, Deleuze considered heterogeneity a determining characteristic of an assemblage which differentiates it from a strata, and would argue that species are not assemblages themselves (DeLanda, 2006: 11). As Deleuze writes:

> "*What is an assemblage? It is a multiplicity which is made up of heterogeneous terms…It is never filiations which are important, but alliances, alloys; these are not successions, lines of descent, but contagions, epidemics, the wind.*" (Deleuze and Parnet, 1987: 69)

DeLanda (2006) argues that as Deleuze explicitly excludes successions and lines of descent, organisms and species would instead be classified as *strata*. This distinction between assemblages and strata is not retained in DeLanda's approach to AT, and is a key difference between his and Deleuzian AT. DeLanda argues for a consideration of heterogeneity and for the level of coding to be positioned on a spectrum: a dial that you can move up or down, increasing or decreasing heterogeneity and coding and therefore able to consider both more and less heterogeneous and/or coded systems (DeLanda, 2006; DeLanda, 2016). I explain coding in greater detail in Section 3.2.2.

Conceiving heterogeneity as being on a spectrum allows for the consideration of not only species but also biological organisms and individuals as assemblages, as DeLanda expresses below:

> "*Assemblages have a fully contingent historical identity, and each of them is therefore an individual entity: an individual person, an individual community, and individual organisation, an individual city.*" (DeLanda, 2016: 20)

Following DeLanda's approach to assemblages allows this thesis to consider assemblages of assemblages (DeLanda, 2016: 3): a never-ending scale-changing relationship between smaller and bigger assemblages; from an individual fish, to a fish species, to a community of different species, and the ecosystem that the fish belongs to. This allows me to use the concept of assemblages to 'tackle the scales' in my thesis (further discussed in Section 3.2.5).

Following Deleuze, DeLanda (2006) posits that assemblages are made up of different heterogeneous components and that the relationships between these components lead to the assemblage having emergent properties (properties that are different or more than the mere sum of their parts). In his books, DeLanda (2006, 2016) describes ecosystems as assemblages and species as assemblages of organisms:

> *"Entities ranging from atoms and molecules to biological organisms, species and ecosystems may be usefully treated as assemblages and therefore as entities that are products of historical processes"* (DeLanda, 2006: 3)

Furthermore, an assemblage is constituted of material and expressive components (DeLanda, 2016); material components include the physical bodies in the assemblage and their proximity, e.g. the rivers, the houses in the villages, the roads between villages, the plates, the fishing nets, the tables, and the list continues. Expressive components include beliefs and attitudes, expressions of solidarity or trust (DeLanda, 2016). I use these two distinctions in Chapter 6 when identifying assemblage components.

In ecology, communities are often seen as assemblages, with Whittaker (1975: 1-2) defining a community as "*an assemblage of populations of plants, animals, bacteria and fungi that live in an environment and interact with one another, forming together a distinctive living system with its own composition, structure, environmental relations, development, and function*". Likewise, Callenbach (2008) describes communities in 'nature' as being groupings of different organisms which are regularly found in the same place at the same time. These groupings, Callenbach explains, are not absolutely fixed, and within these communities, species have complex webs of interdependence. Levins and Lewontin (1980: 139) further assign the following properties to a community (with my comparison to DeLandian AT in square brackets):

> "*The community is a contingent whole in reciprocal interaction with the lower and higher level wholes, and not completely determined by them* [≡ relations of exteriority]…*There are properties at the community level which are definable for that level and which are interesting objects of study regardless of how they are eventually explained* [≡ emergence]…*The way in which a change in some physical parameter or genetic characteristic of a population affects the populations in community depends both on their individual properties and the way the community is structured* [≡ coding, (de)territorialisation and the nature of systemic relations]"

Here we see, as in the DeLandian understanding of an assemblage, there is a focus on wholes made up of parts, emergence, interaction and interconnectedness as well as coding (the latter is discussed further in Section 3.2.2). While an organism is usually not considered an assemblage in ecological terms, Whittaker's, Callenbach's, Levins' and Lewontin's definitions of community have a clear similarity with Deleuze's and DeLanda's assemblage concept, with the latter explicitly dealing with ecosystems and species as assemblages.

One main action that I take in the formation of the IAA is to borrow from DeLanda's AT an approach to 'assemblage' that includes not only communities but also species and individual organisms. I therefore develop the ecological approach to assemblages which only describes communities. As DeLanda (2011: 184-185) writes,

> "*The fact that the properties of a whole depend on the actual exercise of the capacities of its parts implies that removing one of them may indeed destroy the whole's identity, but the part itself need not lose its own identity: pulling a live animal's heart out will surely kill it but the heart itself can be implanted into another animal and resume its regular function…it will be useful to introduce a new word for whole that are*

irreducible and decomposable. We will refer to these wholes as assemblages.*"*

This explains how an individual 'animal' can be an assemblage, built up of various organs, with its own emergent properties and capacities. Removing one organ may lead to the assemblage not existing anymore: the animal dies. However, the assemblage element of the heart does not cease to be a heart, it can still be transplanted into another 'animal' and continue to be the same heart. Furthermore, an artificial heart may be able to be transplanted into the first 'animal'. In this sense, the assemblage elements may change, but the assemblage as a whole continues. This argument as to why an individual person can be considered an assemblage, to me, is sufficiently compelling. The further fact that there is an equal amount of bacterial as human cells in the human body (Sender *et al.,* 2016) also further breaks down this conception of human bodies being an indivisible whole.

There are other notable differences between ecological assemblages and assemblages in AT, with one clear difference being the importance of desire, emotion and intentionality in AT, (Section 3.1.1), which is lacking in ecological assemblages. Basing my IAA on AT allows me to consider these aspects of desire, and the importance of emotion in forming certain assemblages, which as aforementioned plays into debates surrounding values and CES. Further differences between the ecological and AT approach to assemblages, along with similarities, are explored in the following sections in relation to certain key characteristics of assemblages as defined by DeLanda (2006, 2011, 2016), such as coding, relations of exteriority, emergence, stability, resilience and scale.

3.2.2. Coding

As mentioned in Section 3.1.1, properties of assemblage elements are given and known and their capacities are open and unpredictable. Coding can determine various properties and capacities of assemblage elements; this is a term used both in DeLanda's AT approach, as well as in ecology; e.g. genetic codes. Coding involves certain structured interactions to be determined by properties of the assemblage elements, for example genes which, made up of long DNA molecules, provide to some extent a script for how an organism can develop and behave (Callenbach, 2008). Coding causes an assemblage element to behave in a certain way to form relationships with other elements in an assemblage (DeLanda, 2006), such as the licking reflex of bees when their antenna touches a sugary solution (DeLanda, 2016). When looking at trophic levels, genes, or coding, will play a role in determining an organism's place in the food chain. In ecological theory, the properties that emerge at the ecosystem level, from the local to the global scale, are also linked to the traits of the organisms constituting ecosystems, and these traits are the result of evolution, and their genetic composition (Loreau, 2010: 227).

Additionally, certain discourses are a linguistic form of coding, such as an environmental discourse seeking to protect an ecosystem, which will lead to certain relationships occurring between assemblage elements (e.g. how people relate to their environment or other people) (DeLanda, 2016). The relevance of this will become clear in discourses of the 'outsider' and 'relevant animals' in Chapters 6, 7 and 8. Linguistic coding plays a role in shared stories and categories that can emerge through conflict of varying degrees between two or more communities (DeLanda, 2006:58). This leads to the narrative of 'us' versus 'them', as well as stereotyped ethnic or racial categories as part of the process of "*group boundary construction*" (DeLanda, 2006: 59). In AT, stories of conflict and the categories of 'insiders' and 'outsiders' "s*erve to code and consolidate the effects of territorialisation on interpersonal networks*" (DeLanda, 2006: 59). Examples of this type of coding will discussed as a prominent narrative in this thesis, particularly in Chapter 8.

Linguistic forms of coding can also include written or verbal rules which are official or informal, standards and constitutions, and even identification keys used to identify and thereby categorise species in ecology. Linguistic coding therefore also relates to knowledges and how these are formed and communicated. In territorialised, close-knit communities local norms are another process of coding, and as DeLanda (2006: 35) writes:

> *"In the networks characterising tightly knit communities…News about broken promises, unpaid bets and other not-honoured commitments travels fast in those networks: a property that allows them to act as enforcement mechanisms for local norms"*

Through coding, people organise and relate to the world in a certain way and some relationships can be more coded than others: just like the level of territorialisation, the level of coding can be found on a spectrum (DeLanda, 2016). This includes environmental governance, and relations between humans and nonhuman being, including different worldviews and forms of knowledge to understand the human and nonhuman (the latter also determines relationships between the human and nonhuman). This is not explored by DeLanda, nor the relevance of coding to dealing with diverse knowledges or bridging academic disciplines. These are additional key gaps addressed by this thesis.

Coding therefore can determine the occurrence of certain relationships between assemblage elements, as well as the properties and capacities of assemblage elements. Properties, i.e. the known and already expressed attributes or characteristics, of assemblage elements are therefore able to be evaluated, but for capacities this becomes trickier. Capacities are well described by Harman (2008: 374):

> *"We are all the prey of chance, since we all have capacities not unleashed in our current situation, but which may become crucial when certain random events occur. You may be the only reader of this article with the right genetic structure to survive the coming plague of ebola, and hence one of the few who will survive to replenish the human species afterward—ensuring that your other, more peripheral quirks will emerge as key structural features of the human race to come."*

Capacities are unpredictable and their effects remain unclear until a certain event causes them to be expressed. Discussion of capacities is therefore always in the realm of the potential, not in the actual (DeLanda, 2011). Thus, focus in this thesis is placed on properties rather than capacities as capacities are so far unknown, unless of course they have been exercised in the past. In the case of the latter, these examples of capacities will be highlighted to further illustrate the use of the IAA and its applicability. This thesis also refers to potentialities of the future, but avoids too much of this in fear of it becoming merely a hypothesising exercise.

While genes are passed down and inherited through generations, there are also unpredictable events such as genetic drift that cause a 'decoding' event. Similar errors or changes can be introduced into linguistic coding, when passed down over time. Speciation is a process of decoding, or 'recoding' as it is a process which allows the assemblage a certain flexibility in operation (Ditmer, 2014). Therefore, processes which consolidate the identity of the assemblage through determining certain relationships are coding processes, and the opposite a decoding process: when informal rules are undermined and go unpunished, when religions mix or past traditions are lost (DeLanda, 2006). In both DeLanda's AT approach and ecological theory, we see that coding leads to certain properties and capacities of assemblage elements and this is another key aspect that I consider in my IAA of the Sabangau area.

3.2.3. Emergence and relations of exteriority

Relations of exteriority are a defining characteristic of AT, with an emphasis on bringing heterogeneous entities together into some form of temporary relation, without the presumption that these relations determine the individual entities themselves (Anderson *et al.*, 2012). They can therefore be 'plugged' into and out of different assemblages and exist outside of their relationships to other elements (as previously discussed with the animal heart):

> *"The property of density, and the capacity to store reputations and enforce norms, are non-reducible properties and capacities of the entire community, but neither involves thinking of it as a seamless totality in which the very personal identity of the members is created by their*

> *relations: neighbours can pack their things and move to a different community while keeping their identity intact"* (DeLanda, 2016: 11)

Thereby, relations of exteriority allow me to block the 'macro-reductionism' of the seamless whole and the superorganism approach. I provide examples of this in my analysis chapters in relation to the assemblage that this thesis considers.

Emergent properties allow rejection, or blocking, of 'micro-reductionism' (e.g. ecological reductionism) (DeLanda, 2016). Likewise, in holistic geographical approaches, emergence is also a key concept and an emergent property can be defined as "*a process that arises from the (ontologically) intermediate system that is functionally significant vis-à-vis the specific dynamics of the higher level system*" (Bergandi and Blandin, 1998: 199). Ecosystems have long been described as having emergent properties by ecologists (see Alexander, 1920; Broad, 1925; Bertalanffy, 1952, 1968; Ashby, 1956; Odum, 1977; Simon, 1962; Levins and Lewontin, 1980; and Bergandi and Blandin, 1998). More recently, the UK National Ecosystem Assessment (NEA; 2012) described ecosystems as having the following properties:

> "*Management of the environment with an ecosystem perspective should also consider that systems have emergent properties that are not possessed by their individual components, i.e. they are more than the sum of their parts. One example is the resilience of an ecosystem to absorb disturbance and return to its original structure and functioning, such as resilience to the harvesting of crops, animals or timber*."

Therefore there are not only parallel uses of 'assemblage' but also 'emergence' in both Levinsian ecological and DeLandian social philosophical approaches which further support my use of DeLanda's AT for the IAA framing of this thesis.

DeLanda does write about ecological assemblages, including population and community ecology, symbiotic relationships and succession dynamics (DeLanda, 2011). Ecosystems and ecological relationships (e.g. predator-prey relations) are used as examples of assemblages, and in his book *Philosophy and Simulation*, he uses ecological/biological concepts to describe and explain his theory of emergence. He also extensively draws upon examples from chemistry, technology and genetics (DeLanda, 2011). However, DeLanda (2006; 2011; 2016) distinguishes between 'humans' and 'animals'. He does refer to humans *as* animals at one point: "*But even the defining boundaries of fully reproductively isolated animals like ourselves…*" (DeLanda, 2006: 27), but through the majority of his writing there is a clear human-animal distinction which seems to dip, or even plunge, into nature-culture dichotomies:

> *"In fact, in both the biological and the social realms, there are processes of decoding….In biology such decoding is illustrated by animal behaviour…A social example of the result of a process of decoding would be informal conversations between* [human] *friends…*" (DeLanda, 2006: 15-16; addition in square brackets my own for clarification)

In the above excerpt, DeLanda uses the 'human' to describe social behaviours, and the 'animal' to describe biological behaviours. In *Philosophy and Simulation*, he even describes how humans differentiated themselves from 'animals':

> "*We may conclude that when the emergence of metanorms allowed communities to solve the public goods dilemma involved in collective hunting and gathering the transition from animal to human communities was complete*." (DeLanda, 2011: 126).

While DeLanda (2006:3) describes AT as being able to cut across the nature-culture divide, taking the previous quotes with the use of 'animals' and 'humans', 'biological' and 'social' realms; this seems to be referring to the mere ability of borrowing examples from 'human' society as well as 'animal' interactions to support AT. Through his language, the nature-culture dichotomy is not challenged. Of course, this distinction between human and animal, social and biological, culture and nature, are all problematic and enforce the false dichotomies that this thesis aims to break down. I will take DeLanda's approach to AT one step further, drawing on lessons from MTHGs in its use of nonhumans which dissolve these dualities, and thereby forming an approach that is based on DeLandian AT, but is distinct from it.

3.2.4. Stability and resilience: phases and change

In MTHG, as in a Levinsian ecological approach, assemblages are temporally specific and shift over time, and consequently environmental decision-making has to be alert to the shifting assemblage and the resulting effects (Gibbs, 2013). An assemblage is the provisional holding together of a group of entities across differences, and the continuous process of movement and transformation as relations and terms change between entities: it privileges the process of formation and change (Anderson *et al.*, 2012). Change, regardless of whether we notice it or not, characterises both the 'social' and the 'natural' world. Therefore, theory generation, our approaches to philosophy of science and the representation of our world through our work have to change and be able to deal with change (Taylor, 2000). The concept of stability, thresholds and critical points are found in DeLanda's work (2006; 2011; 2016), in which he discusses the different phases of an assemblage where levels of territorialisation and coding can both change over time. DeLanda (2006; 2016) discusses the territorialising-deterritorialising axis which strengthens or weakens the boundaries of an assemblage and therefore deals with the stability and durability of the assemblage. Complex systems, such as SES, undergo changes over time due to stresses and perturbations, causing the system to shift and evolve into something different. Mirroring this approach with SES, the UK National Ecosystem Assessment (UK NEA, 2012) explains:

> *"Ecosystems can be transformed to a different level of functioning if a change in ecosystem structure crosses some threshold level. Such structural changes can be the removal of predators or other levels from the food web, or simplification of vegetation or soil structure. Thresholds can also be crossed when valued species are lost or the functioning of the water and mineral cycles significantly changes."*

Pickett and Ostfeld (1995) furthermore write about the assumptions which they propose are an effective starting point to build bridges between the scales of human and nonhuman community, landscape and ecosystem perspectives in ecology and 'social' science: including the ideas that SES are never self-contained, they rarely have stable point equilibria, they are stochastic, that future conditions have varying levels of probability and that disturbances are common system components. Again, ecological views and DeLanda's assemblage theory are strikingly similar.

When discussing territorialising forces, the idea that an assemblage has strengthened boundaries, and with increasing territorialisation becomes more stable and durable, deals with assemblage resilience. Resilience refers to the ability of a system to "*withstand or to recover from a stress or perturbation and adapt to future stresses and perturbations*" (Tuler *et al.*, 2008: 173). Resilience is a highly contested and critiqued term (see Donovan, 2017), and terms such as 'resilience' and 'vulnerability' can be used as a means of exercising power over populations (Gaillard, 2010; Reid, 2012; Grove, 2013). The idea of what constitutes 'resilience' can also be very subjective (see Donovan, 2017). Keeping this in mind, 'vulnerability' and 'resilience' can also be useful concepts, allowing for multiple social factors to be considered such as poverty, education, housing and gender (Donovan, 2017). Resilience and tipping points can be discussed in terms of SES; considering aspects such as peoples' reactions to changing environments, along with the heterogeneity or biodiversity of a system and the implications of this for the system as a whole.

Social resilience can arise from purposeful responses to change, such as moving from an area prone to flooding to a less vulnerable area uphill. Responses can include limiting exposure to a change or stress, to decrease sensitivity to it, or to limit the severity of the consequences of the stress or change (Tuler *et al.*, 2008). Ecosystem resilience is a matter of particular concern when considering the impacts of climate change and other large-scale stresses and perturbations. Ecosystems can have a great ability to withstand sudden disturbances and then return to earlier states (Callenbach, 2008). However, tipping points can arise when earlier states are unachievable and ecosystems can only move toward a new state and 'equilibrium'. Resilience and tipping points can be discussed in terms of both human and nonhuman systems, as well as SES combining the two; and therefore concepts of resilience and tipping points are also important and useful tools for interdisciplinary approaches.

As territorialising forces maintain the components and inter-component relationships in an assemblage (and thus the identity and the durability of the assemblage) (DeLanda, 2006); deterritorialising forces recombine or replace various components and roles within the assemblage, which leads to the assemblages' dissipation or reformulation (DeLanda, 2006). These forces can include climate change, population change, or other large-scale changes. This thesis provides examples of these that are relevant to understanding the assemblage (Chapter 8).

In general, ecosystems with more diversity are thought to be more resilient as they contain more species in complex interactions, which leads to niches that are more easily filled if their previous inhabitants disappear (Callenbach, 2008; Loreau, 2010). Species diversity is a measure of the compositional complexity of an assemblage and is one of the fundamental parameters in describing an ecosystem; therefore playing a central role in community ecology and conservation biology (Hastings and Gross, 2012). Biodiversity loss is likely to not only have an impact on the magnitude of ecosystem processes but also increases their variability, and therefore decreases the reliability of the delivery of ES: i.e. biodiversity loss causes a loss in ecosystem resilience (Loreau, 2010: 263). In other words, the biodiversity of ecosystems (assemblage heterogeneity) relates to measures of species richness, relationships between the elements and the closeness of the relationships between elements, and consequently therefore also to ES. Trophic levels can provide a way to recognise groups of species in a community that acquire energy in similar ways (Morin, 1999). Therefore, when considering the resilience of an ecosystem, including both its human and non-human components, we can consider people's reactions to changing environments, along with the heterogeneity or biodiversity of a system, the closeness of the relationships between elements of the ecosystem (e.g. trophic levels) and the implications of this for the system as a whole. This outlines some of the main aspects of data collection, analysis and presentation in this thesis.

3.2.5. Temporal and spatial scales

There is a long-standing, complex, and ever developing debate in geography as well as political ecology on the definition and use of 'scale' (e.g see Marston *et al.*, 2005; Neumann, 2009). While certainly needing consideration, it is beyond the scope of this thesis to deal with these debates in their entirety. I will briefly outline and clarify the use of scale in this thesis (predominantly following DeLanda's approach to scale), making reference to AT and its approach to scale.

While AT has been referred to as a 'flat' ontology (e.g. Escobar, 2007), this can be slightly misleading with DeLanda's AT still being scalar (McFarlane, 2009; Legg, 2009). For example, when considering the chapters of *A New Philosophy of Society* (DeLanda, 2006), these tackle one scale at a time (2006:6), starting from persons and ending with nations. As Escobar (2007) writes, AT is an alternative to organic or structural totalities, and does not presuppose essential and enduring identities. DeLanda (2006: 38):

> *"Thus social assemblages larger than individual persons have an objective existence because they can causally affect the people that are their component parts, limiting them and enabling them, and because they can causally affect other assemblages at their own scale."*

AT does not undermine scalar hierarchies, it is instead a transformed conceptualisation of scale (Escobar, 2007) that does not assume that these hierarchies are static conceptual categories that exist with predetermined structures (Marston *et al.*, 2005; Escobar, 2007). It therefore can still be used to consider scales, the politics of scales, and move between micro- and macro-scales in relation to each other (DeLanda, 2006):

> *"The more ordinary examples* [of the part-to-whole relation] *form several levels of organization, each one studied by its own sub-discipline:*

> *behavioural, population, community, and ecosystem ecology… it is important to emphasize that we are dealing here with differences in relative scale, that is, with scale as is generated by the relation of part-to-whole, not with absolute scale: a single contemporary large plant, for example, may house an entire ecosystem of microorganisms displaying all four levels of organisation"* (DeLanda, 2011: 67)

AT may be described as a 'flat' ontology, but it still allows for very complex and multi-scalar relationships to be explored.

Boundaries and scales of time and space are a concern for ecologists, geographers and social philosophers alike. In community ecology, the main processes which influence patterns in the composition and diversity of species are selection (representing deterministic fitness differences between species), drift (representing stochastic changes in species abundance), speciation (the creation of new species) and dispersal (the movement of organisms across space) (Vellend, 2010). All of these main classes of process are dealing with issues of time and space. It is furthermore not easy to define the boundaries of an ecosystem, as Callenbach (2008: 40) illustrates:

> *"Suppose ducks sometimes appear on a pond in your neighborhood. You might consider the ducks part of the pond ecosystem, or part of the Far North ecosystem where the ducks migrate for the nesting season, or part of a much larger joint ecosystem that includes the two*."

Considering the scale of a duck, and the bacteria and other organisms living on and in its body, the duck itself can also be considered an ecosystem, just as DeLanda's plant.

Diversity and scale when considering complexity are very much related. In large streams and rivers for example, an inverse correlation has been found between stream size and the variability of the physicochemical environment (Harrell and Dorris, 1968; Whiteside and McNatt, 1972). That species richness increases with spatial area has been called one of the few laws in ecology (Lomolino, 2000; Scheiner *et al.*, 2011). These relationships are not always straightforward, however, with Tilman (1996) showing that increasing species diversity can simultaneously decrease population-level stability while also increasing community-level stability in grassland plant communities. More recently, Turtureanu *et al.* (2014) illustrated that diversity–environment relationships are strongly scale-dependent in Transylvanian grasslands (other recent studies dealing with the impacts of scale and time on biodiversity include Triantis *et al.*, 2012; Pasari *et al.*, 2013; Proenca and Pereira, 2013). Scale is therefore important to consider when evaluating biodiversity, along with stability and resilience as discussed in Section 3.2.4.

For AT approaches, there are no strict limits on the spatial or temporal scale of an assemblage (Miller, 1999). In DeLanda's approach, territorialisation refers to not only the level of homogenisation of components, but also the determination of the spatial boundaries at a certain moment in time (DeLanda, 2016: 22). The level of territorialisation depends therefore on the homogeneity of a community; how densely it is connected both spatially and socially. If a community is very densely connected then you can expect there to be a reduction in intra-community differences, and a greater degree of 'us' and 'them' extra-community-wise (DeLanda, 2016:22). Conflict within a community can decrease territorialisation, and conflict between communities can increase territorialisation of those communities. Therefore, spatial boundaries and diversity, or heterogeneity of an assemblage, are also relevant to DeLanda's AT approach to understand not only territorialisation, but also resilience and the implications of conflicts or tensions within and between assemblages.

3.3. Chapter conclusion

In this chapter, I outlined the parallel use of a language of assemblages in both ecological sciences and social philosophy. I compared current approaches to systems thinking in AT, ANT and Nexus thinking, highlighting the differences and similarities between these approaches and explaining the rationale in following DeLanda's AT approach, and merging this with ecological assemblage concepts as a foundation for the IAA framework of this thesis. The common language that unites DeLanda's AT approach with the ecological sciences and geography allows a bridge between disciplines. To date, this bridge has not previously been clearly identified, and the use of AT to deal with differing knowledges and being explicitly used to support interdisciplinary research has also not previously been identified. This is a gap that the IAA framework described in this thesis addresses. The key novel steps and 'mergings' that this IAA framework takes are that it:

1. Considers ecological communities as well as species and organisms as assemblages
2. Considers desire and emotion and their role in forming and/or maintaining the assemblage
3. Considers the relevance of assemblage thinking to environmental governance and human-nonhuman relations
4. Challenges dichotomies (nature-culture, human-animal) that are enforced by ES and DeLandian AT, learning from MTHG approaches
5. Explicitly uses assemblages, through the formation of an IAA, to support interdisciplinary approaches

The next chapter introduces the case study used in this thesis: the Sabangau area in Central Kalimantan, Indonesia.

CHAPTER 4

Case Study Rationale: The Sabangau area in Central Kalimantan

This chapter outlines the rationale for the case study at the heart of this thesis: the Sabangau area in Indonesian Borneo, with a focus on two nonhuman (fish) communities (the Sabangau peat-swamp Forest and River) and two human communities (Kereng Bangkirai and Taruna Jaya). In the coming paragraphs, I introduce tropical peat-swamp forests (TPSF) in Indonesia and why I focus on fish in this thesis. I then discuss the main threats that the TPSF ecosystem faces in Indonesia, including deforestation, peat drainage, fires and overfishing, to begin to contextualise the concepts and approach of this thesis.

4.1. Tropical peat-swamp forests

Tropical rainforest ecosystems contain two-thirds of the world's terrestrial biodiversity (Gardener *et al.*, 2009; CBD, 2010). People living in these tropical areas are often those with the greatest direct dependency on biodiversity and ES (Christie *et al.*, 2012). Biodiversity is vital as a regulator of ecosystem processes (such as food webs and nutrient balances), can play a key role in cultural ES, can be a final ES or good, and supports the long-term resilience of ecosystem processes (Mace *et al.*, 2012).

TPSFs are tropical forests that occur in areas with high rainfall and poor drainage, where the consequently waterlogged soils hinder the decomposition of organic materials such as fallen leaves and branches from trees and even entire trunks (Page *et al.*, 1999). Over time, the build-up of these organic materials leads to the formation of peat. Peat soils of TPSFs account for about 14-19% of the global peat carbon pool, and 5-6% of the global soil carbon pool (Page *et al.*, 2011). These are likely to be under-estimates with recent findings of large peat areas in Congo and South America (Dargie *et al.,* 2017; Gumbricht *et al.,* 2017). Peat soils are extremely important for their carbon sequestration role and Indonesian TPSFs store 57Gt of carbon (Page *et al.*, 2011). Sumatra and Kalimantan contain the largest areas of TPSF in Indonesia (Page *et al.*, 2011).

4.1.1. Indonesian tropical peat-swamp forests

The wider study location is the Indonesian province of Central Kalimantan. This province lies within the inter-tropical convergence zone (ITCZ) and experiences a tropical-monsoonal climate with pronounced dry and wet seasons (Moore *et al.*, 2011). The temperature is relatively constant throughout the year (annual mean of 26 °C) (Sundari *et al.*, 2012). The wet season lasts approximately eight months with a four-month dry season and an average of 145 rainy days producing 2,776-3,393 mm of annual precipitation (Welman, 2013).

The TPSFs of Central Kalimantan are among the most extensive in Southeast Asia. However, the Indonesian province of Central Kalimantan has seen major deforestation and forest degradation due to illegal and legal logging operations, plus land clearing and fire for small scale farming and plantations (Graham, 2013). With the rapid expansion of timber and palm oil plantations, Central Kalimantan is now the province with the highest rate of deforestation in Indonesia (Broich *et al.*, 2011). This loss of forest has not only negatively affected biodiversity in the area (Sodhi *et al.*, 2004; Posa *et al.*, 2011) but also the local human communities, many of which depend on the forests for their livelihoods (Page *et al.*, 2009; Graham, 2013).

Until recently, the TPSF of Southeast Asia was a neglected ecosystem with low conservation priority (Posa *et al.*, 2011). However, it is now clear that these forests contain high faunal and floral diversity (Posa *et al.,* 2011; BNF, unpublished data), and unfortunately some of these species are facing the threat of extinction (Posa *et al.,* 2011). TPSFs are home to several charismatic species such as the Sumatran (*Pongo abelii*) and Bornean orang-utan (*P. pygmaeus*), Sumatran tiger (*Panthera tigris sumatrae*), Sumatran rhinoceros (*Dicerorhinus sumatrensis*), Storm's stork (*Ciconia stormii*) and clouded leopard (*Neofelis diardi*) (Morrogh-Bernard *et al.*, 2003; Wich *et al.*, 2008; Cheyne and MacDonald, 2011; Cheyne *et al.,* 2014).

The Sabangau Forest in Central Kalimantan is home to the world's largest remaining contiguous orangutan and southern Bornean gibbon (*Hylobates albarbis)* population (Morrogh-Bernard *et al.*, 2003; Cheyne *et al.*, 2008). A total 45% of mammals and 33% of birds recorded in TPSFs are classified as near threatened, vulnerable or (critically) endangered by the IUCN (Posa *et al.,* 2011). Lastly, due to the unique characteristics of TPSFs such as the acidic water, the rivers and waters of these forests are important fish habitats containing various endemic stenotopic species (species that are only able to tolerate a restricted and specific range of habitats or ecological conditions) (Ng *et al.*, 1994; Noor *et al.,* 2005). With the vital role of biodiversity for maintaining ecosystem processes, long-term ecosystem functioning and ES provision (Loreau *et al.,* 2001; Gamfeldt *et al.*, 2013; Tilman *et al.,* 2014; Balvanera *et al.*, 2014; Perkins *et al.,* 2015; Lefcheck *et al.*, 2015), the focus on fish in this thesis is positioned within not only biodiversity conservation but also the wider role that biodiversity and ecosystems play within the Sabangau.

Figure 4.1: Map of Indonesia indicating the location of Central Kalimantan and locations of Palangka Raya (Central Kalimantan) and Jakarta (Java)

4.1.2. Why a focus on fish?

In 2012, an estimated 58.3 million people worked globally in the primary sector of capture fisheries and aquaculture (FAO, 2014b). Whether involved in the primary sector or other sectors, 12% of the world's population rely (primarily and partially) on fisheries and aquaculture for their livelihoods (FAO, 2016). The numbers of fishers significantly grew from the 1970s to mid-2000s – indeed at a faster rate than the growth of the world's population during this time (FAO, 2006). Nearly 95% of the world's fishers are small-scale fishers, and together they harvest nearly half of the world's fish destined for human consumption (McGoodwin, 2001).

Indonesia has one of the highest diversities of freshwater fish, ranked second in the world following Brazil (Kurniawan *et al.*, 2016). Its various freshwater habitats such as rivers, lakes, swamps, peatlands and brackish waters are home to more than 1,000 species (Kurniawan *et al.*, 2016). In 2012 about 6.4 million people were engaged in fishing and fish farming in Indonesia (FAO, 2014b). Fish are a significant source of protein throughout the country with about 54% of animal protein coming from fish and seafood (FAO, 2014b) and the fishing industry contributed to 3% of the Indonesia's Gross Domestic Product (GDP) in 2012 (FAO, 2014b). More locally in Central Kalimantan, it is reported that in 1999 fish are considered the main source of animal protein for local communities (Saman and Limin, 1999). In Kalimantan, fish are predominantly locally caught and consumed, with the main exports in fish belonging to marine fisheries (not freshwater) from Sumatra, Maluku and Sulawesi (ACIAR, 2013). However, despite its nutritional and economic significance for rural livelihoods and wellbeing in Kalimantan, the topic of fishing has gained relatively little research attention (Schreer, 2016). I intend to explore the importance of fish and fishing to local communities in the Sabangau area in this thesis.

Fish also play an important role in regulating the structure and functioning of freshwater ecosystems (Northcote, 1988; Cowx and Aya, 2011; Durance *et al.*, 2016). For example, the foraging behaviour of fish can directly affect water turbidity, impacting the abundance of phytoplankton, periphyton, and macrophytes, plus plankton and benthic communities through influencing predator-prey interactions (Lévêque, 1995). Consequently, fish also play a role in regulating food web dynamics, plus nutrient cycling and transport in aquatic ecosystems (Lévêque, 1995, Holmlund and Hammer, 1999; Small *et al.*, 2011; Durance *et al.*, 2016). They also contribute to regulating the carbon flux between water bodies and the atmosphere through their feeding dynamics (Schindler *et al.*, 1997; Holmlund and Hammer, 1999; Trueman *et al.,* 2014). For example, predator-prey dynamics between fish, zooplanktivores and zooplankton play a significant role in determining the amount of phytoplankton in the water and thereby air-water carbon fluxes (Holmlund and Hammer, 1999). Fish are also active links between ecosystems, such as marine and freshwater systems as seen in salmonid migrations (Holmlund and Hammer, 1999). It is well established that freshwater fish are among the most threatened groups of vertebrates worldwide (Ricciardi and Rasmussen, 1999; Powles *et al.*, 2000; Ormerod *et al.*, 2010), with more than 35% of the evaluated species considered vulnerable or threatened (IUCN, 2010).

Fish are commonly used as indicators of water quality and the health of aquatic habitats (e.g. Kuklina *et al.,* 2013; Courtney *et al.*, 2014, Ruaro *et al.*, 2016). Fish respond to human impacts in the aquatic environment such as habitat degradation and land use conversion from mining, deforestation, agricultural practises and other perturbations of the water environment (Allan, 2004; Teresa and Casatti, 2017). Responses of fish to environmental changes can be assessed from a taxonomic perspective as well as looking at the structure of fish assemblages, such as species composition and richness and trophic functions (Qadir and Malik, 2009; Ruaro *et al.*, 2016; Teresa and Casatti, 2017).

Fish provision is an ES in itself and has financial value if fish are consumed/sold, but moreover fishing and the cultures and histories surrounding fishing can lead to important cultural ES (Chan *et al.*, 2012). The use of fish can have implications and benefits to communities beyond food provision; for example, traditional and customary systems of sharing fish, as well as subsistence activities can lead to benefits of cultural perpetuation, social networks, reciprocal exchange and collective insurance (Holmlund and Hammer, 1999; Vaughan and Vitousek, 2013). Fishing activities lead directly and indirectly to the provision of jobs, which are central to a sense of personal value and achievement (Chan *et al.*, 2012). These '*inspiration and identity benefits*', are not fully reflected in monetary valuations of the fish provisioning ES (Chan *et al.*, 2012). The conservation of fish and freshwaters is therefore essential for human wellbeing (Campos-Silva and Peres, 2016).

4.2. Threats to forests, fish and human communities in the Sabangau

I have introduced the link between human communities and fish communities, with fisheries a human and a more-than-human phenomenon as I intend to illustrate in this thesis. Following McGoodwin (2001) there is a need re-balance a vision of fisheries as not only an environmental but also a social and cultural phenomenon:

> *"If fisheries management is to be more successful in the future it must integrate social and cultural concerns with the heretofore more traditional biological and economic ones."* (McGoodwin, 2001: 1-2)

As I build a perspective of the fish, human and fisheries entanglements, the environmental threats that face the TPSF in the Sabangau area will likewise have an impact on the fish assemblages for which they provide habitats. In the coming sections I discuss some of the main threats to these systems, including deforestation, peat drainage and fires.

4.2.1. Deforestation

While countries with high levels of biodiversity tend to have high human dependency on biological resources, alarmingly, these countries are experiencing some of the highest levels of environmental degradation worldwide (Butler, 2012). The world has already seen the destruction and degradation of 80% of its forests (World Resources Institute, 1997). In Indonesia, 60% of land is forested, however the country is experiencing one of the highest levels of deforestation in the world (Margono *et al.*, 2014).

The main threats to TPSFs in Indonesia include logging, plus drainage, conversion for agricultural and other development, and subsequent fires, with only 6% of TPSFs showing no signs of human influence (Miettinen *et al.*, 2011; 2016). Miettinen *et al.* (2016) suggest that peatland deforestation has occurred at a rate of 4.1% per year from 2007 to 2015, although the biological implications of this are not fully understood due to the lack of baseline data on TPSF flora and fauna (Miettinen *et al.*, 2011).

The Indonesian province of Central Kalimantan (Figure 4.1) has seen major deforestation and forest degradation, due to illegal and legal logging operations and land clearing for small-scale farming and plantations (Miettinen *et al,* 2011; Graham, 2013). Under business-as-usual scenarios, it has been projected that just under half of the TPSF in Central Kalimantan may be lost by 2020 from a baseline year of 2005 (Fuller *et al.*, 2011), and the biodiversity impacts of this may be further exacerbated by climate change (Struebig *et al.*, 2015). This loss of forest not only negatively affects biodiversity (Sodhi *et al.,* 2004; Posa *et al.,* 2011) but also the local human communities, many of whom depend on non-timber forest products (fishing, hunting, rattan harvesting etc.) for their livelihoods (Smith, 2002; Lyons, 2003; Page *et al.,* 2009; Graham, 2013).

One of the underlying causes of deforestation has been an increase in human populations. In 1980, Central Kalimantan had a population of just over 954,000, which by 2014 had grown to 2.37 million (BPS, 2012 and 2015). The province experienced the most rapid population growth between 1990 and 2000, at almost 3% per annum, making it one of the highest provincial growth rates in Indonesia during that time (BPS, 2012). In comparison, the country as a whole had a falling growth rate of 1.9% in 1990 to 1.43% in 2000. One of the causes of this high population increase in Central Kalimantan was the government's *transmigrasi* programme under President Suharto (see Chapter 6.1.1). By 2000, transmigrants constituted 21% of the population in Central Kalimantan (Rautner *et al.*, 2005).

The government distributed land to transmigrants with little regard for traditional land laws or the Dayak communities already using the land (Graham, 2013). The immigration of transmigrants and other non-Dayak workers during the logging concessions from the early 1970s to the mid 1990s caused new socio-economic factors that changed some of the traditional Dayak land-use behaviours into commercial and concession-based forest logging (see Chapter 5; Rieley and Page, 2005; Medrilzam *et al.*, 2014). When these logging concessions started coming to the end of their licence periods in the 1990s, large scale agricultural projects such as the Mega Rice Project (MRP; discussed further in Section 4.2.2.) as well as illegal logging companies moved into the area (Graham, 2013). Communities grew around these logging and agricultural projects which, along with the transmigration settlements, increased the pressure on forests and land (Fearnside, 1997; Casson and Obidzinski, 2002; Rieley and Page, 2005). Following the failure of the MRP and the cessation of many timber concessions, these communities began participating in non-sustainable activities including illegal logging and intensive agriculture, as there were few alternative sources of income (Graham, 2013).

4.2.2. Peat drainage

One of the other main threats to peatland ecosystems is the disturbance of their natural hydrological balance through the building of canals for the transportation of timber out of the forest or to lower water tables for agricultural purposes, which leads to peatland drainage (Silvius and Suryadiputra, 2005; van Beukering *et al.*, 2008; Wösten *et al.*, 2008; Yule, 2010; Posa *et al.*, 2011; Gopal, 2013; Giesen, 2015). As the water level drops, the peat layers become dry and are exposed to oxygen, which then catalyses their decomposition and increases their susceptibility to fire (Page *et al.,* 2009). Drainage therefore leads to an increased risk of dry-season drought and resulting fire, and following peat decomposition and degradation, land surface subsidence can increase the risk of semi-permanent or permanent flooding (Page *et al.*, 2009; Giesen, 2015). Lastly, peat oxidation leads to carbon dioxide emissions to the atmosphere in the range of 355-874 Mt CO_2 per year for all Southeast Asian peatlands (Hooijer *et al.*, 2006; 2010).

One example of large-scale peat drainage and its environmental consequences is the MRP in Central Kalimantan. Here, a total of 4,600 km of canals were dug to drain the peatland (van Beukering *et al.*, 2008) under a project initiated in 1995 by President Suharto that aimed to convert over one million hectares of deep peatland into rice paddy fields. However, as anticipated by scientists at the time, the acidic land and over-drainage proved unviable for growing rice (Hecker, 2005) and the project was quickly abandoned. Due to the drainage caused by construction of large canals the peat became over dry during the dry season, and fires are now a near annual occurrence that destroys large areas of forest (Page *et al.,* 2009; Gaveau *et al.*, 2014; Cattau *et al.,* 2016; Field *et al.*, 2016). Following the MRP failure, transmigrants who had been moved into the area to work the rice paddy fields were left with no means of income, and many became 'environmental refugees', turning instead towards illegal logging and mining (Adhiati and Bobsien, 2001; McCarthy, 2001; Hoisington, 2010). The MRP has been called one of the biggest environmental disasters of the 20th Century (Hoisington, 2010) and conservation efforts are urgently required to protect the remaining patches of forest, for both its biodiversity and the remaining carbon stored within the underlying peat (Page *et al.*, 2002; Cattau *et al.,* 2016).

One of the main conservation actions to protect peatlands impacted by drainage is to re-establish the peatland hydrology and high water levels through the building of dams that block the drainage canals (Page *et al.,* 2009; Jaenicke *et al.,* 2011; Ritzema *et al.,* 2014). The use of dams for peatland restoration and the perceptions of dams by human communities will be explored in this thesis.

4.2.3. Fires

In Southeast Asia, peatland fires are almost entirely of anthropogenic origin and the large majority occur in the dry season (Page *et al.,* 2009; Gaveau *et al.*, 2014; Cattau *et al.,* 2016; Field *et al.*, 2016). Slash and burn agricultural techniques have a long history in this region (MacKinnon *et al.*, 1996), and the livelihoods of small farmers generally still depend upon fire as the only affordable way to rapidly clear land (Cochrane, 2003; Rieley and Page, 2005; Page and Hooijer, 2016). Therefore, the Indonesian government's recent attempts to ban the use of fire have been met with resistance from farmers (Someshwar *et al.,* n.d.). Large company-owned palm oil plantations and palm oil smallholders also use fire to clear land (Someshwar *et al*, n.d.) and landowners use fire to demonstrate use of land, as under Indonesian law unused land is considered available for occupation (Someshwar *et al*, n.d.). Fires are also started through arson, from cooking fires, to create better access to valuable timber and to hunt animals, including fish (Dennis *et al.*, 2005; Tacconi and Vayda, 2005; Medrilzam *et al.,* 2014). Fires are often used to resolve land disputes and in some cases to drive off settlers (Sastry, 2002). The causes of fire are therefore numerous and multifaceted (see Cattau *et al.*, 2016).

The consequences of fire can be very serious: during the 1997-98 El Niño event approximately 10 million hectares of land across Indonesia burned, including 1.5 million hectares of TPSF (Someshwar *et al.*, n.d.; Page *et al.*, 2002). In Kalimantan, 750,000 hectares of TPSF burned (Someshwar *et al.,* n.d.). This led to an economic loss across Indonesia and Southeast Asia ranging from USD 2.5 to 6.3 billion due to negative impacts on agriculture, tourism, forestry, public health, transportation and the environment (Tacconi, 2003). Income and property losses due to fires, along with smoke haze and associated public health impacts, floods, decreasing income from timber and non-timber forest products and fish, contributed to the impoverishment of local communities (van Beukering *et al.,* 2008).

The implications of peat fires for climate change are also serious; Indonesia is responsible for the third highest emissions of CO_2 worldwide, mainly as a result of peatland degradation, deforestation and fire (Hooijer *et al.*, 2006; Silvius and Diemont, 2007). Furthermore, Page *et al.* (2002) estimated that the 1997 fires contributed the equivalent of 13-40% of global carbon emissions from fossil fuels that year. In 2015 Indonesia was once more hit with disastrous fires: a strong El Niño-related drought combined with forest disturbance and widespread peatland drainage made 2015 the worst fire season since 1997 (Chisholm *et al.*, 2016). The economic cost of these latest fires and associated air pollution (haze) has been provisionally estimated at USD 16.1 billion or about 1.8% of Indonesia's 2014 GDP (Tacconi, 2016). Crippa *et al.* (2016) found that high particulate matter concentrations from the 2015 fires exposed 69 million people to unhealthy air quality conditions, with short-term exposure to this pollution potentially causing almost 12,000 excess mortalities. About 2,611,000 hectares were burnt with significant negative consequences for TPSF flora, fauna and human communities in the affected areas (Tacconi, 2016; Harrison *et al.,* 2016). The fires in 2015 were a catastrophe for the climate, for the environment, for biodiversity and the wellbeing of humans and nonhumans alike. This thesis will further explore the complexity of the fire issue in the Sabangau area.

4.2.4. Overfishing

While Indonesia is one of the most fish-dependent countries in the world (CCIF, 2013), the country's marine and inland fish stocks are rapidly declining due to over-fishing and destruction of habitats (Pet and Pet-Soede, 1999; CCIF, 2013). Overfishing in Indonesia is well-documented and reported in the Java Sea, the Malaka Strait and Karimata Strait (Sari, 2010). Overfishing and the state of fish populations for freshwater inland fisheries are however less well-documented, and I am not aware of any long-term fish population surveys conducted in any peatland rivers in Indonesia. Giam *et al.* (2012) found that there are numerous freshwater fish species in the Sundalands (a biogeographical area that includes the Malay Peninsula, Borneo, Java, Sumatra and their surrounding islands) that are specially adapted to the acidic TPSF waters but which are threatened by TPSF conversion into monocultures such as oil palm. The authors also extrapolated that if TPSF deforestation continues, 77% of fish species are likely to become extinct in Sundaland, with Central Kalimantan being most severely impacted.

Around the Sabangau forest, a previous survey of local communities found that 80% of those fishing reported a decline in their harvests over the previous 10-year period (Lyons, 2003). A total 99% of respondents reported a decline in fish size within individual species caught, with large fish being caught less frequently (Lyons, 2003). Investigation of fish biodiversity in Central Kalimantan is therefore of high relevance and necessity as this can help to inform the classification of High Conservation Value Forest (HCVF; forests which have additional critical environmental and social values that require special consideration, FSC, 2008) (Giam *et al.*, 2012). This is particularly important for areas where communities depend on fishing as a main source of livelihood; in these locations, assessing and understanding changes in the local fish stocks are both vital. This issue of overfishing and the links between resilience and adaptation of local human communities and overfishing will be further explored in this thesis.

4.3. Governmental and conservation response to tropical peat-swamp forest degradation in Indonesia

In response to the catastrophic forest and land fires of 2015, Indonesian President Joko Widodo created the Badan Restorasi Gambut (Agency for Peatland Restoration) (BRG) (UNDP, 2016). The agency was established in January 2016 as testimony to the Indonesian government's commitment to restore degraded peatland ecosystems (Global Landscapes Forum, 2016). The responsibility of the BRG is to coordinate and facilitate the restoration of degraded peatlands in 7 priority provinces: Riau, South Sumatra, Jambi, South Kalimantan, West Kalimantan, Papua, and Central Kalimantan (Global Landscapes Forum, 2016, BRG, 2016). It has an initial target to restore about two million hectares by 2020 (Global Landscapes Forum, 2016; Saturi and Arumingtyas, 2016; BRG, 2016), which will involve blocking canals through building more than 10,000 dams to attempt to peatland hydrological integrity (Saturi and Arumingtyas, 2016; BRG, 2016). Starting in 2017, there will be state budget allocated to the BRG to coordinate and implement the restoration of the target peatland areas (UNDP, 2016). This will also involve working and collaborating with NGOs, companies, civil society and the development community (UNDP, 2016). In light of this new commitment to peatland restoration, I will draw conclusions at the end of this thesis to highlight the relevance of my studies to restoration activities as well as taking biocultural approaches to conservation in the Sabangau.

4.4. Chapter conclusion

Forest ecosystems are vital for biodiversity as well as the human communities that depend on this biodiversity and the ES that it provides. I have introduced the unique TPSF habitat, and its global importance, with Kalimantan containing some of the largest areas of TPSF in Indonesia. I have introduced Central Kalimantan, and the TPSF found in this province, but also some of the key anthropogenic threats that these forests, the rivers, fish and fishing face such as deforestation, peat drainage and fires, and overfishing of the rivers. I furthermore introduce the Indonesian Government's Peatland Restoration Agency (BRG) that was set up in 2016 to tackle peatland degradation. This shows a commitment of the current government to tackle the threats faced by TPSF habitats, and therefore I will be making suggestions based on the results of this thesis in the conclusion chapter that will be of relevance to biocultural conservation and restoration efforts in the Sabangau.

Fish play an important role in the functioning of the aquatic ecosystem, yet they are among the most threatened groups of vertebrates worldwide. They can be used as effective indicators of water quality and health of aquatic habitats, responding to anthropogenic disturbances such as deforestation, agricultural practices and fire. Understanding the fish assemblages and trends within those assemblages can thereby elucidate wider changes in the ecosystem.

Fishing as a source of income and food is vital globally, and in the Sabangau area fish is the main source of animal protein for local communities. The conservation of fish in the Sabangau and across Indonesia is vital for the wellbeing of human communities. Despite the importance of fishing for local communities, the topic of fishing in Kalimantan has received little research attention. I thereby aim to close some of the gaps in knowledge related to the importance of fish and fishing to the Sabangau area.

The threats to fish and fishing such as TPSF loss through deforestation, drainage and fire, as introduced in this chapter, are only a few of the many and complex threats that are impacting the Sabangau area. Through this thesis I aim to elucidate these threats further using fish surveys, focus groups and interviews with members of the local communities. This will involve assessing fish biodiversity, trophic levels and water quality of the Sabangau River and the TPSF standing waters. Alongside this, I investigate the importance of fish and fishing to local communities in terms of subsistence, income and culture, plus their motivations and associated practices with respect to river and fishery 'resource' use. Overall, I aim to investigate the benefits and values related to fish and fishing in the Sabangau TPSF area and explore how interdisciplinary approaches can support a biocultural approach to TPSF conservation. I will apply the IAA to consider the complexity of human-nonhuman relationships and I will use this framework to explore how the Sabangau fish(ing) assemblage is formed and how it functions. This will involve investigating the relationships of the assemblage components, such as those between human, fish and spirit communities. The approach and specific methods to achieve this are now outlined in Chapter 5.

CHAPTER 5

STUDY SITES AND METHODS

Following the clarification of the Interdisciplinary Assemblage Approach (IAA) that I take in this thesis (Figure 1.1 in Chapter 1), this chapter firstly introduces the study sites for this research: the province of Central Kalimantan, the Sabangau catchment and the locations of the human and fish community surveys. The chapter then describes the methods used to achieve the outlined objectives and to answer the research questions. The research methods include both ecological fish and river sampling, along with interviews, focus groups and questionnaires in the human communities.

5.1. Assemblage locations and local partners in Central Kalimantan

Chapter 4 briefly introduced the province of Central Kalimantan; this section now focuses on the Sabangau area (See Figure 5.1). The Sabangau Forest is a TPSF located in the south of the province. Within this assemblage, this study focuses on two human communities and two fish communities. The two human communities are the villages of Kereng Bangkirai and Taruna Jaya (see Figure 5.1). The two fish communities are found in the Sabangau Forest and the adjoining Sabangau River. Lastly, this thesis also includes the spirit communities as another example of a nonhuman community, as will be discussed in Chapter 6. These communities are not being treated in isolation from each other and any boundaries are imposed and not a true reflection of reality. This will be further illustrated and supported by the results of this study in Chapters 6, 7 and 8.

When choosing the human communities for this study, Taruna Jaya and Kereng Bangkirai were two fishing villages that were familiar to the gatekeepers and facilitators of my research: the UPT LLG CIMTROP UPR staff (see Section 5.1.1.). Kereng Bangkirai is located close to the Sabangau Forest and River which were the locations of my fish surveys, and is furthermore close to the provincial capital of Palangka Raya. Taruna Jaya provides a contrast to Kereng Bangkirai, being in the degraded ex-MRP area, further from Palangka Raya and on the Kahayan River. While human communities in the Sabangau are sure to vary between these distinct villages in terms of access to the provincial capital, and proximity to intact versus degraded PSF; in choosing two seemingly very contrasting villages I intended to allow for a more nuanced understanding of how the assemblage works, which local perceptions are related to the importance of fish and fishing, and which key characteristics of the villages themselves may contribute to any differences or commonalities between these perspectives. Both case study locations had also been involved in fish pond projects (see Sections 5.1.4.1. and 5.1.5.1) and I evaluate these fish ponds as potential future deterritorialising forces in the Sabangau area.

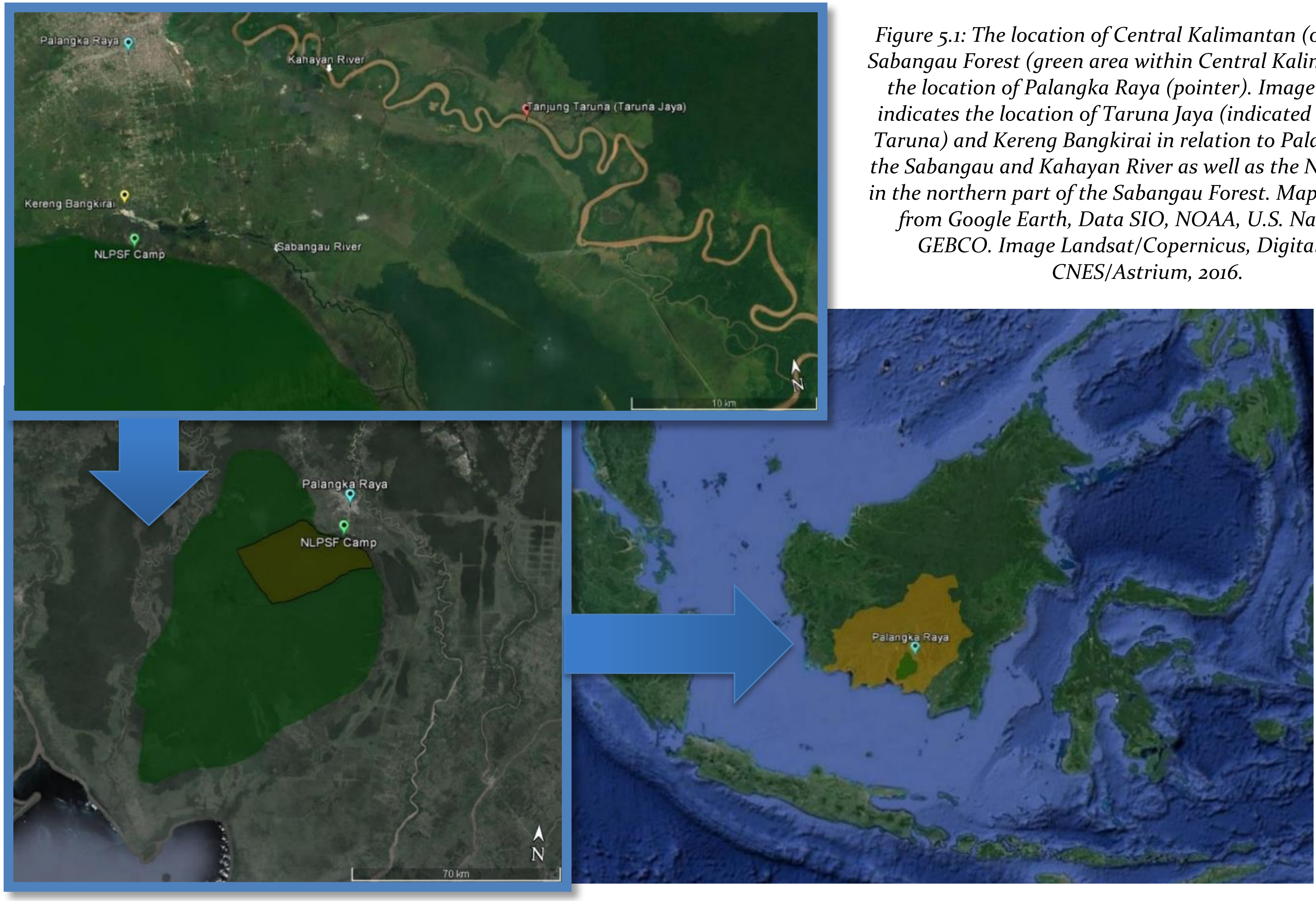


Figure 5.1: The location of Central Kalimantan (orange), the Sabangau Forest (green area within Central Kalimantan) and the location of Palangka Raya (pointer). Image to the left indicates the location of Taruna Jaya (indicated as Tanjung Taruna) and Kereng Bangkirai in relation to Palangka Raya, the Sabangau and Kahayan River as well as the NLPSF Camp in the northern part of the Sabangau Forest. Maps edited and from Google Earth, Data SIO, NOAA, U.S. Navy, NGA, GEBCO. Image Landsat/Copernicus, DigitalGlobe, CNES/Astrium, 2016.

5.1.1. Local partners

The local partners who facilitated the project in terms of supporting logistics, providing research assistants and research permission, were the Centre for International Cooperation in Sustainable Management of Tropical Peatland (UPT LLG CIMTROP UPR) and the Borneo Nature Foundation (BNF). UPT LLG CIMTROP UPR oversees the Natural Laboratory of Peat Swamp Forest (NLPSF) (the location of the forest fish community that this thesis focuses on) and its research camp covers an area of 500km^2 in the upper part of the Sabangau Forest (Figure 5.1). UPT LLG CIMTROP UPR was established in 1998 within the Forestry Department of the University of Palangka Raya (UPR). UPT LLG CIMTROP UPR focuses on the management and restoration of tropical peatlands through international collaboration and local research. UPT LLG CIMTROP UPR also employs a Community Patrol Team (CPT) which works with the local community, patrols the Sabangau forest edge and Sabangau River, and works with community members to discuss legal and non-legal forest activities, and improve fire management practices in the area.

The Borneo Nature Foundation (BNF) is a not-for-profit conservation and research organisation, founded in 1999 with an aim to support biodiversity conservation in Kalimantan. Their longest running programme is the Orangutan Tropical Peatland Project (OuTrop), based in the Sabangau Forest. BNF's founders identified the Sabangau Forest as home to the world's largest orangutan population (Morrogh-Bernard *et al.*, 2003), which eventually led to the designation of Sebangau National Park in 2004. BNF also supports, advises and fundraises for the UPT LLG CIMTROP UPR, along with other fire-fighting units in Central Kalimantan. Both UPT LLG CIMTROP UPR and BNF employees have longstanding experience with the local communities and the local area and were vital for the successful collection of data for this thesis.

5.1.2. Fish Community 1: Sabangau Forest

Figure 5.2: Sabangau Forest in the wet season

Both the Sabangau River and Forest fish communities were explored through fish and river surveys. The first location; the Sabangau Forest (Figure 5.1 and Figure 5.2) is centred on the Sabangau River, and bordered by the Katingan River to the west and the Kahayan River to the east. The Sabangau catchment is the largest contiguous lowland forested area remaining in Kalimantan and covers approximately 9,200km^2 (Morrogh-Bernard *et al.,* 2003; Buckley *et al.*, 2006). This forest is characterised by a dome-shaped ombrogenous peatland with thick peat and low topographic elevation (Page *et al.,* 1999). This peat formation is the oldest known in Southeast Asia: approximately 26,000 years old (Page *et al.*, 2004), and Sabangau's peat is up to 13 m thick (Page *et al.,* 1999; Weiss *et al.*, 2002). The area of the Sabangau Forest selected for the fish community surveys was located in the NLPSF and under UPT LLG CIMTROP UPR's management (see Figure 5.1). As seen in Figure 5.1., Kereng Bangkirai is located adjacent to the Sabangau River and Forest. I will discuss the village in Section 5.1.3.

Despite the protected area designations in place in Sabangau, the area still faces considerable conservation challenges from years of disturbance from the long-term repercussions of uncontrolled illegal logging (Husson *et al.*, 2015). Prior to 1997 the Sabangau Forest was divided up amongst concessionary logging companies who practiced selective logging, removing only timber of a specified size and species (Graham, 2013; Husson *et al.,* 2015). Following the end of concession logging in 1997, although the Indonesian law mandated a set-aside period, there was a huge wave of organised illegal logging (Currey *et al.*, 2001). Uncontrolled deforestation continued in Sabangau until 2004-2005, when the government designated 5,780 km^2 as the Sebangau National Park (Morrogh-Bernard, 2009) and the UPT CIMTROP LLG Community Patrol Team managed to stop illegal logging in the NLPSF (Husson *et al.*, 2015). The impact of these changes in laws and income sources in the Sabangau are further explored in this thesis as deterritorialising forces on the assemblage.

The Sabangau Forest has also suffered the consequences of drainage: during the legal logging period from 1997 to 2004, canals were dug to extract the timber from the forest (Morrogh-Bernard *et al.,* 2003; Graham, 2013). This lowered the peat water table, provided access routes for people into the forest and subsequently increased the risk of forest fire (Husson *et al.*, 2007; Wosten *et al.*, 2008). This was highlighted in the prolonged 2015 dry season, when fire destroyed areas of forest even in this relatively well protected area (Harrison *et al.,* 2016). Since 1997, almost 100,000 ha (1,000 km^2) of the Sabangau forest has been lost to fires (Husson *et al.,* 2015: this figure does not include the 2015 fire damage). Fire is therefore the greatest threat to the Sabangau Forest, especially since fire prevention, fire-fighting and law enforcement are inadequate and under-resourced (Husson *et al.,* 2015). As introduced in Chapter 4, blocking canals to raise water levels is considered a vitally important management action in this area (Husson *et al.*, 2007; Limin *et al.*, 2008; Morrogh-Bernard, 2011) and dams have been built across many of the canals to reduce the rate of peat degradation and risk of fire (Morrogh-Bernard, 2011). In addition to reducing water loss, the dams also prevent the outflow of leaves and other organic materials from the forest, with the intention that the canals will start to fill in naturally leading to a rise in the water table (Morrogh-Bernard, 2011). The building of dams and its perceived impacts on fish will be considered in this thesis as another deterritorialising force.

5.1.3. Fish Community 2: Sabangau River

The second location for the study of the fish community was the Sabangau River. This is classified as a mid-sized blackwater river that arises in the swamp (in contrast to all the main rivers in the area which arise from the hills) and runs through the Sabangau catchment (Tachibana *et al.,* 2006) for about 150 km until its mouth at the Java Sea. Blackwater rivers typically have low quantities of suspended matter, high amounts of humic acids (giving the water a brownish-reddish colour that can look black in certain light conditions) and a pH ranging from 4-5 (Ríos-Villamizar *et al.*, 2014). The source of the river is about 20 km west of Palangka Raya and about 6 km upstream from Kereng Bangkirai (Haraguchi, 2007; Moore *et al.*, 2011). The maximum documented water flux of the Sabangau River is 50 $m^3 s^{-1}$ from December to February, and the minimum is 5 $m^3 s^{-1}$ from June to September (measured at the source of the river in its northern reaches) (Tachibana *et al.,* 2003). There are six main tributaries of the Sabangau River and seven main canals have been constructed off the river (Haraguchi, 2007; Moore *et al.*, 2011). Some of the forested area in the Sabangau catchment has been converted to logging concessions, agricultural use and settlements which have had an influence on water quality (Tachibana *et al.,* 2006), see Figure 5.3.

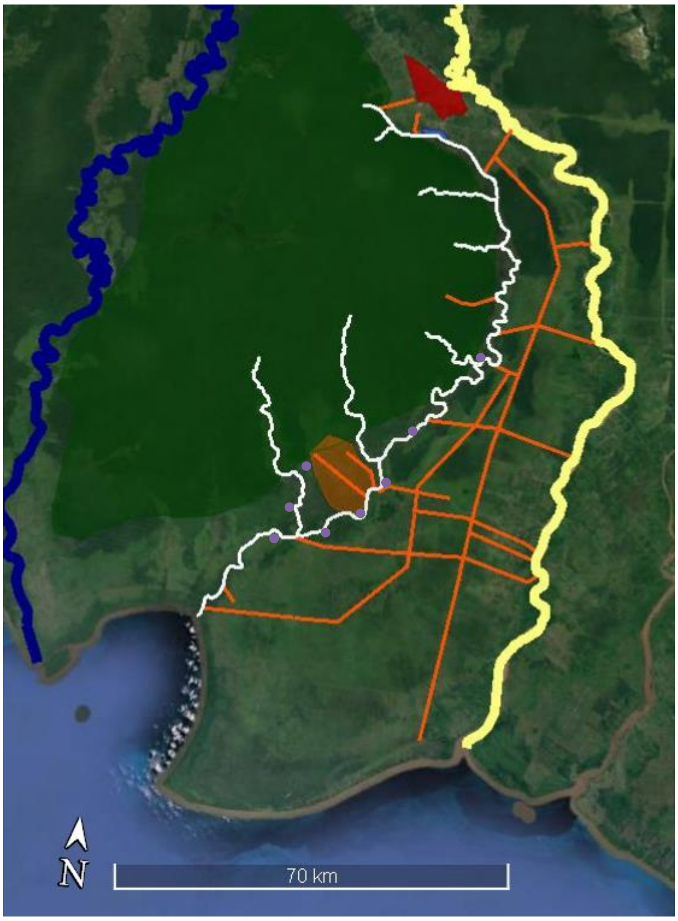


Figure 5.3: Illustrating the Sabangau River with its tributaries (white), Kayahan River (yellow), Rungan River (blue) some of the major canals (orange), villages (purple), Palangka Raya (red), Kereng Bangkirai (blue). Map from Google Earth, Data SIO, NOAA, U.S. Navy, NGA, GEBCO. Image Landsat/Copernicus, 2016.

Along the banks of the Sabangau River are several human settlements and villages, the largest of which is Kereng Bangkirai. These have experienced population increases due in part to the government's transmigration programmes during the past 50 years (Graham, 2013), probably along with an influx of people from other parts of Kalimantan or Indonesia to work in Palangka Raya. The local human communities living along the rivers and the forest have depended on peatlands for millennia for direct livelihood support including fishing, hunting, agriculture, medical plants and timber extraction (Bizard, 2011). In the past, it was traditional in the Sabangau area for small patches of land on shallow peat beside rivers to be cleared and cultivated for rice and vegetables, with the surrounding TPSF resources used for natural produce harvesting including rubber (*jelutong)* (*Dyera costulata)*, gemor bark (*Alseodophane spp.*) and fishing (Rieley and Page, 2005;

Smith, 2002). Sources of livelihoods are changing, however, with increasingly fewer people relying on the collection of non-timber forest products (NTFP) (Graham, 2013) and an increase in the number of people searching for job opportunities in Palangka Raya. I will further explore these pressures of income sources and changing incomes in the Sabangau area and how these lead to territorialising and deterritorialising forces.

5.1.4. Human Communities: Kereng Bangkirai and Taruna Jaya

In Central Kalimantan most of the 2.4 million inhabitants (2014; BPS, 2016) live in rural areas in villages by the rivers of the province, such as the Sabangau and Kahayan Rivers. The two human communities that I focus on are Kereng Bangkirai and Taruna Jaya. Some key characteristics and thereby differences between these villages are tabulated in Table 5.1.

Kereng Bangkirai was chosen as a study location because of its proximity to both the Sabangau Forest and the Sabangau River, as well as Palangka Raya (Figure 5.2). The first documented permanent settlement in Kereng Bangkirai was in 1912, but more people started inhabiting the area once the village got its name in 1957 (Graham, 2013). Kereng Bangkirai is now the largest village and fishing port on the Sabangau River (Lyons, 2003). It is ethnically diverse with part of the population Dayak Ngaju, referring to themselves as '*orang asli*' (=original people), who claim to have always lived in the area (Christel, 2015). There are also people from Banjarmasin, Balikpapan and Java who settled in the area following the transmigration program (Christel, 2015). The term 'Dayak' that is used within this thesis is short-hand for many indigenous ethnic groups found in Central Kalimantan, including the Ot Danum, Ma'anyan and the Ngaju Dayaks. The Ngaju Dayaks are the largest of the Dayak tribes in Borneo as well as Central Kalimantan (Eriksen, 2016). Ethnicity and religion are important characterising elements in the Sabangau area, and I will explore these further predominantly in Chapter 6. In 2003, Lyons reported that village heads described the harvesting of NTFP as a main livelihood activity in Kereng Bangkirai, with villagers depending on these for subsistence needs, while by the time of her research from 2007-2009, Graham (2013) reported a decrease in this dependence. Still, jobs are often seasonal and it is common to supplement any irregular jobs with collection of forest resources (Lyons, 2003; pers. obs., 2014 and 2015). Occupations and dependence on fishing will be further explored in primarily Chapters 6 and 7.

Taruna Jaya is a relatively new village which grew in the 1990s from only five houses in 1984 (TJ14; interview; 22/02/2016). It grew primarily because of people arriving in search of good fishing and logging opportunities. Nowadays the main livelihood in Taruna Jaya is fishing, but villagers also keep goats and chickens and collect NTFP resources such as rubber and rattan. The extent of the dependence on fishing as a livelihood will be further explored by this thesis as an example of the human-fish entangelments within the assemblage. Taruna Jaya has four main parts to it and the Taruna Jaya area considered by this thesis is relatively spread-out, see Figure 5.6:

1. Part 1: located on the concrete road of the Trans-Kalimantan highway (Figure 5.6). This part has easy access to Palangka Raya, which is about 30 minutes away by motorbike.
2. Part 2: located on the dirt road that comes from the highway, which is where the UPT CIMTROP LLG fish pond is located and is in the middle of the severely degraded peatland area (Figure 5.6).
3. Part 3: located further down the same dirt road on the Kahayan River (called Tanjung Taruna; Figure 5.6). For these parts of the village access to Palangka Raya is very difficult and they face a long, uneven dirt path that experiences regular flooding in the wet season (Figure 5.6).
4. Part 4: located on the other side of the river, a 10-minute boat ride downstream (called Pusaka). This part is therefore even more remote, and still does not have access to electricity (per. obs., 2015). For high schools children have to travel further to Kalampangan (about 8 km North on the Trans-Kalimantan highway) or the village of Kameloh approximately 9 km upstream.

Table 5.1: Characteristics of Kereng Bangkirai and Taruna Jaya village and locations in Central Kalimantan. Kereng Bangkirai population figures and school information are from Graham (2013) and Kahayan pH from Haraguchi (2007). Other data from author.

	PSF condition	**River adjacent to**	**River qualities**	**Population (human)**	**Distance from Palangka Raya**	**Access to Palangka Raya**	**Number of schools**
Kereng Bangkirai	Relatively Intact (Sabangau Forest)	Sabangau River (Figure 5.4.)	Blackwater, pH 4-5	5,550	10 km away: 20 minutes by motorbike	Easy: asphalt road (Figure 5.5.)	9 pre-schools 4 kindergarten 4 elementary/primary 1 junior high
Taruna Jaya	Severely degraded (ex-MRP area, Block C)	Kahayan River (East of Sabangau River)	Whitewater, pH 5.5-7.0	700	23 km away: 2.5 hours (motorised canoe), 1 hour by motorbike	Difficult: dirt road or river (Figure 5.6)	2 elementary 1 middle school

Figure 5.4: View of Kereng Bangkirai from the Sabangau River. Photo by Carolyn Thompson

Figure 5.5: The main asphalt road through Kereng Bangkirai towards Palangka Raya. Photo by Carolyn Thompson

Figure 5.6: Taruna Jaya locations and photos of the landscape

5.1.4.1. Fish ponds in Kereng Bangkirai and Taruna Jaya

Fish ponds (*bejes* in Dayak) employ traditional Dayak methods of catching fish. They are usually located in the river flood plain, and during the wet season they fill with water and fish from the river. Following the receding water level in the dry season, the fish are then trapped in the pond and available to harvest. Throughout the Sabangau and ex-MRP area, fish ponds have been used for many years (Gumiri *et al.*, 2005; Jagau *et al.*, 2008). These fish ponds are normally 300m^2 in dimension, and 1.5-2m deep (Jagau *et al.*, 2008). A household with 4 or 5 fish ponds can reportedly harvest between 500-1,200 kg of fish per season; generating an income of GBP 78-222 per year (Jagau *et al.*, 2008). However, the number of fish ponds especially in the ex-MRP has been declining as deteriorating water quality, construction of canals and damage to fish habitats has led to villagers experiencing a 95% decrease in fish pond 'production' of fish, compared to that during the pre-MRP era (Jagau *et al.*, 2008; Setiadi, 2014).

Fish ponds have been built in both case study villages (Table 5.2 and Figure 5.7). The current design of the fish ponds in Kereng Bangkirai and Taruna Jaya is adapted from the traditional ponds as they use artificial structures and are more permanent than those traditionally used (pers. comm. S. H. Limin; 18.08.2014). These fish ponds should therefore last up to 10 years (FAO, 2016). Figure 5.8 shows one of the fish ponds being built in Kereng Bangkirai during the dry season when the water levels are low (Figure 5.9 and 5.10 showing wet season photos of the fish ponds). Note that water was pumped out of the fish pond to allow digging to occur.

The rationale for the fish pond pilot project in Kereng Bangkirai was that, if well managed and not over-harvested, they can provide additional sustainable income during the dry season (OuTrop, 2014, n.d.). Fish harvesting can then continue, with larger fish eating the smaller (non-harvestable) fish and some supplementary foods also provided. The fish that are not harvested then re-enter and re-breed with the natural river population once the wet season returns, and the cycle continues. The aim of the fish ponds was for the income from fish harvests to be distributed between the CPT members' families to compensate them for times when they are away fighting fires and on patrols. In the future, this vision would extend to more villagers of Kereng Bangkirai, to each own one fish pond and thus for benefits to be more widely distributed (OuTrop, 2013). With the potential of the fish ponds to provide a livelihood for local community members, the hope is that they may also be more incentivised to act as fire spotters and fighters, to guard canals (as dam breakage is the biggest cause of dam failure) and support forest protection and firefighting activities. This thesis further explores and considers the viability of these fish ponds; socially, environmentally and economically.

Table 5.2: Basic information of the fish pond(s) built in Kereng Bangkirai and Taruna Jaya (pers. comm. S.H. Limin, 18/08/2014; FAO, 2016)

	Built by	**Funded by**	**Year built**	**Quantity**	**Av. Dimension**	**Total Cost (GBP)**
Kereng Bangkirai	UPT CIMTROP LLG Community Patrol Team	BNF and partners[1]	2015	4	$400m^2$	3,515
Taruna Jaya	UPT CIMTROP LLG with Sumitomo Corporation and Nippon Koei, Co. Ltd	Unspecified	2012	1	$812\ m^2$	4,920

1. *Partners are: The Orangutan Project, US Fish and Wildlife Service Great Apes Conservation Fund, Arcus Foundation and StOLT Foundation*

In Taruna Jaya one fish pond was built on private land of one villager involved in the pilot project (Figures 5.11 and 5.12). The Taruna Jaya fish pond is older, and has already experienced a harvest in 2013. Therefore, the experiences of harvest, and in particular those of the villager that was involved in the project are useful to understand potential implications of the Kereng Bangkirai fish pond project.

Relating back to the IAA, I will consider the role of the fish ponds within the Sabangau, drawing on data from fish and water surveys in the fish ponds and interviews and focus groups in the human communities to explore how these ponds may or may not be a future deterritorialising force.

Figure 5.7: Fish pond locations in relation to the NLPSF Camp (Sabangau Forest) and Kereng Bangkirai. White colour is flooded area of the river in the wet season. Map from Google Earth. Image DigitalGlobe, CNES/Astrium, 2016.

Figure 5.8: Fish pond being constructed in the NLPSF, photo by BNF

Figure 5.9: Fish pond in the NLPSF in the wet season

Figure 5.10: Fish pond in the NLPSF in the wet season (very high water) and showing a CPT member setting traps for the fish pond surveys. Photo by Kris.

Figure 5.11: Photo of the fish bond in Taruna Jaya in 2015 with high water levels. Plants have grown on the fence of the pond.

Figure 5.12: Screen shots of a video documenting the building and harvesting of the fish pond in Taruna Jaya (video provided by Kris, 08/2014)

5.2. Surveying the assemblages: approaching the fish and human communities

The following section involves a reflection of my own positionality, then moves on to understanding the role of facilitators in both 'social' and 'ecological' research, and of local knowledge in this thesis. This further clarifies the chosen research methods, detailed in Section 5.3.

5.2.1. Positionality and personal perspective

As Moser (2008) writes, personal histories, experiences and cultures of researchers themselves influence the data they collect and thereby the results they present. Reflecting on positionality is considered by many researchers as essential (Russell and Kelly, 2002; Watt, 2007; Bourke, 2014; Kusek and Smiley, 2014; Fisher, 2015). As a researcher's position in society is determined by sexual identity, age, social and economic status, gender, ethnicity, education and so forth, these factors may impede or support different fieldwork approaches or interpretations (Hastrup, 1992; England, 1994; Bourke, 2014; Kusek and Smiley, 2014). This examination of positionality, is a reflexive act, and a continuous process of self-analysis that does not finish with the completion of data collection (Bourke, 2014). It is also done with the understanding that pure objectivism is a "*naïve quest*" and "*we can never truly divorce ourselves of subjectivity…We have to acknowledge who we are as individuals, and as members of groups, and as resting in and moving within social positions*" (Bourke, 2014: 3, supported by Kusek and Smiley, 2014; Waldron, 2017). Kusek and Smiley (2014) further note that (qualitative) research conducted in distant field sites has notable effects on the researcher and carries challenges that need to be examined before beginning the research.

As Graham (2013) writes, gaining a university degree is relatively rare and prestigious in Kalimantan, as many villagers do not attain education above the age of 16 or 19. The informal class system that arises following educational level and wealth means that people are often not willing to express opinions in front of people who they consider are of a higher social standing than them (Graham, 2013). This had potential implications for how participants viewed me as a western woman (viewed as relatively wealthy) with a high level of education. However, like Graham's experience, my age was helpful in countering this. Being, at the time of the research, between 23 and 24 years old, I easily fell into the character of 'student' with participants taking a role in explaining and teaching me about the situations being described. The questions I asked were often seen as being very basic, with some seeming so obvious to some participants that it was not uncommon for me to get laughs and comments regarding how 'strange' the questions were. This clarified my role as a student who was learning, rather than as a PhD researcher with a more prestigious social standing. This also likely made participants more at ease to discuss and explain their experiences with me, and being a young woman likely made me less intimidating (Kusak and Smiley, 2014).

The role of insider/outsider is constantly navigated in cross-cultural research (see Bourke, 2014; Kusak and Smiley, 2014). Probably taking a role 'outsider' in most of my qualitative data collection, through being a white foreigner with very non-Indonesian features (pale skin, green eyes), it was therefore important to continuously reflect on my position within the field (Kusek and Smiley, 2014). Ismail (2005) expands on this, showing that positionality is more than merely being an 'outsider' or 'insider', but is also about having insider knowledge, experience of a place and addressing the unique concerns of that place. Recalling my identity as a TCK and cultural marginal, I have always had to navigate through society by peering into other people's worlds. This naturally influences my research approach: drawing from life experiences, it was necessary to approach the human and fish community surveys cautiously and conscientiously. I started to work with the human communities through focus groups (see Section 5.4.1) which allowed me to be introduced to how people talked about certain topics, 'test the waters'; giving me an idea of which topics were not particularly controversial and should be appropriate to approach more directly during in-depth interviews. I also conducted the in-depth interviews much later (January-February 2016) than the other surveys of fish and human communities (September 2014-September 2015) to allow me time to experience the Indonesian culture and learn from difficult and different encounters (Irvine *et al.*, 2008). While there are helpful resources on 'best-practice' guidelines for interviews and research approaches (e.g. Flowerdew and Martin, 2005; Freeman, 2006; Rowley, 2012; Clifford *et al.*, 2016), there are also more personal elements and considerations for 'best-practice' in research: as an experienced cultural marginal, for me it was vital to feel that I had gone through enough 'processing' of the cultural norms before I embarked on the more personal in-depth interviews. Furthermore, as will be clarified later on, the research itself was also part of my experience of a place (Ismail, 2005): the fish surveys and learning local fish names allowed me to gain an experience of fishing on a river using locally used methods, and this was important in building rapport for focus groups and interviews in the human communities. This illustrates the entanglements of identity, research approaches and methods and how these are constantly in conversation and negotiation with each other.

This thesis delves into discussions focussed on spirits and spiritual beliefs. I would only ask questions regarding these beliefs if I felt comfortable to do so; when I felt the participant would be open to discussing these and that it was appropriate to the setting. This was part of my 'management' of the interview as discussed by Rowley (2012). In some cases, a participant refused to give details:

> "*There is a kingdom, where the king was a white crocodile. The location of this kingdom is where there is a whirlpool in the water. This is a story for local people only, not for outsiders.*" KB13F (interview, 25/01/16)

Therefore there are certain spirit/nonhuman stories that are not to be shared with outsiders. My response in these situations, was to clearly express an understanding of what they were saying and that I did not want to cross boundaries and encroach on information that was not for me to 'have' or to 'hear'. This was done to respect their right to choose participation, further ensuring that I was acting ethically and sensitively (Grenier, 1998; Liamputtong, 2008). If necessary, I would re-iterate that participation was fully voluntary and they were free to refuse to answer questions. That I sometimes did have refusals demonstrates that my approach was respectful and allowed participants to feel they had a choice in participation (following ethical procedures as discussed in Flowerdew and Martin, 2005; Rowley, 2012; Clifford *et al.,* 2016; and many others). This is also an example of the barriers to information that may be encountered as an 'outsider'. These may never be overcome, but should not deter from respectful enquiry: indeed, as the results of this thesis will show, even as an outsider I could still gain useful perspectives regarding spiritual beliefs and their relevance to the assemblage in question.

Finally, through venturing into the nonhuman realities of the Sabangau area, I naturally found myself attempting to reconcile my own scientific and non-religious (but arguably somewhat spiritual) background to what I was researching and presenting in my thesis. It however became unimportant what my personal views are regarding the presence or 'real-ness' of spiritual nonhuman beings. In my attempt to understand the Sabangau area, I accept that for some participants spiritual nonhumans are part of the assemblage and a part of their reality. I urge scientists/researchers to not be intimidated by a feeling of having to reconcile their own world views to that which they are reporting. Instead, in this thesis I aim to actively accept, as part of my biocultural approach to conservation (see Chapter 1) other worldviews and to present these as fairly as possible. Indeed, by taking these worldviews seriously, I also gained a certain trust from my facilitators and probably likewise from my research participants which was supportive for fulfilling the aims of this thesis.

5.2.2. Facilitators

To approach both the fish and human communities required the help of 'facilitators'. For the human communities, three main facilitators were involved in order to conduct the focus groups, questionnaires and in-depth interviews (specific details of these methods are described in Section 4.3). For the focus groups and interviews Kris Yoyo, now referred to as 'Kris', and Karno (members of UPT CIMTROP LLG's CPT) helped along with another translator/interpreter (TI) called Erna. Out of the CPT team, Kris was the more senior of the two having worked in the CPT for longer and therefore took the role of lead facilitator, taking part in the organisation of focus groups and finding participants. Karno took a more supportive role, being present to help find participants when Kris was busy and clarifying conversations during the interviews/focus groups. Erna took the role of main translator/interpreter (the use of TIs is discussed in the next subchapter).

Being members of the CPT, Kris and Karno were also the gatekeepers to the human communities of Kereng Bangkirai and Taruna Jaya. Both are from Kereng Bangkirai, and were therefore familiar with the community. They work with the CPT to reduce illegal activities in the area, including the use of poison and electricity when fishing. As Graham (2013) writes, this can have some disadvantages as people may feel inhibited to discuss certain topics with them. This does not apply to the same extent in Taruna Jaya, where the CPT may be known to some people for their firefighting work along with their association with the fish ponds. However, as they have fewer patrolling activities in this area local people were perhaps more likely to discuss certain topics openly during interviews. These differences in the facilitators' position in both these villages need to be considered when evaluating interview and focus group results.

The main facilitator for the fish community surveys was Dudin; a local fisherman who had worked for a long time as a boatman for BNF-OuTrop. Dudin grew up in Kereng Bangkirai and has been fishing in the area for about 20 years. He had access to boats that were needed for the fish surveys, and most importantly had great experience and knowledge of the fish communities of the Sabangau. The importance of local knowledge for this thesis will be further explained in Section 5.2.3.

For approaching both the human and fish communities it was important to have 'shared' experiences with my facilitators as it was necessary to have a team that was engaged in the research over two years. For this to happen, it was vital for my facilitators to have a sense that this research was as much theirs as it was mine in terms of design and experience. During the fish surveys both Dudin and I were learning and exploring what methods worked and which did not, how to identify the species and how to measure the various environmental variables. During the human community data collection, my facilitators were engaged in the research design and I actively encouraged them to include questions they wanted to ask during interviews as well. Lastly, this shared learning experience also allowed my position as a student to be better realised.

5.2.2.1. Considerations when using translators/interpreters in research

For the work with human communities one main limitation was the involvement of translated data. While the translation done by Erna and Kris was done well, it is undeniable that nuances and small details of expression may have been missed that could have added to the understanding of the assemblage. Cross-language research will always face difficulties to ensure that translation and interpretation are done thoroughly and accurately and it cannot be forgotten or ignored that language is a methodological challenge when conducting studies with participants who do not speak the same language as the researchers (Squires, 2009). For this thesis, cross-language research was vital, and steps were taken to ensure that this was done to the best extent possible within resource restrictions.

Translation and interpretation work is expensive, but regardless it was considered necessary to employ a TI who not only was present during interviews, but was also engaged in the methods and research over a longer period of time (as recommended by Temple and Young, 2004). While I have a grasp of conversational Indonesian language, both Erna and Kris can understand and speak English. Erna studied English for her Bachelor's degree from the University of Palangka Raya. Karno is not as comfortable with speaking English, and the primary language when interacting with him was therefore Bahasa Indonesia. Throughout the process the communication between myself and my facilitators was effective and clear.

Initial plans were to conduct the focus groups and interviews in Indonesian; however it quickly became clear that participants were more comfortable talking in either the local Dayak or Banjar languages. Erna therefore played a key role in interpreting between Dayak or Banjar into predominantly English. This is an unfortunate limitation to the data collection, but with little that could be done in circumvention. In the future a more fluent grasp of Indonesian, or even better Dayak, would of course be helpful. Saying this, the participants were keen to share and discuss, but were also happy to wait for things to be translated (as Rowley, 2012 writes, people are usually very keen to share opinions and talk about themselves). Erna was very active and quick to explain things if she sensed that there was some confusion. Translation did not break the flow of the conversation or hinder the participants in expressing themselves; on the contrary, it often created helpful pauses where participants often elaborated more, creating a 'prompt' (Rowley, 2012).

In most interviews, I therefore ended up speaking English, with Erna translating into Dayak or Banjar, then interpreting answers back to me in English. I would take notes, including information that I could understand if they were speaking in Bahasa Indonesia. Interviews were recorded if permission was granted to do so (only one participant refused). Interview transcriptions were started by myself through listening to the recording of the interview whilst transcribing and merging with my notes, adding to these any information I had missed (this was of course only possible with interviews that were completely or partially in Bahasa Indonesia). These typed up transcription notes (in English) were then given to Erna who listened to the original recordings once more (not in English) and checked the transcriptions, adding or altering any details I missed or misunderstood. The final transcription notes (in English) were used for coding and thematic analysis (Squires, 2009).

For the focus groups, Erna was given the recordings and asked to transcribe these herself. She then provided an English version of the transcription which was then used for thematic analysis. This differed slightly to the interview methods because it was too laborious, took too long, and therefore was too expensive for her to do the initial transcriptions of all 40 interviews: it was faster for me to work on the initial transcription to the best of my ability and then have Erna check this and rectify any mistakes. For both interviews and focus groups, having Erna check the final transcriptions using the actual recorded interview/focus group was a vital step to ensure 'correct' interpretations, translations and ultimately my understanding of the situation (Temple and Young, 2004). Analysis was then a matter of examining findings in the resulting transcriptions (Temple and Young, 2004).

It is also vital to note that facilitator inclusion and involvement did not end there. Before any of the activities took place, at least one, if not multiple meetings with the facilitators was held to clarify questions, activities and logistics. This included training in basic interview techniques such as asking un-biased questions, not guiding participants and remaining impartial. These meetings allowed the space for discussions to decide on the best methods, what the clear trends seemed to be and to clarify any confusion or difficulties in understanding. Following training, I also actively encouraged all my facilitators to ask questions during interviews themselves. This was vital to ensure the 'shared' experience as previously discussed.

5.2.3. Role of local knowledge in research design

The input of my facilitators was vital for the design of the interview and focus group questions and research design. This turned into a learning experience for us all and my facilitators' local and cultural knowledge and experience were vital to the project design. Utilising local expertise and familiarity with their culture and landscape furthermore decreased the risk that the research missed out important local cultural and spiritual values which would compromise the validity of the research findings (Christie *et al.,* 2012). This approach was also necessary to be compatible with the biocultural approach to conservation that I argue for in this thesis.

The local knowledge that Dudin shared with me was essential for the fish community data, just as Kris', Karno's and Erna's local knowledge was critical for the human community data collection. Local knowledge was therefore vital to the design of the human and fish community surveys and furthermore has direct relation to the aim of this thesis in challenging knowledge dichotomies and taking a biocultural approach to conservation and research. Together with Dudin, and based on his local knowledge, the fishing gear and bait were selected following a discussion of the goals of the research and the aim to use locally available materials. While I learnt how to build and set the chosen fish trap, Dudin learnt from me how to use a pH meter. This mutual learning and skill sharing helped to balance the dynamic between foreign researcher and local researcher, and his input was not only valued and listened to, it was in fact vital.

Dudin taught me about the local fish species, how to identify them and what their local names were: such as distinguishing between *tapah (Ompok leiacanthus)* and *dadasai (Silurichthys phaiosoma)* (see Figure 5.13). Together, and dependant on his local knowledge, a folk taxonomy was built as presented in Appendix I. Linking to the IAA, folk taxonomies illustrate the coding of the fish assemblage according to local names and can provide an idea of how people relate to the fish species, how these are identified and grouped together dis-regarding evolutionary affinities (e.g.

see May, 2005; Begossi *et al.*, 2008; Ross, 2014; Pinto *et al.,* 2016). It must be explicitly stated that building a folk taxonomy is not done to 'test' the local knowledge in regard to Linnean classifications. It was *only* done to help the analysis of my human community data and could also be helpful for future projects in the area (and hopefully will therefore be added to!). Lastly, learning local names of the fish proved to be a good source of rapport during in-depth interviews. It was a way to find a common ground, to show that I had some experience with the fish species and using local traps. This is furthermore an example of the 'insider' knowledge and experience of a place that Ismail (2005) refers to.

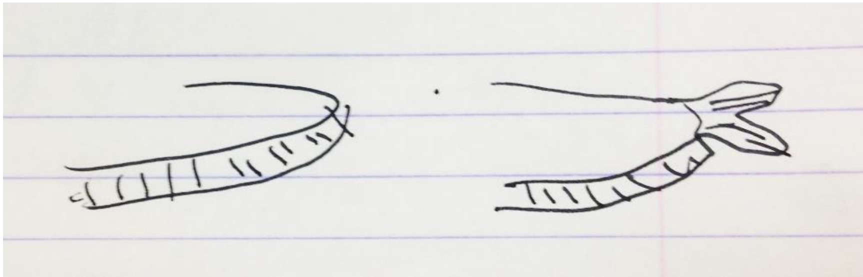


Figure 5.13: A sketch from my notebook to distinguish Dadasai (left) from Tapah (right), following explanation from Dudin.

The information from the folk taxonomy and interviews further illustrates that local names in Sabangau can refer to multiple species. One reason for this could be that names are use-based and there may often be no need for further identification beyond this 'use level' (see Morse, 2015 who gives examples in Anishinaabemowin naming of medicinal plants). With the multiple languages in use and names for species in Sabangau, identification was location-specific and could change depending on the discussant.

When conducting fish surveys in different locations, it is therefore useful to document these different names so that results can be compared between participants who may be using different names for the same species. This exercise highlighted some areas for consideration when folk taxonomies are constructed or identification is done of fish using photographic identification. This proved vital in understanding the assemblage and the relationships between assemblage components, as it allowed for accurate understanding of what species were being discussed during interviews and focus groups. Folk taxonomies and an understanding of local classifications are therefore worthy of attention for biocultural conservation efforts and in future fish projects in Sabangau and elsewhere. It should be kept in mind that these names are very location specific and personal: different people might have their own names for the fish, and the Banjar, Indonesian and Dayak names may therefore differ. This folk taxonomy can only be used as guidance and documents Dudin's experience of the fish in these various languages.

5.3. Methods used with the fish communities

The objectives of the fish surveys were to complete the first in-depth assessments of local fish biodiversity of both TPSF standing water and blackwater river habitats. The data collected can form a baseline for future monitoring projects and improve our understanding of these wetland habitats and their importance for community livelihoods. The fish surveys also allowed me to learn how to fish using local fishing techniques along with supporting the biocultural approach to conservation that this thesis argues for as discussed in Section 5.2.3.

Species data were collected over a 16-month period in the river (from September 2014 to December 2015), and over 8 months in the forest (from January 2015 to August 2015). Using the results from these monthly surveys allowed me to start building a description of the fish communities in both the forest and the river, and thus improve understanding of TPSF ecology and provide a baseline for future Sabangau ichthyofauna monitoring.

As discussed in Chapter 3, diversity is a measure of the compositional complexity of an assemblage and is one of the fundamental parameters in describing an ecosystem. In this thesis species richness is used as a measure of diversity for the fish assemblage, enabling a comparison between the river and forest fish communities. While common diversity indices can appear interchangeable in simple analyses, when considering more complex interactions the choice of which index to use can profoundly alter the interpretation of results (Morris *et al.*, 2014). They therefore have to be chosen carefully according to the aims of the research. Furthermore, it is now recognised that not only the species richness, but the traits of the species present and their abundances are critical in determining relationships between species diversity and ecological functions including the provision of certain ecosystem services (e.g. nutrient cycling) (Stuart-Smith *et al.*, 2013). However, evaluating 'functional' diversity involves a greater knowledge of fish feeding ecology, behaviour and habitat use (see Stuart-Smith *et al.*, 2013). This information is lacking for TPSF fish species at this point in time. Since there is a lack of knowledge on the role of specific fish species including those that are rare, and one of the aims of this thesis was to create a fish species list for the area, I only report species richness.

Many types of fishing gear have been developed by 'indigenous' fishing communities around the world, but relatively few have been adopted for the purposes of research and management (Portt *et al.*, 2006). Safe fishing techniques have often been ignored in the discussion of TPSF fish biodiversity conservation (Sule *et al.*, 2016). Researchers employ fishing techniques that are always more concerned with increasing catchability than the safety and conservation of the fish being studied (Sule *et al.*, 2016). Electric fishing for example is not only not allowed in Sabangau (mentioned in Section 5.2.2 and will be further discussed in the analysis chapters), it can cause serious health effects on fish, and therefore only safe fishing techniques should be employed in fish surveys in TPSF (Sule *et al.*, 2016). Taking this into consideration, and following discussions and an initial trial (where multiple local traps were tested), a wire trap was chosen for the fish surveys called *tampirai*, along with a bait of a mixture of *tempeh* (fermented soya bean) and *terasi* (fermented shrimp paste). *Tampirai* traps are rectangular wire-mesh traps with two tapering mouths, an inner and an outer, which allow fish to enter but not to escape (Figure 5.14). These traps are used locally because of their effectiveness in catching fish. They come in all shapes and sizes, and are therefore affordable, readily available and appropriate to use for future fish monitoring beyond this project. They play a key role in the act of fishing in the Sabangau area, and thereby how human community members relate to and interact with the fish communities. I will further explore this in Chapter 7. Importantly, Dudin's skills allowed him to build the 40 traps needed for the fish community surveys.

Following a trial of various traps, a trap with a mesh size of 0.6 cm and dimensions of 38 x 89 cm was chosen, based on comparison and trials with other mesh sizes that were locally available (all larger mesh sizes). The bait was rolled into a small ball and put into a wire holder that was attached to the inside of the trap. The bait was refreshed every sampling day to minimise impacts from bait predation and bait loss. The trap was set within a minimum of 5 cm of water and with the opening facing upstream to discourage fish from escaping. In the river, traps were set at approximately mid-depth as recommended by Dudin (Figure 5.15). Forest surveys involved two different open water habitats with traps set on the side of canals (max width 2.5 m; Figure 5.16) as well as in tip-up pools (formed when a shallow-rooted tree is uprooted, tearing a cavity into the peat when the tree falls, see Dommain *et al.*, 2015). The latter are pools which have been formed by large overturned trees creating deeper pools than much of the standing water in the forest, thereby potentially providing fish habitat for longer into the dry season. In the standing water pools the traps were set towards the edge of the pools (entrance facing the middle of the pool, Figures 5.17 and 5.18).

Figure 5.14: Photo of the tampirai wire trap used in this study

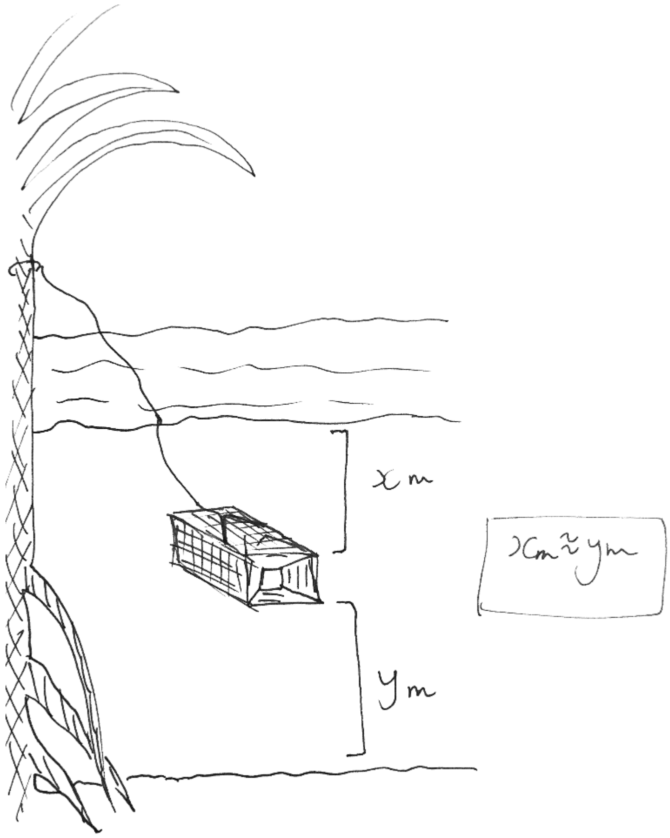


Figure 5.15: Sketch showing trap placement in the river

Figure 5.16: Photo showing trap placement in the forest canals

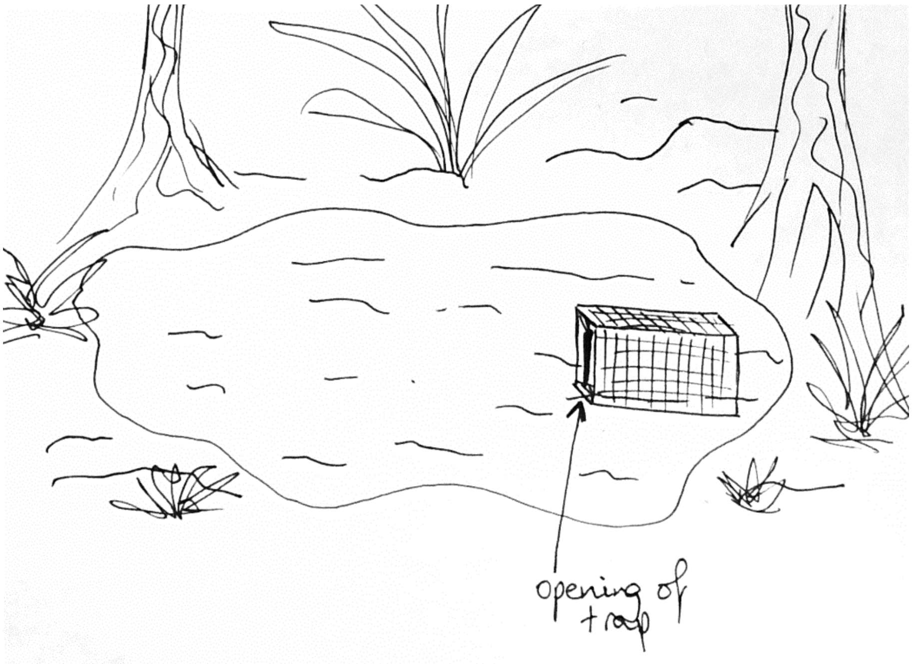


Figure 5.17: Sketch showing trap placement in the forest standing water pools

Figure 5.18: Photo showing an example of a tip-up pool with the fallen tree visible towards the back.

As with any trap, the *tampirai* is a selective gear; having an efficiency of capture that is highly variable among species or sizes of fish (Portt *et al.*, 2006). Worthington (2016) compared the gear used in this study to three other locally available fish traps of differing sizes and identified the *tampirai* (as used in this study) as the most effective overall gear due to its high diversity (thereby low selectivity of catch) of fish species and body lengths caught. With the selectivity of the fishing gear, and the heterogeneity of the river and the forest habitats themselves, it is possible that the 'catchability' of fish in both habitats differs. Knowing whether this is the case is practically very challenging. The results of this thesis provide an initial understanding of what the fish communities look like and thereby establishes baselines for future monitoring.

For the river, monthly data were collected for a year to consider seasonal influences and changes (dry and wet season) on the fish community. For the forest, a shorter sample period was used due to insufficient water depth to set traps during some dry season months. In both the forest and the river, a total of 5 sampling days were completed monthly. In the river, a total of 20 traps were set on alternating sides of the river over a 7 km stretch (a distance of 400 m between each trap; Figure 4.19). This placement aimed to cover the greatest stretch of river as possible while ensuring that the distance between and number of traps were still feasible to check in one sample day.

In the forest, seven traps were placed in each of Canal A and D, with traps located 50 m away from each other (Figure 5.20). Three traps were placed in standing water pools located on Transect C, and a final 3 traps were placed in selected pools spread across the study area. These locations were chosen to maximise the area covered by the traps while keeping it practically possible to check these in one day. Due to the physical difficulty of walking in a peat-swamp, especially during the wet season, the area covered in the forest was therefore smaller than that covered in the river. The trap placement also allowed me to design an efficient route through the forest using the permanent transect system that is in place, covering a 4 km route each day (Figure 5.20).

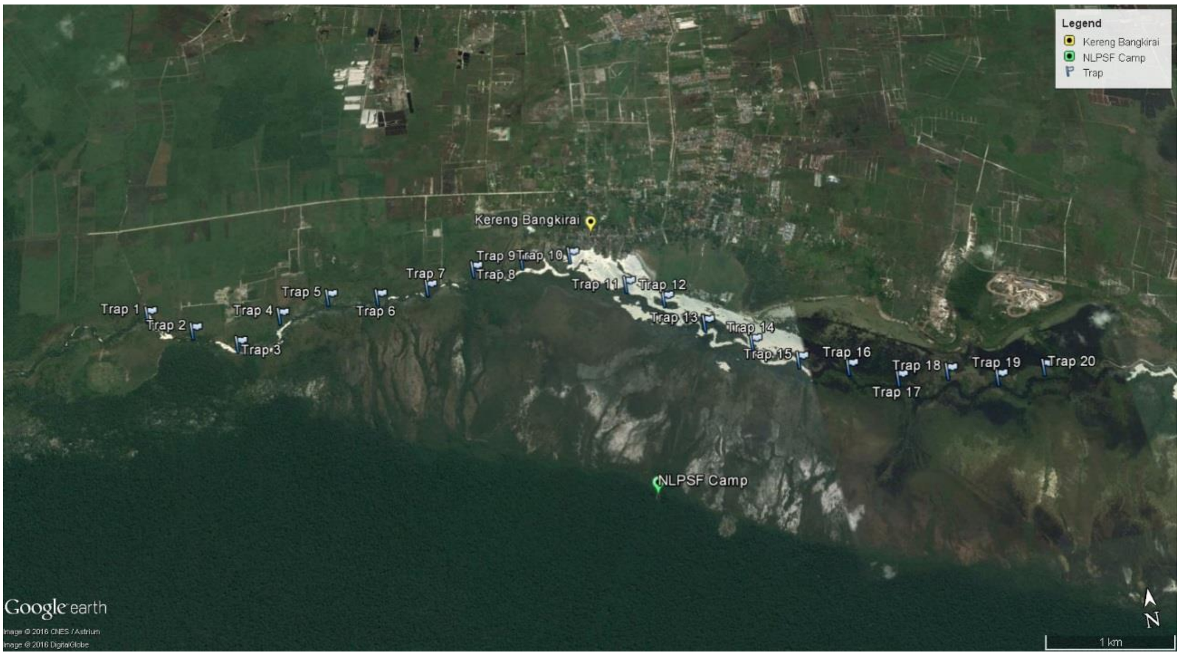


Figure 5.19: River trap locations. Map from and edited in Google Earth, 2016.

Figure 5.20: Forest trap placement, showing traps in canals with the red markers, traps by fallen trees with the tree marker and an example route indicated in yellow. Map from and edited in Google Earth, Image CNES/Astrium, 2016.

In both locations, traps were set the day before the first sampling day. Each trap was then checked and emptied daily (between ~ 0800 and 1400h; this could vary depending on the number of fish trapped) with all fish identified and their standard length (SL) measured to the nearest mm (from the most anterior extremity, mouth closed, to the hidden base of the median tail fin rays; Figure 5.21). If > 100 fish were caught in a trap, a sample of 20 individuals of each species was measured with the rest counted.

Figure 5.21: Dudin measuring the standard length (SL) of a fish trapped from the river

Mortality among fishes associated with a particular gear type is important to consider for the purposes of effective, but sustainable research. Ecological conservation being a primary objective of BNF and the research it sponsors, employing the most non-selective and non-damaging (i.e. with lowest mortality rates) fishing gear was necessary. Any mortality was therefore noted to inform future fish surveys. If fish were showing stress by gaping at the surface of the water, and a large number of fish remained to be counted, discretion was used and this minimum sample number was lowered depending on time, temperatures and the number of fish. Care was taken to not unnecessarily stress the fish collected, by placing fish in water buckets as soon as possible after capture and keeping buckets covered if possible to reduce high temperatures, and measuring fish and returning to the river/forest water as quickly as possible. Every effort was made to prevent excessive stress, damage or death to the fish.

Fish identification was done visually, using Kottelat and Whitten (1992) and subsequent checking using online resources such as FishBase (www.fishbase.org). A local fish expert in Palangka Raya called Hendra Tommy was consulted along with Kalimantan fish expert Dr. Xingli Giam. As all identifications were done visually, in some cases it was only possible to identify fish to genus level in the field, such as *Clarias* spp. (walking catfish). Published resources have conflicting classifications for most members of the family Channidae, as local names are very location specific and therefore difficult to verify (see Yulintine *et al.,* 2005 for an example of local name to scientific classification inconsistency). The same issue has indeed been found for local tree identification (see Harrison *et al.,* 2010) which also complicates the comparison of tree species in a different area in Central Kalimantan. With the aforementioned difficulties of fish identification in the field, future efforts are needed to clarify in-field fish identifications and the variety of local names that can be used for each (hence, building on the folk taxonomy presented in Appendix I). The species list that this thesis provides is therefore preliminary and should be built upon in the future.

The fish species in the fish ponds were also sampled, using the same methods and water quality measurements as in the rivers and forest. Two traps were set in each pond, and the traps were left for three days. Just as in the forest and river, traps were checked and re-set daily. Fewer traps and fewer trap nights were used due to the smaller size of the ponds, resource and time limitations. However, this still resulted in a data set of 48 trap nights per fish pond (192 in total) from February 2015 to the harvest of the fish ponds in September 2015. During harvesting, the remaining water in the fish ponds was pumped out and as many fish as possible were caught, weighed, identified and given to the CPT for personal consumption.

5.3.1. Water variables and analysis

Table 5.3 summarises the environmental variables measured, how these were measured and their frequency.

Table 5.3: Summary of the environmental variables, method of measurement and frequency		
Water variable	***Method***	***Frequency***
Depth	Measuring tape with weight attached	Monthly
Width	Measuring tape or GPS	Monthly
Temperature	pH meter or the ProODO YSI Digital meter temperature function	Daily
Flow rate	Ping-Pong ball and measuring stick	Monthly (Forest only)
pH	Stick meters (Hanna HI-98127 or equivalent	Daily
Dissolved oxygen	ProODO YSI Digital meter	Daily
Turbidity	Secchi disk	Daily
Nutrient content (P, NO_2, NO_3)	Laboratory analysis	Monthly

Measuring water pH levels was considered important as a decrease can disrupt ion balance in fish by inhibiting active salt uptake (Val *et al.,* 1998). pH changes affect the ion and acid-base regulatory mechanisms at the gills of fish as well as mucous secretion and gill structure (Kwong *et al.*, 2014). Dissolved oxygen concentrations also directly affect fish: a low concentration can make the water uninhabitable by certain species and may affect fish ecology due to its impact on energy availability for locomotion, growth, predator avoidance, and reproduction (Kramer, 1987; Breitburg, 2002; Ekau *et al.*, 2010). When oxygen availability is reduced, more energy has to be allocated by the fish to breathing which increases total energy expenditure (Kramer, 1987; Ekau *et al.,* 2010). If the energy allocation to breathing is held constant following a decrease in oxygen availability then in turn the oxygen allocated to other processes has to decline and the fish has to compromise with lower levels of other processes such as movement, growth or reproduction (Kramer, 1987; Ekau *et al.,* 2010).

Increased water turbidity can impair fish visibility and feeding or harm their respiratory system (Bruton, 1985; De Robertis *et al.*, 2003; Kennedy *et al.*, 2004). Turbidity is caused by dissolved organic and inorganic particulate and suspended matter and can be defined as "*the properties of water that cause light to be scattered and absorbed*" (Henley *et al.*, 2010:127). Sources of increased turbidity can be eroded material or sediments that have settled to the bottom of rivers which then become entrained during high flows (Henley *et al.,* 2010). Increases in turbidity can limit light penetration through the water, thereby reducing phytoplankton production (Hötzel and Croome, 1994) and fish food availability. Increases in turbidity also have a negative effect on fish that feed visually (e.g. Crowl, 1989; Utne, 1997; Utne-Palm, 2002), impacting large piscivores negatively while potentially having a positive anti-predator effect on small planktivores (Utne-Palm, 2002). High and sustained levels of sedimentation (which increases turbidity) can therefore cause changes in fish community structure, diversity, biomass, growth, and rates of reproduction and mortality (Newcombe and MacDonald, 1991; Gregory *et al.*, 1993; Utne-Palm, 2002; Henley *et al.*, 2010). Due to these impacts, it is important to measure water turbidity. It was aimed to collect monthly turbidity measurements in the river and forest, however following equipment difficulties and failure, only data collected in the river using a Secchi disk are presented here. These data cover 10 months (February 2015- September 2015, and then November and December following the 2015 fires) which was still sufficient to explore any statistical relationships between the fish assemblage and the water turbidity. The Secchi disk was not usable in the forest due to the water depth being insufficient and therefore no turbidity data are presented for the forest location.

Nutrients are vital for the functioning of the aquatic ecosystem, with nitrogen and phosphorus supporting the growth of algae and other aquatic plants. However, these nutrients can also be toxic at high concentrations, leading to changes in algal growth, eutrophication of the water body, changes in dissolved oxygen levels and even fish mortality (USGS, 2006; pers. comm. Brink, 2014). Two key and standard water quality nutrients are phosphorus and nitrogen (see USGS, 2006; EPA, 2011). Levels of total phosphates (P), nitrite (NO_2) and nitrate (NO_3) were therefore measured. Surface water samples were taken in the sampling locations on the final day of sampling, and on the same day were taken to a fridge and kept at 4°C if storage prior to analysis was needed. The samples were brought to the University of Palangka Raya laboratory where nutrient analysis was performed using Atomic Absorption Spectrophotometry (AAS spectra 30) following standardised procedures: analysis for P was done following the ascorbic acid method of Eisenreich *et al.* (1975) after Murphy and Riley (1962) (see Sulistiyanto, 2005 for further details); NO_2 analysis was carried out according to the Griess test (developed by Griess, 1858 and is a standard procedure for testing nitrite in water, see Sulistiyanto, 2005); and NO_3 analysis followed the methods developed by Yang *et al.* (1998). The volumes, times, and concentrations used for these analyses are presented in Appendix II.

Water body depth and width was measured monthly, as seasonal water depths in both the river and forest can vary significantly. Water temperature has an impact on dissolved oxygen levels, so surface water temperature was also measured (using the pH meter or the ProODO YSI Digital meter that also had a temperature function).

The river and forest surveys had some variations in terms of the environmental data that were gathered. In the river, the water depths (from middle of the river as well as trap locations) were measured from the same locations each month. Lastly, flow measurements were not taken in the river (due to the practical difficulties of measuring flow from a boat, along with resource limitations), but were taken in the forest where surface water flow in the canals was measured by timing the travel of a floating ping-pong ball over a set distance (again, a flowmeter was not used due to equipment failure and then availability of resources). Of course, there are limitations to measuring flow in this way as the water flow will vary with depth of the water column. Ideally, a flow meter would be used at various depths, and this should be considered for future research.

5.3.2. Analysis of fish community data

To standardise captures for data analysis and comparisons, fish catch per unit effort (CPUE) was calculated using the following formula (Merilä, 2015):

$$CPUE = \frac{N_{catch}}{(N_{traps} \times N_{nights})}$$

where N_{catch} = Number of fish trapped, N_{traps} = Number of traps set, N_{nights} = Number of nights set.

When testing correlations between catches and environmental variables, if both data sets showed normal distribution, a Pearson's correlation was used; otherwise Spearman's rho correlation was used.

For trophic level analysis, different species are compared by their fractional trophic level (FTL). This value was taken from the FishBase database (Froese and Pauly, 2015). FTL estimates are based on the diet of the fish species compiled through studies, with many of them based on extrapolations between similar species. Of course this comes with limitations and questions of reliability (if there are unknown/unexpected diet differences between 'similar' species) and future research on the diet of the fish species in Sabangau would improve the FTL estimates used in this study. The average monthly trophic level was calculated for the river and the forest assemblages with the following formula:

$$TL_k = \sum_{i=1}^{m} Y_{ik}\, TL \Big/ \sum Y_{ik}$$

where Y_{ik} is the catch of species i in month k, and TL is the trophic level of species i for m species (Pauly *et al.*, 2001).

There was no FTL data available for *Osteochilus spilurus* from FishBase. Considering other species in the same genus, it is likely to have an FTL between 2.0 and 2.6. The other species of *Osteochilus* trapped, *Osteochilus melanopleura* has an FTL of 2.3. Froese and Pauly (2016) reports that *O. melanopleura* feeds mainly on benthic algae and weeds with some insects. Choy *et al.* (1996) reported that the diet of *O. spilurus* comprised mainly of vascular plants (not algae), with a small proportion consisting of insects. *O. melanopleura* and *O. spilurus* share a similar omnivorous diet and on this basis, *O. spilurus* was thus assigned an FTL of 2.3 for the purposes of this study. Likewise, *Eirmotus sp.* was assigned an FTL of 2.9 as it was assumed to have a similar diet to other *Eirmotus* species that are found in the area.

Using 'Estimates' by Colwell (2013), the expected total number of species was estimated in the forest and river by computing non-parametric, asymptotic species richness estimators: Chao-1 and ACE using abundance data, ICE using incidence data (presence data) and Chao-2 using replicated incidence data (as samples were replicated over several days) (Gotelli and Colwell, 2010). As recommended by Colwell (2013), the classic instead of the bias-corrected option was used for these calculations, as Chao's estimated coefficient of variation for Abundance distribution and CI for Incidence distribution was high (exceeded 0.5). The larger Chao-1 Classic and ACE are therefore reported as the better estimates for abundance-based richness, and the larger Chao-2 and ICE as better estimates for incidence-based richness (see Colwell, 2013 for detailed descriptions of these estimators and procedures).

AccuCurve (Drozd and Novotny 2010) was used to calculate the species accumulation curves (SAC) for each site. SACs are computed via a randomisation process, using presence-absence data over the sampling period with the accumulation rate of new species encountered. It therefore only includes the fish species that are actually trapped during the survey and fewer species are included than appear in the final species list. However, this should not have considerable impacts on the reliability of the results or the shape of the curve as it only discounts two species from the forest and three from the river.

5.4. Methods used with the human communities

A variety of methods were chosen to deal with the information that this thesis aimed to gather: focus groups for general information, brainstorming and to get a better idea of the situation before continuing with the in-depth interviews; questionnaires in an attempt to quickly gather information on demographics, fish use, the selling of fish, the dependency on fish as income source etc.; and more in-depth semi-structured interviews to collect more detailed information regarding the local perceptions and experiences of environmental changes and disturbances. Combined, these methods allowed a better understanding of the human communities and the Sabangau area as a whole. However, I was unable to untangle group and individual perceptions and values, as will be discussed later in this section, because many of the 'individual' interviews ended up taking place with multiple people listening and sometimes joining the interviews. Future research dealing with shared and individual values would therefore be helpful.

For recruiting participants the same methods were used for both interviews and focus groups. When considering the most appropriate participants to approach (as described in Rowley, 2012); the aim was to explore perspectives from both men and women, plus fishers and non-fishers. Figure 5.22 gives the age ranges of the 260 participants. Aiming for an equal balance between genders, overall, there was an over-representation of male participants with 28 more male participants: two more in the focus groups and the rest of the difference from the questionnaires (116 female participants and 144 male participants in total). For the in-depth interviews there was equal gender participation. On-site recruitment was used (Clifford *et al.,* 2016) led by Kris as villagers could feel unable to decline participation if I was the one recruiting (see Graham, 2013; pers. comm. Kris, 2014). Kris had sometimes already recruited participants the day before, or in the case of Taruna Jaya, had recruited participants on the same day as the interviews because remoteness of the village made it difficult for recruitment to occur earlier. While this meant that we had to spend time searching for participants on the day, which was less efficient than if they were previously prepared, practicalities necessitated this approach.

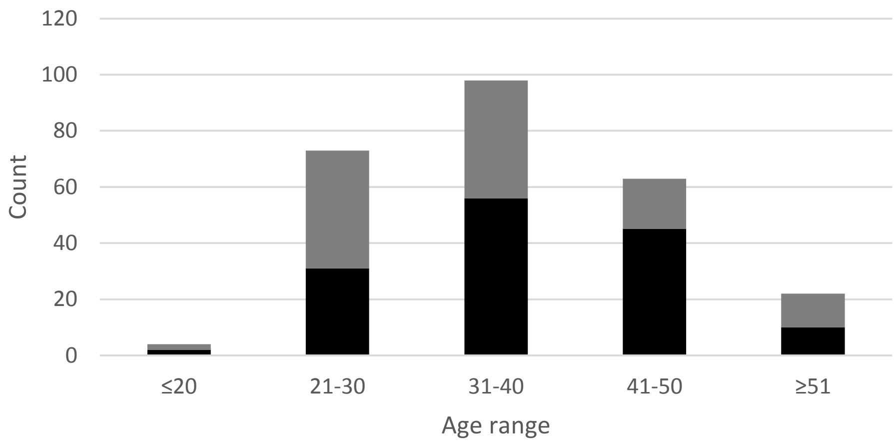


Figure 5.22: Ages of recruited participants in this study for each gender, male (black) and female (grey) (incl. questionnaires, focus groups and interviews), n=260

In all cases when I was present during recruitment, the facilitators would approach possible participants with me waiting out of ear shot. This would again allow people to decline participation without facing me, and therefore was considered less confrontational. Kris was provided with a project information sheet and letters showing formal consent from UPT CIMTROP LLG and the University of Palangka Raya. Participants were able to see this information sheet and read it to clarify any questions they had. This was not used often, with Kris verbally explaining the research, its aims and activities with the participants and then gaining verbal consent of their participation. Verbal consent was preferred as information sheets are often seen as more formal, potentially intimidating participants with some potentially losing face if they had literacy difficulties. Once participation had been obtained, a sheet with basic information about the participants was completed by Kris or Erna (see Appendix III), again to avoid any illiteracy issues and potential embarrassment of the participants. Verbal consent was always gained before using the recorder; only one participant was unwilling to be recorded.

Interviews were conducted at participant's houses or in front of their houses (see Figure 5.23), except for one in Taruna Jaya (TJ9M, interview, 18/02/16), which was conducted in front of a shop where appropriate seating was available. These locations were chosen as the settings were as neutral as possible, informal, and easily accessible, thus participants felt at ease (Clifford *et al.*, 2016). For focus groups, various locations were used: in Kereng Bangkirai the men's group was conducted in the CPT office and the women's group in a public stand by the river. In Taruna Jaya both the men and women's focus groups were conducted in front of participants' houses. All locations were chosen by participants and the facilitators in discussion with each other allowing a location to be chosen where participants felt at ease and to ensure a more relaxed and informal atmosphere.

Figure 5.23: Woman's (above) focus group in Taruna Jaya held outside of a participant's house, and Men's (below) focus group in Kereng Bangkirai held at the CPT office

5.4.1. Focus groups

There is no one-size-fits-all solution for designing focus groups, with the specific approach depending on the purpose of the focus group and the type of information being sought (Freeman, 2006). This thesis used focus groups primarily to generate ideas and to get an idea of the variety of opinions and issues that are relevant when discussing fish and fishing in Sabangau, which then informed more specific and relevant in-depth interview questions. In focus groups, conversations are had with multiple people together, and therefore there is a 'group effect' (Morgan, 1996; Varga-Atkins *et al.*, 2015; Johannessen and Garvik, 2016) where shared values and opinions are expressed rather than individual ones. The strategy of using focus groups complemented by in-depth interviews has the advantage of first identifying a range of experiences and perspectives along with important topics, with interviews then adding more depth in exploring specific opinions and experiences and to address experiences over time: the focus groups provided breadth of information, with in-depth interviews then providing depth of information (Morgan, 1996; Ben-Arye *et al.,* 2014 use a similar approach to their design of questionnaires from focus groups).

Separate groups were convened for males and females, following Smith's (2002) and Graham's (2013) recommendations that women may not feel as comfortable as men when attending more formal focus groups and expressing strong views or knowledge. I also decided to keep the focus group participant numbers low to enable not only effective cross-language communication for myself (I expected to encounter greater difficulties with language barriers and managing these barriers in larger groups), but also to keep them intimate and make sure that all participants were able to contribute. From a trial focus group that I held in May 2015, this approach proved useful. Two small focus groups (with participant numbers ranging from 3-5) were thereby conducted in both villages: one with men and one with women.

As group-based participatory approaches such as ranking exercises can provide a solution to overcome literacy and language issues (Kenter *et al.*, 2011) and when discussing tangible management options (Failing *et al.* 2007), various brainstorming activities were used to explore these questions. Listing and ranking exercises were used along with activities adapted from Graham (2013). The first activities involved ranking exercises, where a laminated sheet (Figure 5.24) was laid in front of the participants. Laminated cards were given to Kris or Erna with a permanent marker to note down answers given by participants. First, they were asked what was generally important for their wellbeing, this was not restricted to fish, river or forest related aspects. Participants brainstormed, with all answers written down on cards. Then these cards were given to the participants, and they were asked to place them on the ranking sheet in the order of most to least important. Participants were then asked to arrive at a consensus. These ranks were noted down. This activity was then repeated, with participants asked why the river was important, and then how fish and fishing were important. Answers were again first written down, and then participants were asked to rank them.

The final activity used a large sheet (Figure 5.25). This was an activity adapted from Graham (2013) originally based on Gobster's (2001) 'visions of nature', which she used to discuss the importance of the forest. For my discussions, a large sheet was used that had a photo of a river in the centre, with the question "why is nature important? Why do we need the river?" underneath. The sheet was split into four sections; river function, river symbols, use of the river, and value of the river. Short sentences clarifying each of these sections were placed under the respective headings. With the help of my facilitators, participants were talked through the sheet and asked to help fill out the appropriate sections, either dictating to Kris or Erna, or using pens to fill out the sheet themselves. They were told that any words or sentences could be written on the boards, or even drawings: they had the freedom to brainstorm in the way they preferred. I then followed this up with a discussion regarding what had been written down to clarify their answers and discuss in-depth any subject that needed further elicitation.

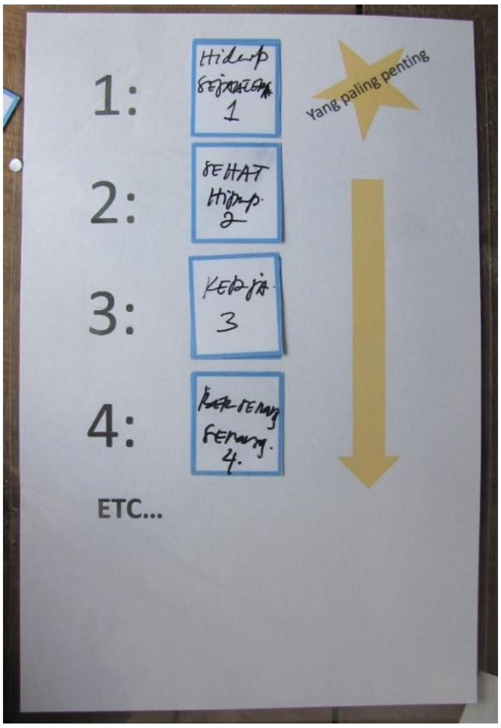


Figure 5.24: Ranking sheet showing written brainstorming cards from the focus group

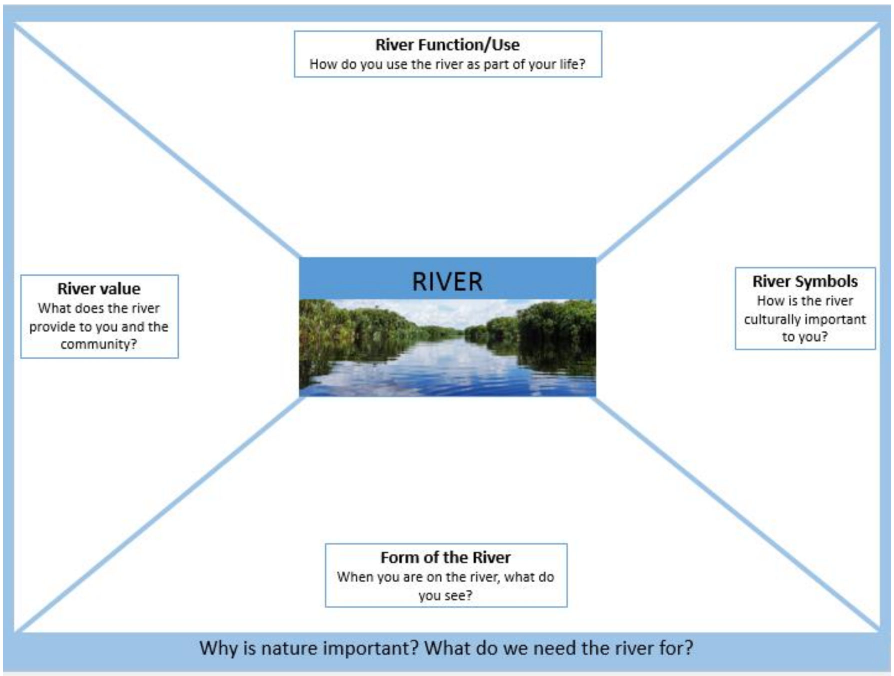


Figure 5.25: Brainstorming sheet used to discuss various aspects, forms and values related to the river.

Finally, short questions regarding dams, canals, fish ponds and fire were asked regarding their impact on fishing and participant's perceptions of these. This was to allow participants to express issues that they found important, to identify the types of questions to include in the in-depth interviews. In this way, any assumption that I knew "*all the important questions*" was avoided and this further allowed the results of the focus groups to guide the scope of the interviews (Johannes *et al.*, 2000). As I aimed to explicitly consider local perspectives, the focus groups allowed assemblage elements to be identified through local experience and perceptions rather than my external view and experience as a foreign researcher. Through the discussions, a vision and representation emerged of what the assemblage looked like to local community members and what elements were particularly important to them. These were then expanded on and discussed in greater detail during in-depth interviews. Through the participation of communities in identifying elements of the assemblage that were important and relevant to them, an understanding of the Assemblage was created that was relevant to the area, to the local communities and their culture, thereby forming a more holistic and equitable appreciation of the relationships between people and their environment. This was vital in the aim of keeping with the biocultural approach as outlined in Chapter 1, which challenges knowledge dichotomies and aims to respect and incorporate different worldviews and knowledge systems, thereby promoting a more progressive understanding of 'interdisciplinarity'.

5.4.2. Semi-structured in-depth interviews

The results from the focus groups were used to design the in-depth interviews to further clarify the assemblage, its elements and peoples' perceptions of fishing, environmental change and potential deterritorialising forces. Interviews can help discuss the "*emotional landscape of desire, morality and expectations that people inhabit*" (Pugh, 2013: 50). They can also help reconstruct the temporal and narrative structure of events that have occurred or practices that the researcher cannot observe (Jerolmack and Khan, 2014). Therefore, most of the human community analysis presented in this thesis comes from the in-depth interviews as these provided the greatest depth of data and allowed participants to express personal experiences and stories.

When conducting in-depth interviews, Klain and Chan (2012) found that the number of new concepts associated with each additional interview tended to diminish between 20 and 30 interviews. Rowley (2012) on the other hand recommends about 12 interviews of 30-minute length, with more interviews conducted in a second phase if needed. Guest *et al.* (2006) agrees that for research aiming to understand common perceptions and experiences among a group of 'relatively homogeneous individuals', 12 interviews should be enough, depending on group size. Being new to conducting interviews, I decided to aim for 20 interviews as a generous number in each location, which I could increase if necessary. Like Klain and Chan (2012) I found while conducting the interviews that information saturation point (when I stopped collecting 'new' information, and could almost predict what answers would be) was actually reached before the end of the 20 interviews. I therefore kept to this number for both locations; ultimately conducting 20 semi-structured interviews in Taruna Jaya and 20 in Kereng Bangkirai, with an equal split between male and female main participants (in case there were gendered differences). This provided a total of 40 interviews, with each interview lasting on average an hour (ranging from 30 minutes to 2 hours).

The in-depth semi-structured interviews were originally planned to be done individually. However, it was very common for members of the family or neighbours to join discussions or sit and watch (Figure 4.29). While there was always one main participant to whom I was directing questions, groups could vary from an individual to 11 or more villagers observing and occasionally contributing to the conversation. People would walk in and out of interviews, and therefore the number of participants involved varied throughout the interview itself as well. While perhaps not fulfilling the 'ideal' individual semi-structured interview characteristics, forcing the interview to take a certain shape would likewise have negative impacts on the chosen approach for the interviews to be informal and friendly and thus would hinder my efforts to keep the participants feeling at ease (Clifford *et al.*, 2016). Sometimes the 'ideal' interview situation can therefore be culturally inappropriate. This is where the interviewer's discretion comes into play, balancing the situation with the information that the interviewer seeks to collect. Being not strictly individual interviews does have its downsides as the information I collected will have been influenced by the presence of other members of the village and, potentially, more shared values and opinions were expressed rather than individual ones. Saying this, shared views and values, as discussed in Section 5.4, may even be more relevant in these villages where decisions are usually made at the clan or extended family level (Kenter *et al.*, 2011).

At the beginning of the interviews, a task was used to explore local human community perceptions related to various forest species. Tasks can be used as a technique to warm participants up for discussions, to engage them in the interview and to encourage participants to reflect and talk (Rowley, 2012). As I was conducting a primarily cross-language interview, this task also prepared both myself, my facilitators and the participant to how the interview would flow, and assisted in making sure everyone was comfortable. The task consisted of asking participants to place a limited number of 16 coins on various pictures of forest species according to how 'important' they deemed them to be to their lives. Their reasoning was then discussed. While the exercise involved discussing a variety of nonhuman forest species (fauna), this thesis will limit the scope of the discussion to that revolving around fish. Table 5.4 below shows the chosen animal species along with my reasons for inclusion.

Table 5.4: Chosen forest species and their reason for inclusion in the weighting activity used at the beginning of interviews	
Species	**Reason for inclusion**
Fish	Important source of income and protein, main nonhuman community that this thesis considers
Lesser green leafbird (*Chloropsis cyanopogon)*	A popular bird locally which is hunted and kept as a pet as a sign of social status
Gibbon (*Hylobates albibarbis*)	Has international conservation priority
Orangutan (*Pongo pygmaeus*)	Has international conservation priority, is perhaps the most charismatic species of the list
Sun bear (*Helarctos malayanus)*	Has international conservation priority
Hornbill (*Buceros rhinoceros*)	Is an important symbol in Dayak culture
Crocodilian (*Crocodylus sp*.)	False gharials and crocodiles can be seen as mythical creatures in Dayak tradition: again, there is a potential cultural importance to these animals
Clouded leopard (*Neofelis nebulosi*)	Has international conservation priority

For interviews, Rowley (2012) suggests six to 12 well-chosen questions, with each question potentially having two to four sub-questions or prompts to make sure the main question is explored fully, thereby leading to a total of 24-48 questions (including sub-questions). I followed a similar approach, preparing a semi-structured interview guide taking 8 main themes with an average of four questions per theme. This totaled 31 different open-ended questions (including prompts if needed) (see Appendix IV). The questions were used as guidelines, with the flow of the conversation guided by the participants themselves (Rowley, 2012). Open-ended questions that were as neutral as possible were used to allow the participants to fully express their viewpoints and experiences (Turner, 2010).

With potentially sensitive or controversial topics such as electric fishing, questions were only directed once participants themselves had brought up the subject. This was recommended by my research assistants to not make participants uncomfortable and hinder their willingness to share information (this approach was also used by Harrison *et al.* (2011) when conducting questionnaires on fruit bat hunting in Central Kalimantan). Questions began with general fishing questions that were not expected to be controversial, these led to questions regarding fishponds, fire and dams (again, moving slowly towards potentially more controversial questions towards the end of the interview). I then asked questions related to cultural aspects of fishing, if participants use any type of offerings and finally if they know of any spirits that live in the river (with details elicited if this was the case). These were potentially the most personal questions, related to beliefs and spirituality. Moving towards the end of the interview I brought the questions back again to more neutral and general issues (to prepare participants to come out of the interview), dealing with access issues to cities and markets, followed by general questions dealing with wellbeing. I ended the interviews with questions regarding what they would like to see in the future of the area, and if there was any more information they felt I should know. Engagement therefore started with questions related to participant's life and work, and I made sure that there was always scope for opinions and experiences to be discussed (see Rowley, 2012).

5.4.3. Questionnaire

Questionnaires were used to collect information regarding the economic importance of fish including how much income is generated by fish, what the financial transactions are, as well as asking questions regarding fish consumption, the importance of fish conservation, the importance of forests to the conservation of fish, the use of fish ponds, etc. They were designed with Kris's help over several meetings and were conducted by Kris and Karno following their advice. Kris and Karno therefore decided it would be easier for them to conduct the questionnaires without me, as my presence frequently caused interest in the village which would have a negative impact on the efficiency of the questionnaires (which was indeed experienced during the interviews which thereby were commonly not individual interviews as discussed in Section 5.4.2.). As the questions were pre-determined and highly structured, my presence was unlikely to have any added benefits except for potentially eliciting clarification or further information. This potential drawback was balanced by the in-depth interviews. Furthermore, this would allow me to continue other aspects of data collection such as my fish surveys in the river and forest while they were out conducting these questionnaires.

Participation was intended to be random and gender stratified. For randomisation, I gave Kris and Karno a dice, and asked them to start at a chosen house and use the roll of the dice to decide on how many houses to walk past until they approached their new participant. Later it became clear that an opportunistic approach was used instead, with them walking around town and recruiting those they came across. They explained that this was because they were not having success in coming across houses that were occupied and that an opportunistic approach was more efficient and effective in recruiting participants. I accepted their change in method as it was clearly impractical to demand a random sample. While an opportunistic approach can introduce biases, e.g. through Kris and Karno potentially preferring to approach members of the community that they knew or were close to, the information needed from these questionnaires was not controversial. Upon asking for feedback on how the questionnaires were going, Kris expressed that it had been helpful for him to approach a wide variety of people, allowing him to have conversations that were also valuable for his role as a CPT member. This expressed willingness to approach unfamiliar people, should have limited any grave bias in the selection of participants.

Before Kris and Karno embarked on interviews, we had several meetings discussing the interviews and the sampling method, which included training in interview techniques along with practice interviews at the NLPSF camp with BNF-OuTrop employees. This allowed me to see their approach to questions and to suggest any changes and improvements to their questioning.

The questionnaires were used to gather information from both fishermen and non-fishermen (males and females). In total, 206 questionnaires were conducted: 197 in Kereng Bangkirai and 9 in Taruna Jaya. More questionnaires were planned to be conducted in Taruna Jaya however these were cancelled following the 2015 fires, initially due to health and safety concerns. After the fires, I decided not to re-start these questionnaires as the fires would have likely introduced an added bias in some of the answers given, such as fish prices, sources of income and relations to the environment. These questionnaires were intended to support my assemblage analysis to take into consideration a representative population of the different human communities. Given that I was unable to complete these surveys this was not feasible and my comparisons have to go by personal communication with villagers during semi-structured in-depth interviews, research assistants and my personal experience in the two villages. This sample is not ideal; however, it is still possible to draw some conclusions on the general economic importance of fish and fishing in the Sabangau area, considering the villages together. This furthermore acts as a starting point for further research regarding the economic importance of fishing to local communities in the Sabangau.

The questionnaire had 5 sections, and depending on the participant's occupation (if they were a fisherman or not), whether they ate fish, bought fish or sold fish would determine which sections they would be asked. Questions were asked by Kris or Karno, with the other writing down the answers. The first section of the questionnaire was for everyone and dealt with basic information such as religion, age and occupation. The final section was also for everyone, where participants were asked an ending question related to if they had any more information they felt was important. The questionnaire guide is available in Appendix V.

From the questionnaire data, there was an under-representation of Banjarese. This group is not invisible in this thesis, still being included in in-depth interviews. This calls for future questionnaire surveys in the area to ensure that under-representation is avoided, or at least that similar evaluation is done before conclusions can be drawn related to ethnicities and resource use or other issues of interest. Furthermore, from these results it is evident that using a variety of methods can help to ensure better representation of various population groups (with interviews balancing out the under-representation of a certain group during the questionnaires), and further highlights the importance of considering heterogeneity of the region and villages themselves.

5.4.4. Analysis of human community data

Throughout my time living in the Sabangau area I took notes on any conversations that were related to fish outside of my official data collecting periods. This included notes on discussions that I had with Dudin or other research assistants or BNF staff members outside of my survey work in the informal environment of the NLPSF camp. Occasionally, BNF staff would sit down with me to talk about my project, and would offer information regarding a certain species or a story they knew. I made notes of these once the conversation was over to be added to the overall data analysis for this thesis.

Interviews and focus groups were anonymised and in this thesis, I will refer to interviewees by a code (KB for Kereng Bangkirai or TJ for Taruna Jaya plus the interview number and F for female or M for male; e.g. KB3F). Taking the translated notes, transcriptions and results from the listing and ranking exercises from the focus groups and interviews, I manually coded the interviews, and then sorted quotes and discussions into the main themes and issues; thereby using thematic analysis (Squires, 2009). The themes generally followed the main themes of the interview/focus group questions: e.g. perceptions of fires, perceptions of fish population changes, spiritual beliefs etc. New themes also were introduced through the interviews and focus groups from participant's responses such as the discourse surrounding 'outsiders'. The information gathered under each theme was then used to inform my understanding of the assemblage, its elements and the relationships between the assemblage elements.

For assemblage elements, the aim was to gain information regarding the human community composition (e.g., occupations, expenditures on fish, percentage of protein that comes from fish) to identify and compare these through questionnaires from both villages. As previously mentioned, questionnaires were not continued following the 2015 fires and therefore most of the identified elements came from the focus group and interview data. The questionnaire results were coded and entered in SPSS for analysis.

5.5. Chapter summary

In this Chapter, I describe the specific methods which I used to address my research questions and objectives using the IAA outlined and discussed in Chapters 1-3 (Figure 1.1). I introduced the chosen study sites of the Sabangau area in greater detail: namely the forest and river locations of the fish communities and Kereng Bangkirai and Taruna Jaya as the locations of the human communities. I furthermore introduced and discussed the partners, gatekeepers and facilitators that were key to this project.

I reflected on my own positionality, discussed the role of facilitators in all aspects of the research undertaken as well as the vital role of local knowledge for this project. This latter part needs to be kept in mind throughout the analysis chapters of this thesis: without the local knowledge of my research assistants this thesis would not have been possible. Once more, the boundary between 'local' and 'scientific' knowledge thereby shatters. I discussed the limitations of working with translators and interpreters in research and what my efforts were to overcome these.

I then outlined the methods used to investigate the fish communities which involved traditional wire fish trapping methods and water quality surveys along the river Sabangau and in the Sabangau forest. During these surveys I identified, measured and counted the fish that I trapped over a year in the river and 5 months in the forest. I also used the same trapping techniques to monitor the fish ponds by the Sabangau Forest and Kereng Bangkirai.

For the human communities, focus groups were used to collect general information, brainstorming and to get a better idea of the situation before continuing with the in-depth interviews; questionnaires were used to quickly gather information on demographics, fish use, the selling of fish, the dependency on fish as income source etc.; and the more in-depth semi-structured interviews were used to collect more detailed information regarding the local perceptions and experiences of environmental changes and disturbances. In this chapter I discussed the limitations and the rationale of each of these approaches.

Following the discussion of research questions, objectives, approaches and methods, I now move onto the analysis chapters. These will take the steps as outlined in Chapter 1, Section 1.3.1. In Chapter 6, I take Step 1 which focuses on identifying assemblage elements. In Chapter 7, I take Step 2 which focuses on identifying the relationships between assemblage elements. Finally, in Chapter 8 I take Step 3, which discusses deterritorialising forces acting on the Sabangau area, and the emergent properties of the assemblage.

CHAPTER 6

STEP 1:

Identifying assemblage elements and properties

As introduced in Chapter 3, the material and expressive elements of the Sabangau area were identified by community members using focus groups (Chapter 5). This was done to de-centre my worldview as an outsider. From focus groups, material components included fishers, builders, organisations such as UPT CIMTROP LLG and the World Wide Fund for Nature (WWF), fish, spirits, crocodiles, plants and other animals. They included the rivers, their meandering, length, depth and flow; the forest, canals, dams, boats and gold that can be found in the upper reaches of the Kahayan. Expressive components included the attitudes towards 'traditional' and non-'traditional' fishing methods, expressions of changes in fish populations and expressions of mistrust and at times anger towards outsiders. These are all aspects that will be expanded on, particularly in Chapters 7 and 8. With a lack of space to consider the endless expressive and material components of the assemblage, this chapter focuses on the social ensembles as material components and some of their expressive components such as religious identities. More specifically, this chapter deals with three prominent communities of the Sabangau area: the human communities, the fish communities and the spirit communities. The coming sections identify and discuss some of the properties of these communities that are important to understand further relationships (Chapter 7) and emergent properties of the assemblage (Chapter 8). As Frosh and Pinchevsky (2014: 603-604) guide their analysis;

> *"It is by regarding all these different elements (and many others that have been left out) as interconnected and interrelated that we can get a rough idea of the contours of the assemblage"*

To do this, the chapter draws on the information collected from questionnaires, focus groups and interviews in the local human communities along with the fish surveys completed in the Sabangau River and Forest. The interconnections between these elements will be explored further in Chapter 7.

By taking these examples, this thesis can also illustrate aspects of territorialisation of the IAA. Territorialising processes work to consolidate the assemblage, with deterritorialising forces leading to assemblage change (DeLanda, 2006; 2016; Frosh and Pinchevski, 2014). In communities, territorialising forces include commonalities between community members including aspects of religion and ethnicity, as will be discussed. It is important to note that territorialising and deterritorialising forces do not cancel each other out, or balance each other but "*coexist in the assemblage in constant disharmony, releasing unexpected mutations and variations*" (Frosh and Pinchevski, 2014: 602). These concepts are therefore important to keep in mind throughout these three analysis chapters to understand the ephemerality of the assemblage in the Sabangau area and how the territorialising and deterritorialising forces are acting upon it.

The forest and river fish assemblages are a part of the bigger assemblage in the Sabangau area which also includes the human community assemblages. The human communities relate to the different fish community assemblages (the forest and the river) in different ways, depending on, for example, what fish species they are aiming to trap, and so such relationships will also depend on the element properties (the target fish species). Indeed, DeLanda's (2016:20) third characteristic of assemblages is that they can be component parts of larger assemblages: and in agreement with this approach I will argue that ecosystems are assemblages, communities are assemblages, and even individual species are assemblages through the IAA (Chapter 3). This understanding of the embeddedness of assemblages is vital, as forces of deterritorialisation and territorialisation have implications for all the assemblages which make up the larger assemblage in the Sabangau area, although not necessarily with equal consequences. Chapters 7 and 8 will elaborate on the complex relationships within and between different scales that complicates an understanding of ecosystem responses to change. The separation of the human, fish and spirit communities is artificial as the role of the assemblage framing is about their connections and entanglements. This chapter is therefore only focussed on describing the properties of the assemblages and building foundations to which future chapters will add. This chapter is therefore predominantly descriptive. Based on my results it takes the first step of the IAA framework: identifying assemblage elements and properties. It starts now with the human communities and their properties.

6.1. The human communities

Human communities can be characterised according to the location of the community, ethnicity of participants, village population, occupation of villagers and religion (e.g. see Palmer *et al.,* 2005; Corbett and Keller, 2005; Kreager, 2006; Kreager and Schröder-Butterfill, 2007; Henriques and Louis, 2011, Nijman and Nekaris, 2014). Of course, numerous other aspects can also be considered, such as the family system, age structure of the village, proportion of households owning land (e.g. Kreager, 2006; Kreager and Schröder-Butterfill, 2007), access to the village (e.g. Corbett and Keller, 2005), population growth rate (e.g. Henriques and Louis, 2011) and information on the nearest towns and markets (e.g. Palmer *et al.*, 2005). This thesis focuses on four human assemblage properties: ethnicity, religion, occupation and education. These have been chosen due to their importance for the chapters to come and they emerged from my data as being important; they are key aspects of the Sabangau human communities and also help to clarify certain relationships and emergent properties of the larger assemblage in the Sabangau area. These aspects have certain territorialising implications through delineating the community boundaries with other communities, and further draw out differences between the two case study locations such as dependence on fishing, availability of job opportunities and the access to education and markets. This section compares the properties of the human communities to provincial statistics where appropriate, to highlight the heterogeneity of the wider assemblage across Central Kalimantan and the need to take this heterogeneity into consideration if the results of this thesis are generalised over the wider geographical area.

6.1.1. Ethnicity

Bornean societies are varied and complex, and the history of ethnic identities and tensions in Kalimantan is key to understanding cultural differences and conflicts over resources in the Sabangau area (see Schreer, 2016). Both Kereng Bangkirai and Taruna Jaya are considered Dayak communities (Graham, 2013; pers. comm. Kris, 2014), however as Graham (2013) found in Kereng Bangkirai there are other ethnicities represented in the village.

Recalling from Chapter 5, the use of the term 'Dayak' within this thesis is short-hand for many indigenous ethnic groups found in Central Kalimantan, including the Ot Danum, Ma'anyan and the Ngaju Dayaks. The Ngaju Dayaks are the largest of the Dayak tribes in Central Kalimantan (Eriksen, 2016), and Dayaks in both Kereng Bangkirai and Taruna Jaya are predominantly from the Ngaju Dayak group. Questionnaire results, as illustrated in Figure 5.1., show the vast majority of participants identified as 'Dayaks' (90%), with a minority identifying as Javanese (8%). Suyanto *et al.* (2009) also found the three main ethnic groups in their study area (ex-MRP) to consist of Dayaks (94.4%- 100% depending on the village), Banjar (0-3% depending on the village) and Javanese (0-3% depending on the village). Figure 6.1 illustrates the ethnicities represented in all of the study sites combined.

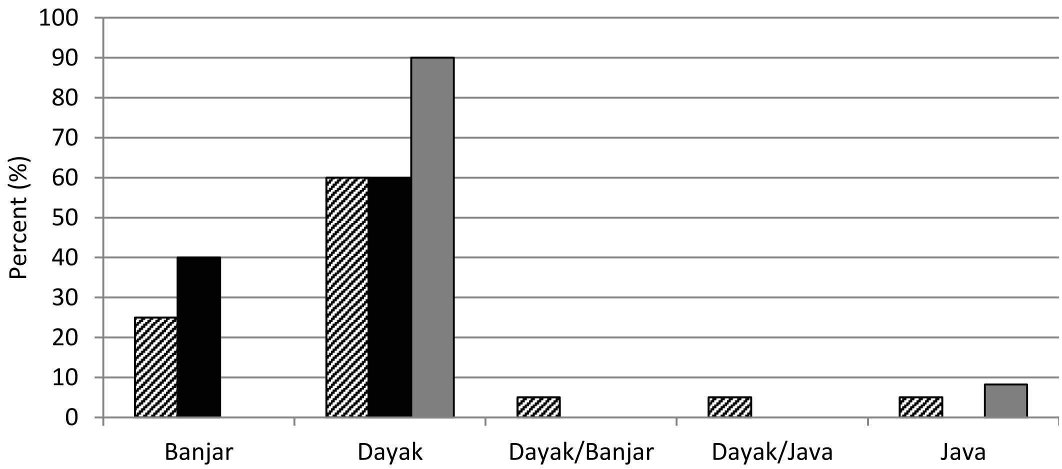


Figure 6.1: Percentage (%) of in-depth interview participants in Kereng Bangkirai [diagonal lines] and Taruna Jaya [black] identifying to each ethnic group, n=40, compared to the percentage (%) of questionnaire participants identifying to each ethnic grou

From Figure 6.1 it is notable that no participants identified as Banjarese in the questionnaire sample, although Banjarese were present in the in-depth interviews. In 2010, the Banjarese were the third largest ethnic group in Central Kalimantan forming 21% of the population (Ananta *et al.,* 2015). The questionnaire sample is likely to have been more representative of the Banjarese population had the questionnaire surveys been continued in the Taruna Jaya area following the 2015 fires. Saying this, when compared to provincial statistics, there was an overrepresentation of Banjarese for the in-depth interviews (in Kereng there was only a slight overrepresentation with 25% of participants identifying as Banjar). This important ethnic group is therefore still included in the thesis analysis.

In 2010, people identifying themselves as Javanese made up approximately 22% of the population of Central Kalimantan (Ananta *et al.*, 2015). Taking this information, there seems to be an underrepresentation in the in-depth interviews of Javanese compared to the provincial statistics. This is likely due to the specific history of the villages chosen for this study. Both Kereng Bangkirai and Taruna Jaya have a very different history to transmigrant villages. Between 1980-85, over 100,000 migrants were moved to this province from other parts of Indonesia, as part of the government's plan to lessen the population pressures experienced on overpopulated islands such as Madura and Java (Hugo, 2002), or to relocate residents to work on large agricultural projects such as the MRP and to develop the economies of less populated islands, including Kalimantan (Hecker, 2005). Following the peak of transmigration, many transmigrant villages were formed, such as Basarang Jaya that is predominantly Balinese and Sabangau Permai that is predominantly Javanese (both located in the Sabangau catchment) (Jewitt *et al.*, 2014).

In 2010, Dayaks made up approximately 47% of the population of Central Kalimantan (Ananta *et al.*, 2015). Notably, for the in-depth interviews in both case study locations, 60% of participants identified as Dayaks and therefore there was an overrepresentation of this group compared to the provincial statistics. The results show the expected majority presence of Dayaks in the community and the in-depth interviews did include both Dayaks and Banjarese in both Kereng Bangkirai and Taruna Jaya.

Taking the wider assemblage across Central Kalimantan, the distribution of different ethnicities is not spread evenly across villages, with the result that individual village statistics may not necessarily align with average provincial statistics. The relationships which are explained within this thesis therefore potentially differ from transmigrant villages, illustrating the importance of considering scale, with the larger assemblage of the Sabangau area exhibiting properties that are likely different to the even wider assemblage across Central Kalimantan.

6.1.2. Religion

As with ethnicity, religion can also be a territorialising force in delineating and stabilising communities and identities (DeLanda, 2006). Indigenous religious beliefs in Sabangau include Ngaju beliefs originating from the Kaharingan animistic traditions (Schreer, 2016). In 1980, Kaharingan was recognised by the Indonesian Department of Religion as a form of Hinduism and thereby given the status of a 'religion proper' (Baier, 2007; Schreer, 2016). Figure 6.2 shows the percentage of participants for the questionnaires (n=206), focus groups (n=14) and interviews (n=40) that identified with the main religions, and compares this to official provincial statistics of 2015 (BPS, 2016). The surveys show a slight under-representation of Muslims, and a slight over-representation of Christians, with no Hindu-Kaharingan included in the study sample. There are very few Hindu-Kaharingan present in Kereng Bangkirai (Graham, 2013), which explains their absence from the surveys, with the same potentially true for Taruna Jaya, especially as the in-depth interview results indicate a potentially larger proportion of Banjarese in Taruna Jaya, who typically do not follow this religion.

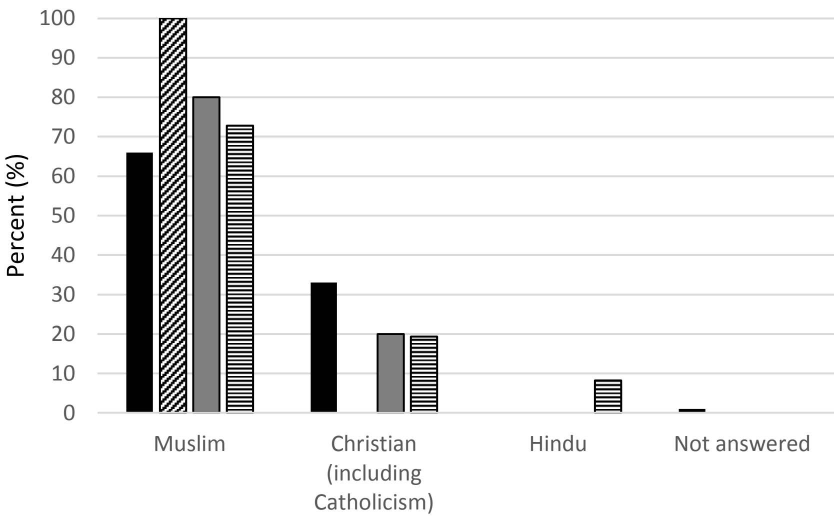


Figure 6.2: Percentage (%) of participants identifying with each religion in the human community surveys (questionnaires, n=206 [black], focus groups, n=14 [diagonal line], interviews, n=40 [grey]) compared to official statistics for Central Kalimantan in

When comparing the two case study locations (Figure 6.3) a similar trend is found, with a majority Muslim representation in both locations. Taruna Jaya did have a higher representation of Christians at 30% (n=40) compared to 10% (n=40) in Kereng Bangkirai. When averaging the participants from all surveys (n=260), 82% were Muslim (compared to the official provincial statistic of 73%) and 18% were Christian (compared to 19%). This indicates a relatively good representation of the two main religions of the province across all surveys, albeit with a slight over-representation of Muslims. As previously explained, comparing provincial statistics to certain villages can produce disparities, as some villages have different histories which can impact their religious characteristics. The results of this study are, however, comparable to those found by Graham (2013) in her research in Kereng Bangkirai, where approximately 80% of the participants identified as Muslim and 15% as Christian.

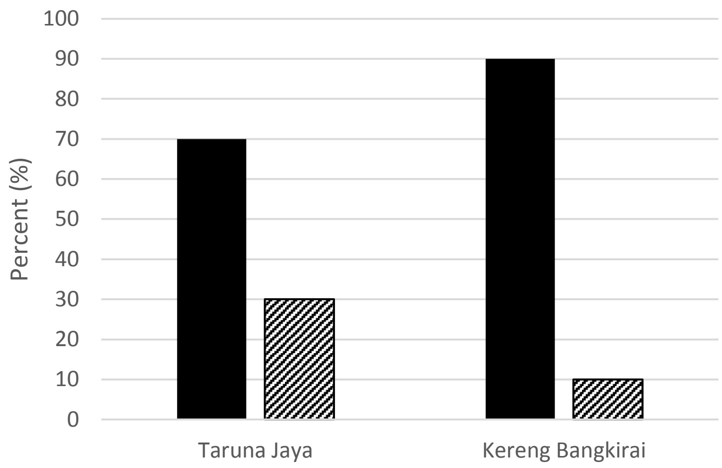


Figure 6.3: Percentage (%) of in-depth interview participants identifying with each religion; Islam (black), Christianity (diagonal line), n=40.

6.1.3. Link between religion and ethnicity through changing Dayak identities

Religion and ethnicity are characteristics which are linked in the Sabangau area and using the IAA can further elucidate the relationship which these characteristics have to temporally changing identities in the Sabangau.

Historically, Dayaks in Central Kalimantan predominantly practiced Christian faiths and a conversion to Islam meant also a change in ethnic affiliation; a Dayak would 'become' Banjarese (Chalmers, 2006). Recently, with a growing Islamisation in the province there has been a greater number of Dayaks converting to Islam, and thereby a new Dayak identity has arisen of 'Muslim Dayak' (Chalmers, 2006). Now the fluidity that previously characterised the relationship between Hindu-Kaharingan and Christianity in the Dayak community also extends to Islam (Chalmers, 2006). Indeed, Graham (2013: 156) reported that she heard numerous times "*I'm a Dayak first, Christian/Muslim second*" illustrating this strong Dayak identity, and the fluidity of both Christian and Muslim faiths characterising the new relationship between religion and ethnicity in the Central Kalimantan Assemblage. The Dayak identity can be understood to be undergoing de- and reterritorialisation with respect to religion.

Indigenous Dayak religious beliefs in Central Kalimantan have furthermore undergone stigmatisation, often seen as not ‘modern’ or ‘backwards’ (Schreer, 2016). This contrasts with the Muslim identity, which is seen as having a connection to the global community of Muslims and thereby an identity of “*modern cosmopolitans*” (Schreer, 2016: 81). It is in a search and desire to be considered modern citizens that Dayaks are identifying as Muslims although they may still practice rituals and traditions that are linked with past animistic beliefs (see Schreer, 2016 and this thesis). Rituals and traditions are therefore deterritorialised and it is in this ambiguity that various spiritual beliefs and taboos linked to animistic beliefs are allowed to persist alongside the changing religious identities and continued Islamisation. Just as an assemblage experiences constant change, so do indigenous identities, but the choice of what constitutes e.g. ‘Muslim practices’ can be heterogeneous between people and between communities as will be clarified in Chapter 6. The IAA can therefore allow an understanding of changing identities.

6.1.4. Occupation

Stereotyped beliefs about an ethnic group, such as Dayaks, may be matched to job categories that exclude them from certain positions and force them into others (DeLanda, 2006). This is another act of territorialisation, and was indeed experienced following the transmigration program where Dayaks were excluded from certain jobs as migrant workers who were seen as “*more skilled and more willing to take on the work*” (Smith, 2005: 10). Davidson (2009) suggests these perceptions were linked to Dayaks being seen as ‘backwards’ in Indonesian society (Davidson, 2009) likely due to their Hindu-Kaharingan or Christian beliefs. Thereby, religion and ethnicity have been tied to occupations in the Sabangau area in the past. This section now begins to consider what the main occupations are in the Sabangau area and the approaches for income generation.

Figure 6.4 illustrates the main occupations from all surveys (n=260). The most common occupation during 2015-2016 was fisher, followed by housewife, in agreement with the findings of Graham (2013).

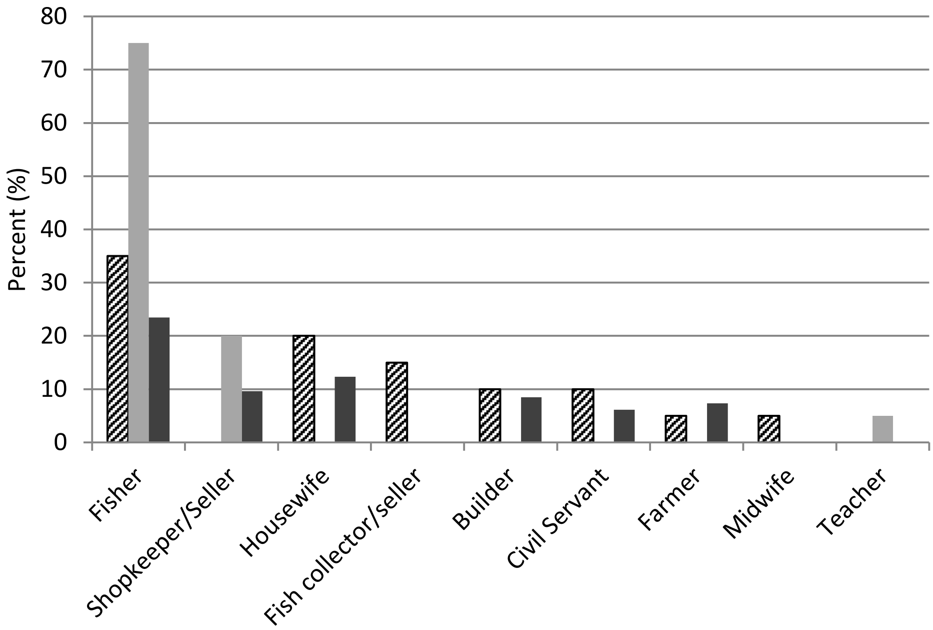


Figure 6.4: Main occupations comparing Kereng Bangkirai [diagonal line] and Taruna Jaya [grey] (% of participants), n=40; compared to the average for those occupations across all participants [black] (%), n=260.

Importantly, fishing is commonly complemented by other sources of income, with many participants having more than one occupation: 51% of the questionnaire respondents (n=206) reported that they had another job apart from their reported main occupation. It is well known that societies in Borneo adapt to shifting resources in a flexible and dynamic way (Schreer, 2016). Diversification of income activities is done to minimise risk resulting from the unpredictability of the environments that these societies are located in, with Gönner (2011: 165) referring to villagers in East Kalimantan and their highly adaptive resource use dynamics as "*surfing on waves of opportunities*". Therefore, decisions on income sources (e.g. whether to fish or work as a builder) are dependent on resource availability (e.g. fish populations), market prices, seasonality and individual cash demands (Gönner, 2011), in other words the properties of other assemblage elements (fish species and numbers, market prices and costs etc.). The relationship between fishing and livelihoods will be further discussed in Chapter 6, and this section focuses again on highlighting differences between the two locations which is vital when understanding relationships between communities in later chapters.

The results of the in-depth village interviews (Figure 6.4) indicate a higher proportion of fishers in Taruna Jaya (75% of participants vs. 35% in Kereng Bangkirai; n=20 in each location). This was also corroborated by self-reported statistics (Figure 6.5). In Kereng Bangkirai, there was a greater variety of occupations including builders, civil servants, fish collectors and sellers and one midwife (Figure 6.4). In Taruna Jaya, the only other occupations were shopkeeper/sellers (4 participants comprising 20% of total participants) and one teacher. Therefore, a notable difference between the two case study locations is a higher number of fishers in Taruna Jaya compared to Kereng Bangkirai.

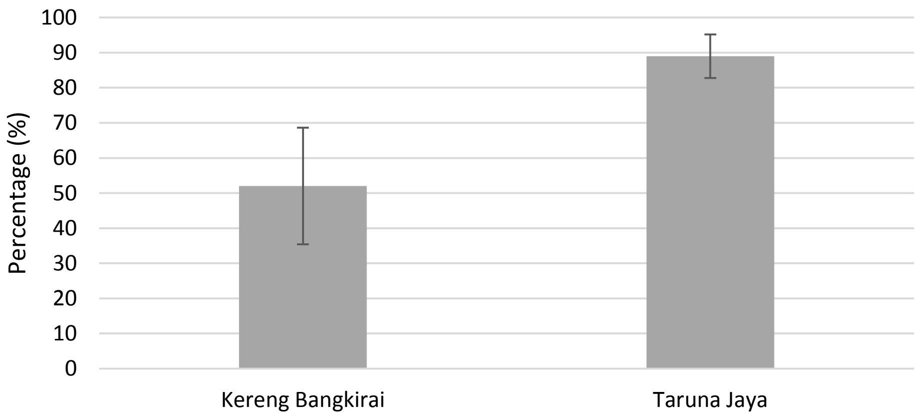


Figure 6.5: Average self-reported percentage of villagers working as fishers in Kereng Bangkirai and Taruna Jaya, error bars showing standard deviation. Difference is statistically sig.; Mann-Whitney U=0.0001, n=40, p=0.0001

There was a gender difference between the two villages in terms of women fishers. In Taruna Jaya, 30% of fishers were women compared to 15% in Kereng Bangkirai. From the interviews, 6 women in Taruna Jaya fished and 4 worked as shopkeepers. In Kereng Bangkirai, 4 women described themselves as housewives, 3 as fishers, and others as a seller, farmer or construction worker (one participant each). In Kereng Bangkirai participants KB12F, KB13F and KB20F explained that women mainly take on the roles of childcare and housekeeping until the children are older, when the women can go to the river to fish (interviews, 25/01/16 and 02/02/16). This is supported by Graham (2013) who found that female interviewees in Kereng Bangkirai often described themselves as housewives who still fished in their spare time close to the house. Participant KB12F furthermore reported a seasonal aspect to the female involvement in fishing, saying that during the wet season it was only men who went out fishing while women stayed at home, and in the dry season more women would join their partners fishing (interview, 25/01/16). The reasons for this will be explained in Chapter 7 as it deals with the relationship between fish, people and seasons. Women in Kereng Bangkirai are therefore still engaged with fishing, but to a lesser extent than those in Taruna Jaya, where none of the women identified as housewives. Also, all shopkeepers/sellers (as they might not have a physical store front) in Taruna Jaya were women (n=4). In contrast to Kereng Bangkirai, in Taruna Jaya women talked of fishing as their main job (e.g. TJ5F), and they were often highly involved in the processing of fish such as cleaning and drying (TJ7M); this was not dependent on seasons. For participant TJ5F, there were few other options apart from fishing as the flooding in the area prevented farming. The assemblage properties (in this case, regular flooding due to the geographical characteristics of the area) are therefore limiting job options through downward causality:

> "*Assemblages emerge from the interactions between their parts, but once an assemblage is in place it immediately starts acting as a source of limitations and opportunities for its components*" (DeLanda, 2016: 21)

Three of the women who worked as shopkeepers (TJ15F, TJ19F and TJ20F) also explained that they caught fish on the side for mainly consumption purposes, and therefore were still involved with fishing regardless of this not being their main occupation. Taking the men in the village; all men in Taruna Jaya worked as fishers, except for the teacher interviewed. This is in contrast to Kereng Bangkirai where 4 male interviewees were fishers, with others engaging in a variety of other occupations (see Figure 6.4). This indicates that there are greater pressures in Taruna Jaya for women to more actively contribute to earning the household income and providing food due to the lower availability of alternative occupational activities for men. As a result, women engage more actively in fishing or shop keeping on top of childcare and housekeeping. From the interview results, the women in Taruna Jaya also had fewer choices of occupational activities compared to women in Kereng Bangkirai and therefore fishing took on a greater importance. Both men and women in Taruna Jaya depended on fishing more than those in Kereng Bangkirai. These differences are defining properties between the two villages and are important in understanding various relationships between assemblage elements as will be discussed in Chapters 7 and 8.

6.1.5. Formal Education

There is a link between being a fisher as a main source of income and level of education achieved, as participant KB8F explained:

> *"Even though you just graduated from elementary school you easily become a fisher...If you are well educated maybe you can work in an office and never try to become a fisher."* (Interview, 18/01/16)

This is still predominantly the case in Taruna Jaya, but is less so in Kereng Bangkirai due to improved facilities, choice of schools and better access to education. Educational level has a clear link to occupations in the villages and *vice versa*, as this subsection will now explain.

In Taruna Jaya the majority of participants either had their highest level of education from Primary School or Junior Secondary School (Figure 6.6). Provincial statistics only provide net enrolment rates at each level, however these finding are in line with those of Suyanto *et al.* (2009) from a study in the ex-MRP (where Taruna Jaya is located) where they found that for all except one village, less than 50% of the population had an education of more than six years duration (i.e. up to secondary school level). The same was the case in Kereng Bangkirai, but there were more participants who had achieved higher levels of education.

In Taruna Jaya, most participants were happy with the quality of education provided in the area with 14 interviewees (70%) explicitly describing education as being 'good' or 'quite good'. The main barriers to further education were described by five participants as access to schools above middle school, quality of teachers and insufficient facilities. The quality of the road (see Chapter 5) causes difficulties for both students and teachers as participant TJ10M explained (this was also supported by three other participants):

> *"There access to schools and markets is not good. We feel tired to use the road and it takes a long time to get somewhere especially for students to get to school and they come late to school. There is good education, but the quality of teachers is not very good. All the teachers are from Palangka Raya, and while the facilities are good the teachers usually come late."* (Interview, 18/02/16)

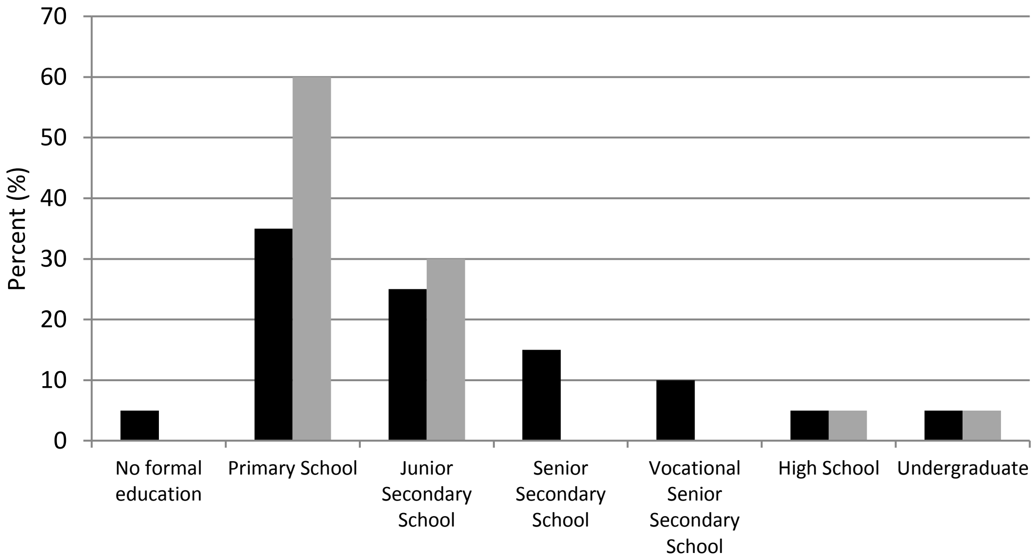


Figure 6.6: Highest reported level of education reached for each participant (percentage) in Kereng Bankgirai [black] and Taruna Jaya [grey], n=40

In Pusaka access is especially difficult, as described by participant TJ11M:

> *"There are a lot of challenges with access to schools...Children have to use a boat to Taruna and then a motorbike to get to school....I hope for better*

education, such as the arrival of SMA [highschool] closer to here, maybe in Tanjung Taruna. The problem is that this is still far and it is expensive to use a boat…Therefore, we can't afford education and I worry about the future to be able to send my children to school…All of this means that you can easily count on one hand the students who have gotten SMP [middle school] level education here." (Interview, 22/02/16)

Difficult roads and limited access can thereby become a barrier to education. The material components of the assemblage (the condition of the road) impacts the other components of the assemblage such as the mobility of community members to be able to go to school. This in turn will affect the properties of the villagers in terms of formal education level and even potential future occupations that are available to them. It also impacts the availability and potentially the quality of teachers in Pusaka (Taruna Jaya), as described by participant TJ12F:

"I hope in the future to see better school facilities. There is difficult to access, and teachers from Taruna don't want to come here to teach. This means that maybe underqualified teachers become head teachers." (Interview, 22/02/16)

Within the Taruna Jaya community there is clear heterogeneity in access to education which likely leads to the lower proportion of participants realising a higher level of education in the village compared to Kereng Bangkirai. The road quality and the geographic location of parts of Taruna Jaya in relation to schools impacts on the access to schools for some community members and teachers alike. The properties of the assemblage elements affect each other and are co-shaping.

In Kereng Bangkirai on the other hand, *all* participants described education opportunities and the access to education as being 'good'. The only issues mentioned, were the facilities (KB1M), the cost of school being high (KB1M, KB6F) and the general quality and level of discipline of the school needing improvement (KB2M). KB10M however explained that on the whole, every year he perceived the educational opportunities as improving along with a changing perception towards the importance of education:

"Parents have realised that education is important and that children have to go to school. In the past they would get education from elementary school, then they would buy the tools to fish." (Interview, 20/01/16)

This change of perception towards the importance of getting higher levels of education has occurred as it becomes clearer that fishing offers little opportunity to improve your life in both of the case study locations, as participant TJ10M describes:

"Fish are just to survive, you can't get a better income. Being a fisherman is not a promising job" (Interview, 18/02/16)

An image of fishing as an occupation begins to be formed, with a desire of local community members to have jobs that are seen as more promising for the future, and a further desire for improved access to education in order to facilitate this. This is further elaborated in Chapter 7.

6.1.6. Conclusion on the properties of human communities

Ethnicity and religion are defining elements of communities in Central Kalimantan and the Dayak identity itself. It is also clear that the Dayak identity is changing over time. This may of course vary between villages and should not be considered as homogeneous for the whole province. It does however indicate that identities themselves are as fluid as the assemblages of which they are a part. Lastly, the properties of education and occupation have direct relation to the capacities of the human community elements. Fishing is considered a fall-back occupation, and therefore those who depend on it as a primary source of income potentially do so as they have few other options. If this is due to a limitation of access to other job opportunities as well as education, this will influence an individual's capacity to change their occupation or respond to certain unforeseen circumstances such as any fish declines (see Chapters 7 and 8). One clear relationship, through the occupation of fishing, is that between the human and the fish communities. The latter will now be characterised through a consideration of the fish communities, including species richness and trophic levels.

6.2. The fish communities

Through fishing, the human communities in Sabangau are linked to the fish communities, and their properties influence each other: as Campos-Silva and Peres (2016: 1) write;

> *"Human settlements, for example, are heavily dependent on freshwater resources such as fish, and the top-down structure of entire fish communities is often governed by the intensity of human overexploitation".*

The human communities are (to an extent) dependent on the fish communities, while the structure of the fish communities can be heavily influenced by human behaviours: these communities are entangled. These entanglements will be further explored in Chapter 7, while I focus here on characterising the fish communities to understand their heterogeneity and within-assemblage complexity under the IAA. As mentioned in Chapters 2 and 3, when evaluating the properties of fish communities, their composition, species richness and trophic levels can be considered as a coding process, consolidating the identity of fish species and the assemblage, providing information on the structure of the fish assemblage and the closeness of the relationships between the fish elements. The following sections therefore consider and discuss species richness and estimated total species richness and trophic level analysis results. As with the human communities, understanding characteristics of the fish communities will be important in understanding relationships and temporal changes between assemblage elements as discussed in later chapters (7 and 8).

6.2.1. Species richness

A total of 55,147 fish of 39 species were trapped and counted during fish river surveys from September 2014 to September 2015. This was the result of 1,300 trap nights, with 22,917 fish measured. In the forest, a total of 3,938 fish of 27 species were trapped and counted from February to July 2015 over 600 trap nights, with 3,905 fish measured. Four other species were not trapped during surveys but were trapped opportunistically: *Rasbora kalbarensis* and *Kottelatlimia pristes* along with two *Mystus* species trapped at the mouth of a canal by the river. Some other species are also known to be in Sabangau from published literature: *Betta hendra, Silurichthys ligneolus, Hemirhamphodon tengah* (Page *et al.*, 1997; Ng and Tan, 2011; Schindler and Linke, 2013). With these additions, our final species list comes to 29 species in the forest and 41 in the river, with a total of 55 species from 16 families in the Sabangau peatland ecosystem (Appendix I).

This Sabangau species total is higher than that found by Page *et al.* (1997) of 34 species (22 species in the river) and Haryono (2012), who reported only 11 fish species in the Sabangau River. Sule *et al.* (2016) recently compiled lists of fish species recorded in Malaysian peat-swamps. In Peninsular Malaysia, the authors list 114 species from North Selangor TPSF, 49 from Paya Beriah TPSF, 13 from multiple sites in Johor, 58 from multiple sites in Pahang and 9 from Pahang and Terengganu. In Malaysian Borneo, 31 species from 12 families and 40 species belonging to 13 families were recorded from Sabah and Sarawak, respectively (see Sule *et al.*, 2016). In concurrence with Sule *et al.* (2016), this study found the highest number of recorded species for the Cyprinidae family, followed by Osphronemidae, Bagridae and Siluridae (an equal number of species was encountered for Bagridae and Siluridae). While direct comparisons are difficult, with the highest species richness recorded in Borneo (i.e. 55 species) it is clear that Sabangau is a notable area for TPSF fish diversity. Furthermore, this is a higher number of species than at least three of the 5 sites in Peninsular Malaysia reported by Sule *et al.* (2016).

The river had a higher species richness than the forest, with a higher average catch per unit effort (CPUE) of 42.2, compared to 6.1 in the forest (Mann-Whitney U=0.003, n=19, p=0.003). The difference between observed species richness in the two locations could be due to the surveys in the river covering a larger area compared to those in the forest (see Section 5.3).

6.2.2. Dominant species

However, the forest and the river are not only characterised by differences in species richness, but also in terms of dominant species (Figure 6.7). The river fish assemblage is dominated by *Osteochilus spilurus, Sphaerichthys acrostoma, Desmopuntius foerschi, Mystus olyroides* and *Rasbora cephalotaenia*; with the forest dominated by *Rasbora kalochroma, Betta anabatoides, Encheloclarias tapeinopterus, Channa gachua* and *Belontia hasselti.* It is clear that these are two distinct assemblages. However, these assemblages are not isolated from each other, as is clear from the species list (Appendix I), with a total of 17 species trapped in both the river and the forest (which constitutes 45% of the total species count for the river and 63% for the forest). Through canals, these assemblages will also be connected to the fish assemblages of the River Kahayan, which are themselves connected to other assemblages in those forests and tributary rivers. And so, a view of reality is formed in which "*assemblages are everywhere, multiplying in every direction…*" (DeLanda, 2016: 7).

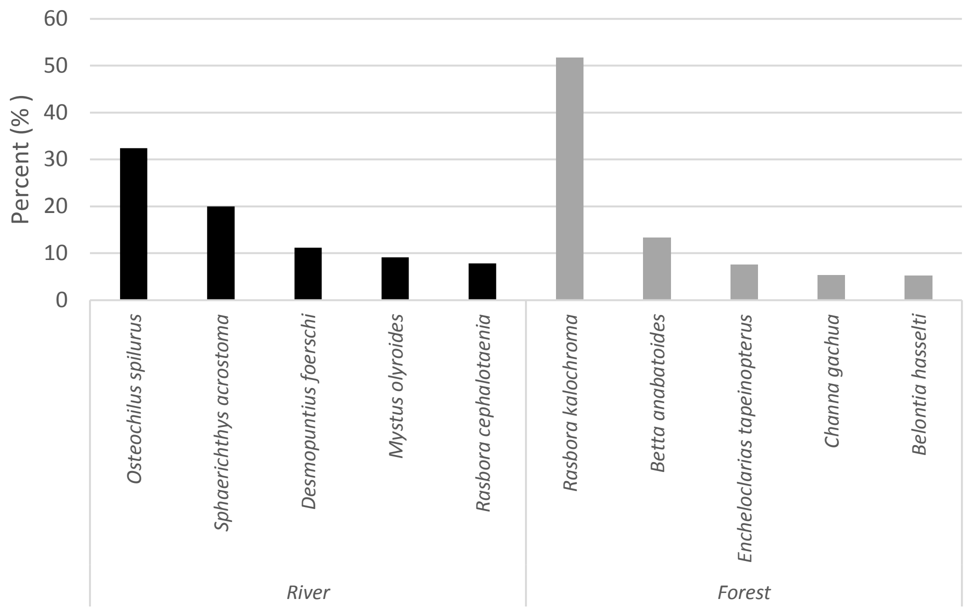


Figure 6.7: Percent of total catch represented by the most dominant species in the Sabangau Forest and River, only including species that comprised over 5% of total fish catch

From these results, it is notable that not only the number of species in the two locations differ, but they are different assemblages with different properties: such as the dominant species present.

6.2.3. Estimated total species richness

From the study, it is not certain that all species present were captured in the fish surveys. To understand the potential number of species that may be missing from the surveys, species accumulation curves (SACs) can be used. Using the survey data SACs were produced for both the forest and the river by plotting number of species against a measure of sampling (for this study, one sample is one sampling day). Using the AccuCurve Excel programme by Drozd and Novotny (2010), the SACs are computed via a randomization process as outlined in Chapter 5, and the resulting SACs for the forest and river are shown in Figure 6.8. While the SACs for both the river and the forest have not yet plateaued, they are both approaching plateaus, suggesting that the fish surveys encountered most of the species possible to catch in the areas using the chosen methods. No other TPSF fish sampling studies have provided SACs and therefore a comparison of sampling effort versus species accumulation for other locations is not possible.

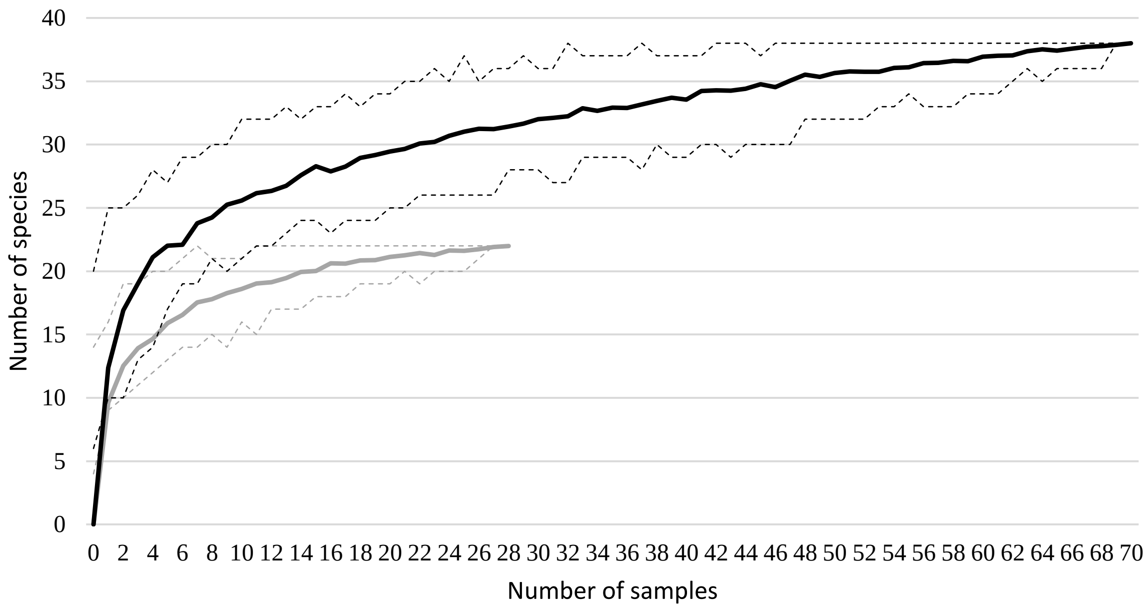


Figure 6.8: Sabangau River and Forest Species Accumulation Curves. S= Species, Average Species estimated in Forest [grey] and River [black] with Maximum and Minimum Estimations [dashed lines]

As it is difficult to use SACs to determine the final plateau level (and thereby the final estimated number of species present), EstimateS by Colwell (2013) was used to estimate the expected total number of species in the forest and river (described in Chapter 4). In Figure 6.9, the ACE, ICE, and Chao estimates of species richness in the forest and river are compared to the 'total known' species (including all trapped species, and those found opportunistically, documented in the scientific literature and/or identified in folk taxonomy and by local fishers). Based on this estimate, this study found 75-94% of the estimated species richness of the river (average of 47 species estimated), while the trapping in the forest found more than the estimated species richness (29 species are documented for the forest, with an average estimation of 26 species). In both the river and the forest, ACE estimators were the most conservative, with the Chao-1 estimator always giving the highest estimated species richness. For the forest estimates there is a good agreement between all richness estimators (min = ACE with 25.69, max = Chao-1 with 25.99) while the river estimators show higher variance (min = ACE with 43.57, max = Chao-1 with 54.99).

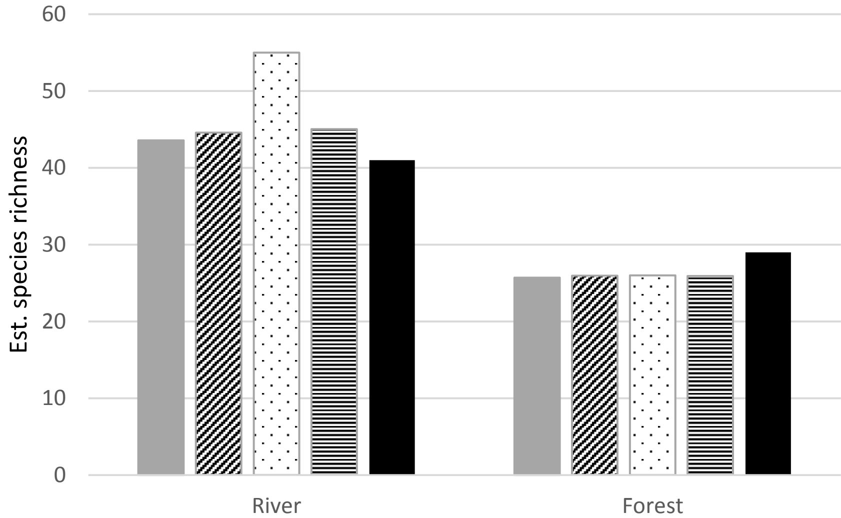


Figure 6.9: Estimated species richness in the Sabangau Forest and River using ACE [grey], ICE [diagonal line], Chao1 [dots] and Chao2 [horizontal line], compared to final species list numbers [black column]

Across all estimators, there is a clear underestimation for the forest species, as more species were trapped than estimated. This could relate to the 'catchability' of the forest species being lower than in the river, and therefore the forest SAC has a lower gradient than the river; i.e., it is harder to catch new species, but this does not mean that they are not there. Using a variety of other sampling methods, such as nets, could provide further information regarding any difference in bias introduced by the use of traps in the forest compared to the river. Furthermore, the estimators themselves are also subject to bias because they all tend to under-estimate true diversity (O'Hara, 2005). The Chao-1 estimator was originally derived as a 'minimum asymptotic estimator' (Chao, 1984), but Gotelli and Colwell (2010) write that all other estimators should be treated as estimating the lower bound on species richness. Nevertheless, both the survey results and all of the estimated total species richness results indicate a lower fish species diversity in the forest compared to the river. This is therefore a defining characteristic between the forest and the river fish assemblages and illustrates the heterogeneity of these assemblages across the wider assemblage in the Sabangau area.

6.2.4. Trophic level analysis

Trophic level analysis can provide a way to recognise groups of species in a community that acquire energy in similar ways (Morin, 1999) and is another method for understanding the properties of a fish assemblage and the closeness of the assemblage elements (the fish species). As it is related to what the fish eat, this also allows an initial idea of the behaviour of the fish and their links to other assemblage elements such as aquatic plants or invertebrates.

The Fractional Trophic Level (FTL) value expresses the trophic level of the species (Pauly *et al.*, 2001), and therefore relates to the coding of these species through their genetics and evolutionary history. Plants (primary producers) and detritivores belonging to trophic level 1, herbivores (primary consumers) to level 2, lower level carnivores (secondary consumers) to level 3 and so on (Pauly *et al.*, 2001). The average FTL can then be compared between the forest and river assemblage. The average monthly trophic level was calculated as outlined in Chapter 4 and is illustrated in Figure 6.10. This figure illustrates that the FTL in the forest stays relatively constant over the 6 months of sampling, with an average FTL of 3.30 ± SD=0.03. The river has a lower average FTL of 2.87± SD=0.23. A two-tailed t-test indicates this difference in the average FTL in the two locations is statistically different ($t=-6.77$, $df=12$, $p=0.000$).

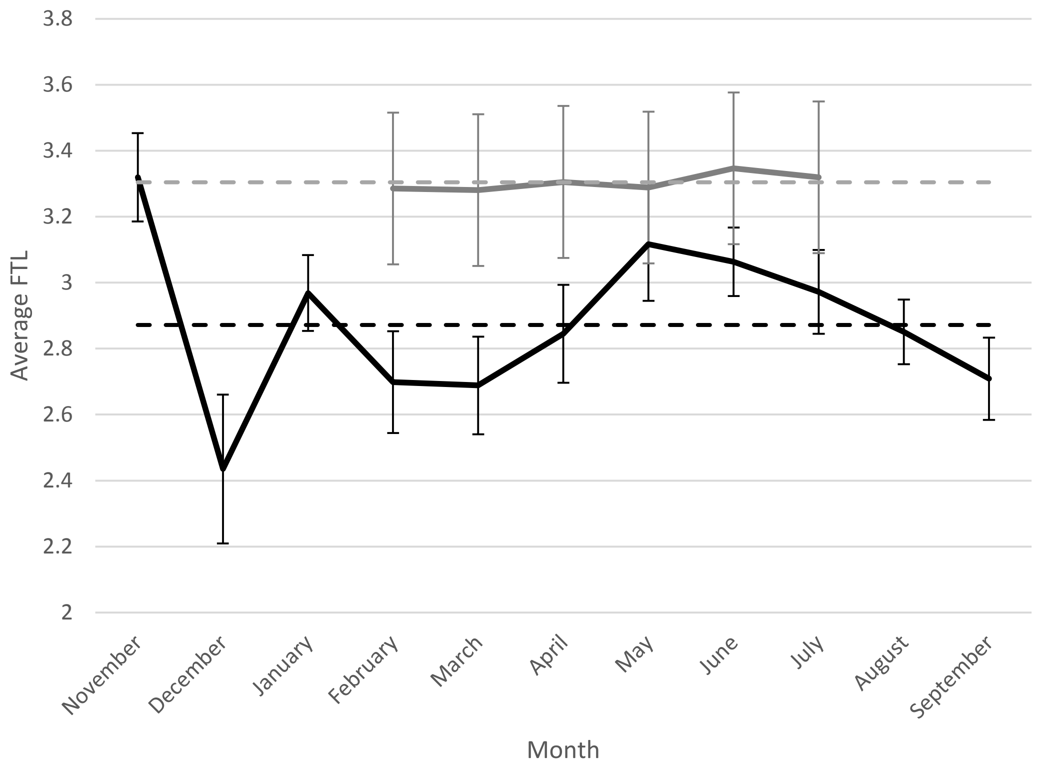


Figure 6.10: Average Fractional Trophic Level (FTL) in the river (grey) and the forest (black), with error bars showing standard deviation (all values weighted to n). Dashed line indicating average FTL in each location.

Most ecosystems are dominated by omnivorous species (trophic level class 3-3.5) (Froese *et al.*, 2005). Figure 6.11 plots the number of species in an ecosystem per trophic level class, creating a trophic signature (Froese *et al.,* 2005). To compare the river and forest, the abundances of each species were converted to the percentage of total fish caught. Figure 6.11 confirms that there is a dominance of omnivorous species in both the Sabangau River and Forest, but with a particular dominance in the latter, along with some lower level carnivores. While there is dominance by omnivores in the river, there is also a high number of herbivores. In contrast, there were no primarily herbivorous fish trapped in the forest, where all fish had FTLs greater than 3. Almost all (99.88%) of the herbivorous fish in the river were *Osteochilus spilurus*. This is a river-specific species, and being the dominant river species, this pushes the average FTL for the river down during months of high catches. Linking this to the IAA, it exemplifies how the property of one species (one assemblage element) can influence the property of the fish community, or assemblage, as a whole. It is therefore important to evaluate the properties of assemblage elements.

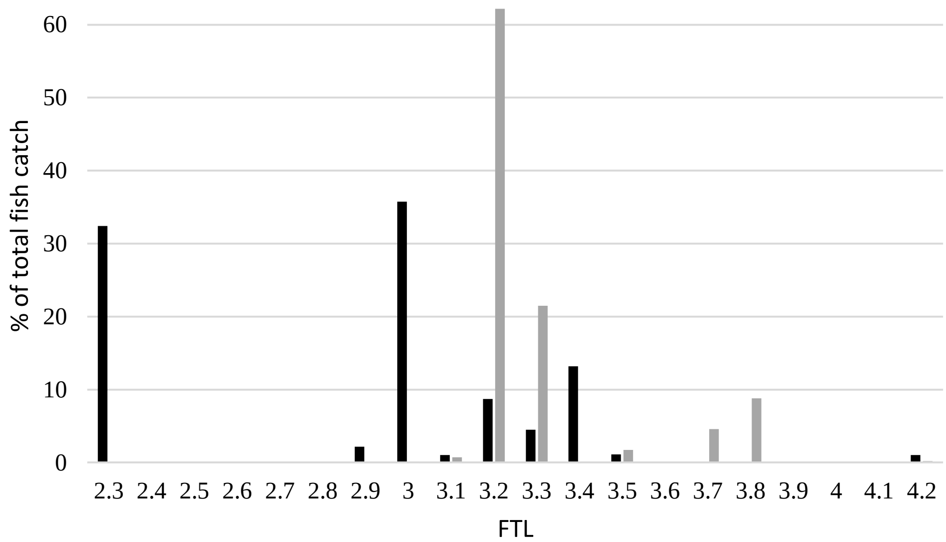


Figure 6.11: Percentage (%) of total fish catch representing each FTL in the river [black] and forest [grey]

Another reason for the dominance of lower-FTL species in the river could be due to sampling bias. Traps were set on the river edge for practical reasons (see Chapter 4), being set close to plants such as *Pandanus sp.* and floating plants such as water hyacinth (*Eichhornia sp.*). This might skew the trophic signature as it could be proposed that herbivorous fish are more likely to be found near the plants they feed on and hide in, whereas (especially larger) carnivorous species may use the open water more, in which case these trophic signatures will also reflect the trapping methods. This may, however, not be the case, and while plant cover has been shown to impact predation rate (Coull and Wells, 1983), the use of vegetated areas by predators depends on predator species, prey species and their behaviours (e.g. schooling behaviours and ambush behaviours) (Savino and Stein, 1989; Eklöv and VanKooten, 2001). Some predator species do prefer vegetated areas to sit and wait for prey to pass rather than searching in open water (Savino and Stein, 1989; Eklöv and VanKooten, 2001). A better understanding of peat-swamp fish behaviours is therefore needed to understand the relationship between fish assemblage elements and habitat characteristics.

Furthermore, the trophic level may be skewed due to the size selectivity of the traps (e.g., perhaps there are more species in the forest that are too small for the traps). While smaller mesh sizes for the traps were not available to test, Worthington (2016) compared the trophic signatures for larger locally used traps including larger mesh sizes along with the trap used in this study. Worthington (2016) found that across all trapping gears FTL variance (i.e. trophic level diversity) was consistently low (standard deviation ~0.3 for all gear types); and that the average FTL was typically low (3.3) even for larger traps designed to catch larger species. This suggests that using the locally available traps will always leads to low FTL in the river. For the forest this was not tested, and therefore more sampling effort using other appropriate methods is needed to clarify if lower FTL species are being missed due to their smaller body size and ultimately if the trophic signatures presented here are accurate reflections of the forest and river assemblages. Future monitoring using both the *tampirai* and other trapping methods such as hand nets (which are available with smaller mesh sizes) would also enable an investigation of whether the Sabangau food web is being 'fished down': i.e. where catches are dominated by lower-trophic level organisms following the depletion of the larger predatory fish at the top of the food web (Pauly *et al.*, 1998). With the links to the human assemblage, this would have an impact not only on the fish communities, but also the wider assemblage in the Sabangau area as a whole. This will be clarified in Chapters 7 and 8.

6.2.5. Conclusion on the properties of fish communities

Knowledge of the properties of the Sabangau fish communities has been enhanced here through the study of community species richness, dominant species and trophic level signatures. The results illustrate the heterogeneity of the fish assemblage and the biodiversity of the TPSF ecosystem, which could contribute to an improved appreciation of the potential impacts of deterritorialising forces. A change in biodiversity and thereby in the heterogeneity of the system could have direct implications for the delivery of ecosystem services, and the resilience of the overall assemblage (Loreau, 2010: 263). It is therefore vital to monitor assemblage elements and, through an understanding of temporal changes, to strive for adaptive assemblage management actions under biocultural conservation. I will return to these conclusions in Chapter 9.

This study also emphasises, as explained in Chapter 1, the need for area-specific experts. While I argue a need for conservation researchers who have a broad understanding of a system which includes the human elements, taxonomists and researchers experienced in dealing with certain fish species will enable a greater understanding of the system as a whole. Species that are tolerant of harsh abiotic conditions, such as those found in tropical TPSF (low pH and hypoxia), are particularly vulnerable to extinction as they often have relatively small niches due to a trade-off between abiotic and biotic stress tolerance (White *et al.,* 2015). The properties and capacities of species therefore have implications for their adaptability to environmental changes. This study stresses the need for greater research efforts to understand the specific behaviours and environmental limitations of the species found in the Sabangau area. Furthermore, the species list presented herein needs to be added to through further taxonomic and species discovery research in the area. As this section highlights, an understanding of the assemblage elements is important to understanding the properties of the wider assemblage.

Results from the fish surveys and the species richness estimations both found higher species richness in the river compared to the forest with also a distinct trophic signature in both areas. While the forest was sampled for fewer months and further sampling might encounter more species and thus alter the forest's trophic signature, this difference in diversity is also likely due to the river providing a greater range of habitats than the forest in terms of, for example, greater range of water depths, vegetation densities and types. The area sampled in the river was larger than in the forest, and therefore scale could also be influencing these results. Lastly, there is a potential that the 'catchability' of fish in the forest was less than in the river due to the specific properties of the forest including the water depth, and the ability of fish to move through water bodies towards the traps. I will expand on this aspect in Chapter 7. It is clear that more fish surveys, incorporating additional appropriate methods, and analyses of fish behaviours and diets are all important areas for future research, to expand upon the findings in this thesis and better understand the form and functioning of the fish communities of the Sabangau.

6.3. The spirit communities

The third prominent community that this thesis discusses is that of *hantu* (spirit/ghost). Through interactions with my research assistants and other employees of BNF, along with the results of the focus groups, it became clear that many had a strong belief in spirits. The following diary entry, recalls a conversation with my research assistant Iwan, and a conversation I had with another BNF staff member, Udin:

> "*I then told him [Iwan] that Udin had told me about ghosts related to saluang karing [Rasbora kalochroma], and asked if he knew any more cerita hantu [ghost stories]. He said that the story is the same for all saluang in the forest. You can't bake them [fish] and eat them in the forest, otherwise ghosts will come in the night and will kill you. So people don't bake them, even in Kereng (but there are other ways of cooking them which will apparently not make ghosts come). He said that if someone wanted to bring problems to our research camp, they could run into camp, bake a saluang fish and run away. Ghosts would then come in the night and kill everyone. I told him I didn't like the sound of that, and asked if there was anything you could do to protect the camp. He said he didn't know, but that he thought that definitely someone had to die. If at least one person died, then that would work.*" (Pers. comm. with Iwan, 10.12.2014)

Interviewees also reported the presence of *hantu*, and that these can take various forms. Gill (1967: 87) describes them as a class of spirits that appear across Dayak Borneo, taking form as "*gigantic monsters with flaming and sparkling eyes with long, clawed fingers and covered with shaggy black hair*". There is categorisation of spirits: those that are god-types, those that are ancestral and those spirits derived from deceased people that have taken on special characteristics (Couderc and Sillander, 2012). Schiller (2001:74) writes of these as kinds of '*supernatural beings…[which] are believed to have the ability to assume human guise…*". Spirits are said to inhabit forests and rivers, are therefore seen as having a home, or some location of residence. They are described as having their own communities, living in a world that is parallel to ours; an "*extramortal dimension that operated on a supernatural plane*" (Taylor, 1994: 125).

At this point, it is important to reiterate that the religions present in the Sabangau area are predominantly Islam and Christianity. Not all people believe in *hantu*. Those interview participants that believed in *hantu* were both Dayak and Banjar or Javanese; those that gave offerings were either Dayak or Javanese (not Banjarese), and were both Christian and Muslim. In Kereng Bangkirai the two Christians interviewed did not believe in *hantu*. Therefore, the interview results indicate that a belief in *hantu* is not necessarily determined by ethnic or religious identities.

Table 6.1 summarises the number of participants in each village who reported believing or not believing in *hantu*, along with some demographic information on their religion, sex and ethnicity. The numbers do not add up to the total 20 participants in each location because occasionally, through the natural flow of the conversation which followed the semi-structured interview approach (see Chapter 5), the topic of spirits was not always discussed. The data indicate that there is no clear relationship between religion, sex or ethnicity and belief or disbelief in spirits.

Table 6.1: The number of participants in each village who said they believe or do not believe in hantu, along with some demographic information on their religions, sex and ethnicities

Town	Yes	Demographic info	No	Demographic info	Undecided	Demographic info
Kereng Bangkirai	13	- Men, Women -Dayak, Banjarese, Javanese - Muslim	6	- Men, Women - Dayak - Muslim, Christian	0	
Taruna Jaya	7	- Men, Women - Dayak, Banjarese - Muslim, Christian	3	- Women - Dayak, Banjarese - Muslim, Christian	9	- Men, Women - Dayak, Banjarese -Muslim, Christian

The most commonly mentioned river *hantu* during interviews were the *hantu banyu* (*banyu* means 'water') and the *hantu pujut*. In Kereng Bangkirai, female participants explained that the *hantu banyu* actively searches for human victims (KB8F); tricking children to go into the river, and if a child drowns in the river, it is said that this is because of this spirit (KB6F, KB7F, KB8F, KB19F). The *hantu* *pujut* is less dangerous, described in both case study locations as taking the form of an 'animal' (KB8F), or having a long head (TJ18F). It eats fish that people have caught and bothers people (KB6F, KB8F, TJ18F), with one participant (TJ18F) reporting that *pujut* can also harm people. TJ20W had experienced *pujut* before:

> "*Pujut has taken buwu [fish trap] from the river, from local fishermen. It broke the buwu and ate all the fish. The pujut has never bothered my fishing but it has bothered my buwu and tampirai. We are afraid to catch the pujut because the pujut will take revenge. So you don't bother the pujut. Don't do anything if it bothers you*" (Interview, 01/03/16)

It is also important to note that *hantu* are not necessarily bad or evil, with Participant KB17M (Dayak, Muslim) telling a story about when he got lost on a river, and a nonhuman helped him find his way back home:

> "*I saw light follow me when I once got lost on Bakung. But I enjoyed this because the lights shined in a green and white colour. I didn't know what it looked like and I am afraid to say what it is. When I was lost the lights helped me find my way by shining very bright. It lit up to 300m and I could see. When I got closer to them they would turn off and when I got further from them they would shine brighter. It happens a lot. I used to go home late at night. They never bothered me*" (Interview, 26/01/16)

As humans can be acted upon by spirits, so can spirits be impacted by humans with interviewee KB18F explaining that the spirits had, as a response to an increasing number of people in the area, moved further from the village. Therefore, the spiritual nonhuman beings and human beings are both affected and affective, they are entangled and co-shaping.

There was also the occasional use of spirits or other nonhumans to explain strange inexplicable occurrences. For example, participants discussed *pampan* which is the clumping together of a riverside vegetation called *rasau* (*Pandanus sp.)*, which happens when *rasau* becomes uprooted, floats down the river and then starts clumping together eventually blocking the river. *Pampan* can make access for fishing difficult by hindering boat traffic through the river, making it difficult to collect fish, to sell fish and to get access to fishing locations (KB13F). This was described as a natural occurrence (KB13F, KB20F), or caused through human error by people leaving sticks in the river, which slowly block more and more of the *rasau* that is floating downstream (KB13F). On the other hand, the clumping together was also explained by the presence of an ancient *naga* (a type of dragon) that acts as the river guardian (KB13F, Javanese, Muslim; KB19F, Dayak, Muslim). Alternatively, KB19F (Dayak, Muslim) explained that every 50 years the *naga* will show itself, and when it arrives it will clean the river and therefore unexplained clearing of *pampan* was also attributed to the acts of *hantu* or *naga* (KB15M, Dayak, Muslim; KB19F, Dayak, Muslim).

This thesis understands agency as being the *potential to make a difference* (Waterton and Dittmer, 2014), attributable to both human and nonhuman actants (e.g. Bennett, 2005; Brenner *et al.,* 2011; Waterton and Dittmer, 2014), as Bennett (2005: 461) writes;

> "*Humans and nonhumans live and act in open wholes that pulse with energies, only some of which are actualized at any given time and place*"

In Deleuzian ontology it is replaced by affect which is the capacity to affect or be affected (Fox and Aldred, 2013). Human and nonhuman actants are constantly engaged with each other through "*an intricate dance… with the urgings, tendencies, and pressures of other bodies, including air masses, minerals, microogranisms, and for some people, the forces of fate, divine will, or karma*" (Bennett, 2005: 454). Agency is therefore constituted by an involvement in practice (DeLanda, 2006), bringing together and forming relationships between the social and material (McFarlane, 2009; Waterton and Dittmer, 2014) with an assemblage also able to exhibit agency (Bennett, 2005; McFarlane, 2009). Taking the Sabangau, *hantu* and other elements such as the *naga*, can therefore exhibit agency, behaving in ways that significantly impact the human communities. Using these other forms of nonhumans, it is possible to now understand a further relationship which people in the Sabangau have with the water spaces and nonhuman beings in the assemblage. These various communities (human, fish and spirit) interact with each other in co-shaping entanglements that also form the assemblage. Lastly, the assemblage also acts upon the communities themselves through downward causality as I will explore in greater detail in Chapter 7.

6.4. Chapter conclusion

This chapter began by briefly describing the material and expressive components that were identified through focus groups, including the presence of three communities: human communities, fish communities and spirit communities. It discussed characteristics of these communities that also can territorialise them: such as ethnicity and religion in the human communities and dominant species in the fish communities.

Both Kereng Bangkirai and Taruna Jaya were shown to be predominantly Dayak villages, with a greater proportion of Banjarese found in Taruna Jaya than in Kereng Bangkirai. Both villages had a Muslim majority, but with Taruna Jaya having a higher representation of Christians. As discussed in Section 5.2.4, religion and ethnicity are linked in the Sabangau area, and this fluidity of Dayak and local identities is another de- and re-territorialising force that is occurring in the assemblage. I will return to the importance of this in Chapter 8. Occupation is another factor that Section 5.2.4 linked with ethnicity and religion. Fishing is often complemented with other income sources, and strategies of diversifying income and the significance of these will be further discussed in Chapters 7 and 8. Women were more involved in fishing with this being less dependent on season in Taruna Jaya compared to Kereng Bangkirai, and they had a greater choice of income source in the latter location. For both men and women, there was a higher dependence on fishing as a source of income in Taruna Jaya compared to Kereng Bangkirai. There is lastly a link between occupation and education, with fishing as a job often being linked to low education levels. In Kereng Bangkirai, there were more interview participants who had achieved higher levels of education than in Taruna Jaya due to access to schools.

From the fish surveys, 39 species were trapped in the river and 27 species in the forest. There were 17 species present that were found in both assemblages. This creates the first comprehensive fish species list for the Sabangau area of 55 species from 16 families. The forest and river assemblages differ in terms of dominant species and there was a higher number of species trapped as well as estimated in the river compared to the forest. This section has illustrated an example of coding in the fish communities which lead to fish predator-prey interactions that can be preliminarily evaluated through their FTL. This provides information on the assemblage as a whole (e.g. trophic signature), the differences between the forest and fish assemblages (the forest had on average higher FTL) and lastly illustrates how an assemblage element, such as *Ostechilus spilurus*, can impact the properties of the assemblage as a whole (by pushing down the trophic signature through being a key herbivore in the river assemblage). It ended with the implications of trapping methods used, and how these can influence the understanding of the assemblage and assemblage element properties.

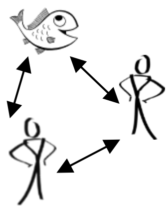
Lastly, the chapter provides information on the spirit communities that was gathered from interviews. Section 6.3 discusses how a belief in spirits is still important for some of the human community members and thereby they are part of their assemblage. They can take various forms and inhabit the rivers and forests. I found no clear relationship between religion, sex or ethnicity and a belief or disbelief in spirits. Both the spiritual nonhuman beings and human beings were found to be entangled and co-shaping. I explain towards the end of this section that *hantu* and other elements such as the *naga*, can exhibit agency, behaving in ways that significantly impact the human communities. Using these other forms of nonhumans, it is possible to now understand a further relationship which people in the Sabangau have with the water spaces and nonhuman beings in the assemblage.

This chapter has illustrated how the human and nonhuman elements of an assemblage can be approached, and including both fish and spirit communities in the latter. Of course, there are other nonhuman elements in the Sabangau area, and, being a part of the ecosystem these will also have an impact on the fish communities; from aquatic macrophytes (Kurniawan *et al.,* 2016) to the water of the rivers. Chapter 7 will delve into some of these other elements including the relationship between fish communities with properties of the water. Clearly, an attempt to understand all assemblage elements, their properties and relationships is a complex undertaking that, due to its dynamic nature, will by definition never end. Saying this, structured approaches such as long-term fish community surveys in combination with human community interviews and discussions can elucidate complex relationships, changes in the environment, and the nature of the assemblage as a whole. This chapter has also highlighted certain territorialising aspects of the assemblage in the Sabangau area, including ethnicities, religion, occupations and coding of the fish assemblages. Following on from an understanding of the basic foundations and differences between the case study locations and some of these territorialising properties, the next chapter builds upon these to elaborate relationships between the human, fish and spirit communities that lead to the emergence of the assemblage in the Sabangau area.

CHAPTER 7

STEP 2:

Identifying relationships between assemblage elements



"It is inside these multispecies entanglements that learning and development take place, that social practices and cultures are formed. In short, these relationships produce the possibility of both life and any given way of life. And so these relationships matter."

van Dooren (2014: x)

In this chapter I now explore the most prominent relationships between the human, fish and spirit communities along with other elements of the assemblage in the Sabangau area. This is a vital step as it is from these relationships that the assemblage emerges (DeLanda, 2016). These relationships are ephemeral; always changing, developing, in flux, reassembling in sometimes unpredictable ways and shifting as the assemblage itself evolves (Fox and Aldred, 2013; Henderson, 2015; Huff and Cotte, 2016). Because of these dynamic relations, the assemblage as a whole is in constant flux (Huff and Cotte, 2016).

This chapter draws on results from the fish surveys, and questionnaires, focus groups and interviews in the human communities. The relationships discussed include the importance of fish for human livelihoods, fish as a food source for human communities and the taboos that can be associated with eating or preparing fish, the act of fishing itself and how 'watercraft' is learned, along with the environmental aspects that fishers need to consider for successful catches. Depending on whether human community members believe in spirits, and if they do, this relationship sometimes requires gestures or offerings to be made to spirits or other nonhumans for successful fish catches. These could all be considered under the Ecosystem Service (ES) paradigm, with fish as a provisioning service, and fishing involving cultural ecosystem services (CES) such as traditions and beliefs, for example. However, through the IAA and in my attempts to challenge the anthropocentricity of ES, this chapter uses a vocabulary that was introduced in Chapter 3 that is very much centred in more-than-human geographies (MTHG) and the Interdisciplinary Assemblage Approach (IAA). Lastly, the rules associated with fishing are discussed, which provides another example of assemblage coding.

As introduced in Chapter 3, coding can include various laws or rules that are present in the assemblage. It is also related to community-based management strategies through determining how community members should act or fish. Levels of coding are a variable parameter (DeLanda, 2016), and as explained in Chapter 3, coding can determine properties and capacities of assemblage elements (e.g. genetic coding) as well as structuring the relationships between assemblage elements (DeLanda, 2006). Examples of coding that this chapter deals with are: taboos of eating and cooking fish, the local rules of fishing, and the methods used for fishing.

Notably, while consideration is given to human-fish-spirit interactions, information on these interactions will be based solely on human perspectives and experiences, as it is not possible to discuss relationships from the fishes' or spirits' perspective, as Wittgenstein (1994: 213) writes:

> *"if a lion could talk, we could not understand him"*

However, the 'natural sciences' enable some account of the fishes' ways of life, where they live and how they are entangled within the assemblage (van Dooren, 2014). For spirits, this is solely based on human perspectives. Chapter 6 already highlighted the particular importance of fishing as an occupation in the village of Taruna Jaya, and this chapter now begins with a more detailed examination of the importance of fishing to livelihoods to build an understanding of the human-fish entanglement.

7.1. Livelihoods

Understanding relationships between humans and nonhumans, such as fishers to the river and fishing, is a complex undertaking. McGoodwin (2001) writes that in small-scale fishing, like in Sabangau, fishing as an occupation is closely tied to fishers' personal and cultural identities. Pollnac and Poggie (2008) write that fishing is not only a livelihood, but a lifestyle, and is a crucial component of individual and collective identities. The values which people in the Sabangau attached to fishing were very 'practical': job equals income which equals buying food and sending children to school. This is not to say that income is the only value given to fishing: as Riley (2017) writes and I will support through my data, 'economic capital' is very much entangled with 'social' and 'cultural capital' (see Table 7.1 for a clarification of these terms). Together, the interactions between the various forms of 'capital' contribute to the 'good fisher' position (Riley, 2017) as I will further elaborate in Section 7.2.2. I note here that I find the vocabulary of 'capital' as used by Riley (2017) problematic as this once again delves into the capitalist and anthropocentric approaches critiqued in Chapter 2. The connections that Riley (2017) makes between the various forms of 'capital' are helpful, though, to illustrate how these economic, social and cultural elements are entangled. As much as possible, however, I will avoid the 'capital' labels in my future discussion.

Table 7.1: Examples of economic, social and cultural capital (from Riley, 2017)

Economic capital	Income
Social capital	Access to help and equipment of others, support of others leading to 'safety nets'; respect from other fishers
Cultural capital	Ownership of boats, equipment and fishing skills (skills = 'embodied cultural capital')

In contrast to Schreer's (2016) findings that fishing covered basic needs while also allowing for saving and slow but steady economic improvement, the survey results of this study revealed that fishing was mainly seen as a fall-back option (KB8F; interview; 18/01/2016). As Chapter 6 illustrated, it was often described as a job that does not allow an improvement of life but merely sustains it, with KB3M also describing fishing as "*menyambung hidup*" or scraping a living (interview; 18/01/2016). As discussed in Chapter 6, fishing in the Sabangau area is perceived as the likely job to go into if you have no higher formal education and no other job opportunities; both men and women are more dependent on fishing as a main source of income in Taruna Jaya due to a combination of lower access to education and other job opportunities.

Figure 7.1 shows the results of the ranking exercise (described in Chapter 5), where interview participants in the two case study villages were asked to place a limited number of coins (16) on photos of nonhuman forest species according to their perceived importance of these nonhuman species to villagers' lives. There was a clear trend of most coins being placed on the fish compared to all other forest species, with an average of 8.75 coins placed on fish in Kereng Bangkirai, and an average of 9.90 coins placed on fish in Taruna Jaya (differences between villages were not significant: t=-0.69, df=36, p=0.494). Fish were the highest ranked forest 'species' as they were considered the most relevant to people's lives and a vital source of livelihood, as discussed further below. As Schreer (2016: 162) describes;

> *"fish…and fishing penetrated people's everyday routine. Fish just seemed omnipresent – in everyday discourse, in sight, touch, smell, sound, and taste."*

The species that received the second highest number of coins in both villages was the lesser green leafbird (*Chloropsis cyanopogon*).

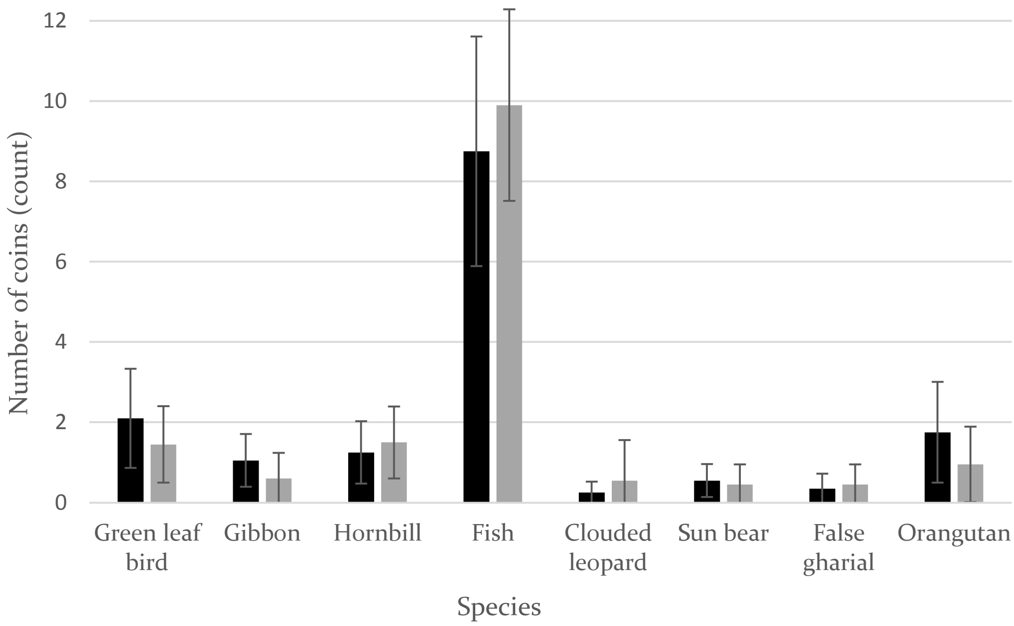


Figure 7.1: Average number coins (count) placed on each species for the two case study locations; Kereng Bangkirai (black) and Taruna Jaya (grey), error bars showing standard deviation

In both villages, most coins were seemingly placed on fish due to fishing being a primary source of income and food for households:

> "*Fish has the most because I am a fisherwoman. You can eat fish and I sell fish. It is for income, for life and my work*" (KB19F, interview, 02/02/16)

> "*Fish have the most coins because it is my main job. 95% of people here are fishers. They focus on fishing here, and it is for their everyday lives. 5% have other jobs for example sellers. There are no other options other than fishing.*" (TJ11M, interview, 22/02/16)

Fish therefore are seen to have the most relevance to participants' lives (e.g. KB11M, KB13F, and KB14F) and these views predominantly fall within utilitarian and commodity-based attitudes (Kellert, 1996; Montgomery, 2002). Saying this, the income earned from fishing has links to many other important aspects of villagers' lives, such as the desire and ability to send children to school (e.g. KB13F). To some, the green leaf bird (Figure 6.3) was also seen as a source of income (they are hunted and sold to be kept as pets) which was again the main reason given by both male and female participants who ranked this species highly. Species that were not a source of income and therefore seen as less relevant to people's lives were ranked lower (KB5M, TJ2F, KB17M).

Notably, fish were ranked higher than any other species, many of which have high conservation priority to the national and international communities, such as the orangutan. The orangutan, which is Sabangau's primary flagship species, was not considered as relevant to human communities' lives compared to fish, yet fish have received little if any dedicated conservation effort in the area. It is true that the orangutan can act as an umbrella species: the protection of its habitat can promote the survival of other species (Nantha and Tisdell, 2009; Pearson *et al.*, 2011). However, it may be questioned if this connection is clear enough to human communities, with there being an imbalance between what has been decided as important by the international community versus what is considered important for local livelihoods.

Chapter 6 illustrated that fishing as a source of livelihood in Sabangau can be linked to lower education levels, but it can also be linked to low income levels. As fishing can be done without significant initial financial investment, it can often attract the poorest members of the community, but in Sabangau it fails to lift them out of poverty (McGoodwin, 2001). Fishing income provides an important support to these members of the community: Suyanto *et al.* (2009) found that income from fishing in the ex-MRP reduced the overall inequality of income within each village, with this source of income being relatively high for the poorer segments of society, with about 97% of respondents engaged in fishing (and therefore is also in support of the high dependence of fishing found in Taruna Jaya in this study). These aspects of fishing, as being both supportive but predominantly a fall-back occupation, are relevant when considering the lack of emotional connection to this occupation that was expressed by the participants in this study, even though it has been a traditional occupation in the area historically (see Chapter 5). The main concern villagers have is to feed themselves and their families, regardless of what source of income this involves. Their desires are linked more to the results of the fishing (i.e.

providing food and income) rather than the act of fishing itself. Therefore, in areas with greater income and job opportunities, such as Kereng Bangkirai, fish and fishing become less important.

As this section has highlighted, fish are seen as important in both case study locations as a source of income and food for the human communities. Section 7.1.1 now explores the importance of fish as food in greater detail, focusing on not only fishers, but the general population in the Sabangau area.

7.1.1. Fish as food

Fish is still the main source of protein for most people, fishers and non-fishers alike, in Central Kalimantan (Schreer, 2016) and this study found that the average annual amount (kg) of fish consumed per person in Sabangau was 49.4 kg; about 2.6 times more than the global average of 19.2 kg (FAO, 2014a). This is comparable to previously reported annual fish consumption figures by Saman and Limin (1999), which reached 40.08 kg per person in 1998 for Central Kalimantan. These figures illustrate a continued and high dependence on fish as a main source of protein. Furthermore, the questionnaire data showed an average annual expenditure of approximately GBP 506 equivalent on fish. Comparing this figure to average household income statistics from the KFCP project (Atmadja *et al.*, 2014); 29% of household income is potentially spent on buying fish for consumption, again indicating a high dependence on fish for livelihoods in the area. This is supported by Suyanto *et al.* (2009) who found that in the ex-MRP, the share of expenditure on food (fish and other foods) was 75-79% of family income.

These figures are notable as Engel's Law states that the ratio of food expenditure to income/total consumption declines when income increases (Hagenaars and de Vos, 1988; Suyanto *et al.*, 2009; Pritchett and Spivak, 2013); i.e. the poorer a household, the greater the percentage of their total income/expenditure tends to go on food. Olivia and Gibson (2013) found that food expenditure accounted for a mean of 29% of total household expenditure between 2007 and 2008 in Indonesia. In the Sabangau, however, this figure represents the expenditure on fish alone, indicating that the Sabangau area experiences higher expenditures on food compared to the national average which again suggests high local poverty levels.

When choosing what fish species to eat, the questionnaire data revealed that price, interestingly, was not the determining factor for selection. Instead, the taste and the readiness of availability were the two most common reasons for fish species selection (see Figure 7.2). People in the Sabangau are therefore not basing their choice of food source solely on price and income restraints. Of course, fish prices are dependent on not only supply, but also demand aspects such as personal preferences: there are fish that are considered tastier than others, as participant KB6F described for a *Rasbora* species:

> "*This is my favourite, it is delicious. You fry it with flour and it is like a snack*" (Interview, 18/01/2016)

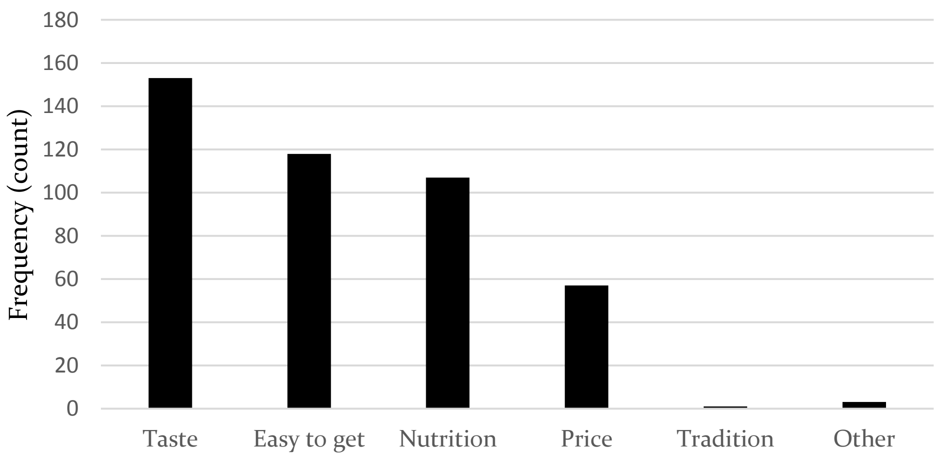


Figure 7.2: Reason for fish preference showing the number of times an option was selected by participants (n=206) (more than one option could be selected)

While fish are an important food source for local human communities, not all fish are suitable to be eaten. The next section discusses this aspect of the human-fish relationship which also involves spirits. The entanglements between these three communities i.e. humans, fish and spirits, will thereby begin to be further clarified.

7.1.2. Taboos of eating and cooking fish

There are many sorts of *pali* (sins or taboos) in Central Kalimantan (Lumholtz, 1920; Zuesse, 1974). The literature on these beliefs or norms is very limited and therefore mostly old references are cited in these paragraphs. Breaking *pali* is believed to lead to miserable lives, sickness, even death of individuals, families and communities (Zuesse, 1974). Fish that are considered *pali* are usually forbidden to eat for a certain family, with ancestral taboos often inherited through the family line (Couderac and Sillander, 2012). For those who believe in *pali,* this is therefore a clear example of coding as it determines the behaviour towards and therefore the relationship between humans and certain fish species.

This example of coding is illustrated by the story of the *saluang karing* (*Rasbora kalochroma*, see Appendix I for the folk taxonomy). This was introduced in Chapter 6 and was also reported by both men and women in Kereng Bangkirai and Taruna Jaya (see also Couderac and Sillander, 2012). Participant KB2M (Dayak, Muslim) reported that "y*ou can't bake saluang karing as you will become possessed. You can't bake anywhere in Sabangau, but you can fry it. There are no other fish that I know that is like this"* (Interview, 15/01/2016). In Taruna Jaya participant TJ18F (Banjar, Muslim), reported that spirits would come and strangle you to death if you baked the fish in the forest. TJ14M (Dayak, Muslim) had a similar story, where he had heard about the consequences of baking *saluang*:

> *"There were people from Rungan and one of my cousins burned saluang and one of the children from the group disappeared. They later found the child but he had died and around his neck there was bruising. The child was stolen by a spirit. This was saluang bahandang, you can't bake it in the forest."* (Note that 'saluang bahandang' is another name for *saluang karing*; see Appendix I: this is an example of where the folk taxonomy was valuable) (Interview, 25/02/16)

Participant TJ13M (Banjar, Muslim) also experienced consequences of baking a certain fish in the forest:

> *"We saw giants last year in the dry season. "Oooomm", the giants made that sound. They were red coloured and had big feet. They came because we were baking eels in the forest. Saluang, undang, lindung, pehang, you can't bake these in the forest in the afternoon, as this invites something not good to come. There were two giants: one female and one male. They came because we broke adat, so they bothered us*" (Interview, 22/02/16)

The misuse of fish, as seen here with the baking of *saluang karing* (*Rasbora kalochroma*), can therefore have severe consequences to humans. This is an example of how human behaviour is coded according to the presence of spirits and the expectance of punishment if the fish is not treated 'properly', i.e. in a certain and coded acceptable way.

Comparing the case study locations, in Kereng Bankirai only two participants out of the 20 interviews reported *pali* fish while in Taruna Jaya 12 of 20 participants reported *pali* fish (see Table 7.2 below). In Kereng Bankirai both participants reporting *pali* fish were Muslim, one was Dayak and the other Javanese. In Taruna Jaya participants reporting *pali* fish identified as Muslims and Christians, Banjar and Dayak. There is therefore again no strong suggestion that these beliefs are linked to either ethnic or religious identity. While *pali* has been connected to Dayaks in literature, this thesis hypothesises that it can also be understood as a 'taboo' that is recognised by both Dayaks and non-Dayaks of both Islam and Christianity in the area, and thereby it links to reterritorialisation of both Dayak and other Bornean identities, as Chapter 6.1.3 discussed. Table 7.2 lists the fish species that were considered *pali* to eat, along with the variety of reasons for this belief (along with non-spiritual reasons such as taste and aesthetics), and the ethnicity and religion of the male and female participants that identified these fish as *pali*.

Couderac and Sillander (2012) illustrate that there is a link between *pali*, its ancestral inheritance, spiritual beliefs and traditional Dayak mythical narratives, writing how in Dayak mythology the upperworld people do not mix with humans because they disapprove of human ways such as eating tabooed food, including grilled fish (Couderac and Sillander, 2012). Because of this separation of the upperworld and the human world, the observance of *pali* by Dayaks can be a way to maintain ritual relations with the upperworld ancestors, to ensure continued alliance with powerful spirits, as well as symbols of descent lines to particular important ancestors (Couderac and Sillander, 2012). While there was no explicit link made between ancestors and *pali* in the interview data, it was common to see familial aspects of *pali*, with it being brought down through generations (e.g. TJ17F whose parents determined what was *pali*), and that eating a *pali* fish could lead to a curse on your children and even lead to their death (see Table 7.2.). Through intermarriages *pali* can also be mixed, abandoned and new prohibitions or taboos can be introduced to the next generation (Couderac and Sillander, 2012). They are therefore able to undergo deterritorialisation and temporal change. As seen from the results of this study and in accordance with Couderac and Sillander (2012), there are people who still respect ancestral taboos which are said to run in their descent lines.

Taboos, and their link to spiritual beliefs have direct implications for how certain people, to whom these beliefs are relevant, interact with specific fish species. In this way, taboos and the consequences of failing to adhere to the rules of taboos within an ancestral line can have significant negative consequences. These are, therefore, further evidence of notable relationships within the Sabangau area. Coding and desires are determining these relationships and in turn play a role in forming the assemblage.

For any fish to be eaten, it must first be caught. This requires knowledge of the rules of fishing, learning how to fish, choosing the appropriate fishing methods and being able to read the environment to have successful fish catches. Section 7.2 now deals with the act of fishing and what this involves in greater detail.

Table 7.2: Fish species considered pali, reasons for being pali and demographic information of participants who considered them pali

Fish species	**Reasons for being *pali***
Pangasius sp. ('lawang')	If you eat then child becomes cursed (TJ1F, Dayak, Muslim) If you eat it your child(ren) will die. (TJ2F, Dayak, Christian; TJ13M, Banjar, Muslim; TJ14M, Dayak, Muslim) You can eat *lawang* when you are still single, but when you are married you can't eat it. (TJ14M, Dayak, Muslim)
Channa micropeltes ('tahuman')	Pali because I don't like eating the meat, if you eat the liver you will get "*drunk and die*" (KB18F, Dayak, Muslim) If you eat it your child(ren) will die. (TJ1F, Dayak, Muslim; TJ12F, Dayak, Christian; TJ13M, Banjar, Muslim; TJ18F, Dayak, Muslim) If you get married and eat it your children will die. If you are single, it is OK to eat. (TJ20F, Dayak, Christian)
Macrognathus spp. ('telan')	Pali because it looks like snake (KB18F, Dayak, Muslim) If you eat it then your skin will look like *telan* skin. (TJ2F, Dayak, Christian) If you eat it you will get a disease in your fingers. You will eventually lose them. (TJ11M, Dayak, Muslim) Your children will die if you eat this. (TJ18F, Dayak, Muslim; TJ19F, Dayak, Christian)
Scleropages formosus ('kalakasa')	Is pali, and my husband is allergic so cannot eat (KB13F, Javanese, Muslim) If you eat this your children will die. You can eat when you are still single, but when you are married you can't eat it. (TJ14M, Dayak, Muslim)
Clarias spp. ('lele'), Mystus spp. ('baung'), Channa striata ('gabus')	Pali because it looks like snake (KB18F, Dayak, Muslim) It is *pali* to eat *lele*, *baung* and *gabus*. This is because I throw it up if I eat them. It is not an allergy. (TJ15F, Banjar, Muslim) *Lele* is *pali* because it has a head like a snake and we are again disgusted by it. (TJ16F, Banjar, Muslim)
'Pari' (Species of stingray)	It is *pali* because we feel disgust, I saw it spawn and was grossed out by it (TJ16F, Banjar, Muslim)
'Behekang' (another species of catfish)	Because our parents told us not to eat it (TJ17F, Dayak, Christian)
Nandus nebulosus ('tawon')	If you eat your like will become heavy, like a stone (TJ1F, Dayak, Muslim)
Channa pleurophthalmus ('kerandang')	Caused an allergic reaction when eaten (TJ20F, Dayak, Christian)

7.2. The act of fishing

This section now deals with the act of fishing, including the rules of fishing in Section 7.2.1 and learning how to fish (or 'watercraft') in Section 7.2.2. This second section delves into the ways which fishers in the Sabangau choose fishing methods and read the environment. This can be elucidated using data from the interviews, but also data from the fish surveys. The fish and water survey data is not used to 'test' the interview data, but rather the two used together can further elucidate the human-fish relationship and the decisions made by fishers. Lastly, for those community members that believe in them, the act of fishing can also involve certain gestures to spirits, as will be discussed in Section 7.2.4.

7.2.1. The local rules of fishing

Following the example of coding with taboos of eating and cooking certain species of fish, another example of coding in the Sabangau area are the laws and informal rules that relate to fishing. Both national and traditional law ('*hukum adat'*) are applied in the Sabangau. This thesis uses the term *adat* cautiously as it tends to have a vague meaning and can have various definitions depending on context and person. It can refer to knowledge and wisdom that is passed through generations and dating back and evolving from the earliest Dayak settlements, but everyday politeness can also be seen by some as '*hukum adat*' (Christel, 2015; Schreers, 2016). It can also be closely linked to religion (Schreers, 2016), as will become clearer through this chapter.

There are rules in the Sabangau area related to fishing methods and locations. Knowing these rules and the choices made to interact with fish and other fishers according (or not according) to them is also part of the act of fishing. Participants of this study reported the Sabangau River as free to use for all locals and 'outsiders', which contrasts to Schreer's (2016) findings on the Katingan River where fishing was the exclusive right of the local community with outsiders needing to seek permission. Customary rules and the coding of fishing practices therefore appear geographically heterogeneous in this area. Both men and women in Kereng Bangkirai reported that there are no strict rules regarding fishing or where fishing traps and nets can be placed, and if there are any disagreements these will be usually handled through informal discussions (Kris pers. comm., 24.11.15). The only rule mentioned by some participants was that using electricity and poison to fish were prohibited (KB4M, KB9M, KB16F). This is considered a local rule, but it is also prohibited through Article 6 of the National Fisheries Law 31 of 2004, which states that fish cultivation must observe traditional and local laws and rules. KB9M and KB4M reported that locals try to catch people who use harmful fishing methods and the consequence of breaking this rule is that their fishing equipment or, in this case, their boat will be broken by the local community members:

> *"There were four times that outsiders used electricity. By accident local people saw a boat from an outsider. They saw there were a lot of fish in the boat and they brought the people to the police office in the national park. The fish was divided to the local people and they sunk the boat of the outsiders."* (KB9M, interview, 20/01/16)

While the main Sabangau River is free for all to fish on, this is not the case for the smaller tributary rivers flowing into the Sabangau River. Close to Kereng Bankirai, there are three river tributaries that merge into the larger Sabangau River: the Bakung, Rasau and Bangah (see Chapter 5, Figure 5.3). These tributaries are owned by members of the community who hold a certificate that states their sovereignty of their river as recognised through national law (Christel, 2015). This certificate is passed down through generations, with the current rights holders being descendants of those villagers who originally started fishing in those tributaries (Christel, 2015). The riverholders are responsible for the maintenance of the tributary as well as decisions regarding their accessibility: family members can fish but other community members must first seek permission from the rights holder before being able to fish (Christel, 2015; Krisyoyo, personal comm., 24.11.15). This coding of rights of access, which is dependent on 'who got there first', is also seen in fishing communities in Kerala, India (Santha, 2008). In Sabangau, participant KB10M explains the procedure of fishing:

> *"There are no rules. You just ask people if you can place your methods next to theirs. Every tributary river has an owner, but you just ask the owner for permission. In Sabangau, everyone has some family relation to each other, so therefore no-one can have a monopoly. From Bakung to Paduran, these rivers have owners, but others can fish there too if you ask permission."* (KB10M, interview, 20/01/16)

Close familial relations to other fishers, as mentioned above, are likely to promote peaceful resolution of fishing disputes. On the other hand, Banjarese who have settled in Sabangau do not share close family ties locally, so are rarely granted access to the tributary rivers and therefore are only able to fish in the main Sabangau River (Christel, 2015). If people enter river tributaries without proper permission, sanctions are decided by the riverholder which usually includes packs of cigarettes or a small amount of money (Christel, 2015). Linking this to the IAA framework, this is an example of how rights of access to resources, and the assemblage itself, are being territorialised according to ethnic backgrounds and social capital (Riley, 2017). The properties of the people themselves, the assemblage elements, and the coding of access rights thereby determine their relationship to other assemblage elements (in this case, the river and fishing locations).

In Taruna Jaya, while the Kahayan River is generally seen by both female and male participants as free for all to use with no fishing rules, both men and women reported that a privately held river or fish pond was not free for all to use. There is a lake that is held by Pusaka, access to which is determined by the Pusaka villagers (TJ11M). While the village has access to this lake, all others, including those from Tanjung Taruna, need to ask for permission to fish there with a payment occasionally required by the Pusaka villagers for access (TJ11M, TJ12F). The Pusaka residents clean the lake and this gives them rightful ownership (TJ11M). This is another example of the territorialisation of fishing locations for natural resource management.

Notably, territorialisation is occurring between two parts of the Taruna Jaya village (their boundaries are being strengthened) due to a discourse defining ‘appropriate fishing methods’. In Taruna Jaya there was a clearer division of fishing locations between the different parts of the village (Tanjung Taruna versus Pusaka) compared to Kereng Bangkirai. Pusaka villagers were seemingly not allowed to fish close to Tanjung Taruna and *vice versa* (TJ16F). This was due to the fishing methods used in the two areas differing: those in Tanjung Taruna reportedly use more ‘modern’ methods, while in Pusaka they use ‘traditional’ methods (TJ16F). If villagers from Tanjung Taruna fish in Pusaka, it will anger the Pusaka villagers but there will be no punishment unless poison or electricity is used, and in this case the police will be called (TJ16F, interview, 25/02/16). There is thereby a territorialisation of fishing access, through a discourse of ‘appropriate’ or ‘acceptable’ fishing methods, in an attempt to protect Pusaka villagers’ livelihoods and resources.

In interviews, most participants in Taruna Jaya reported that *adat* was still used in fishing practices (only one participant said that it was not used anymore, TJ2F). In contrast, in Kereng Bankirai, 8 out of the 16 participants, both men and women, said there was no role of *adat* in fishing activities. In both locations, with fishing, the role of *adat* was considered mainly as not interfering with other peoples’ fishing locations (such as touching or moving traps), and asking permission to fish if the location is owned by a river holder (TJ1F, TJ3M, TJ5F, TJ12F, TJ14M, KB11M, KB13F, KB14F and KB19F). This also included, as participant KB3M explained, avoiding fishing in an area with a spirit. TJ14M reported that it was important to tag or mark fishing tools to show who owns them to deal with any disputes, and TJ12F explained that if people do interfere with another’s fishing location, local people will give a warning, but no actual punishment follows. TJ1F warned of more serious repercussions if there is interference with people’s fishing locations: “*people will kill each other if this happens*” (Interview, 11/02/2015). While there is a certain level of coding determining the appropriate way of acting in terms of dealing with other people’s fish traps, the terms of punishment if these rules are not adhered to do not seem set or coded.

The interview results indicate that there is greater territorialisation of fishing resources in the Kahayan River than in the Sabangau River because of the intra-community coding and division in the former. Pusaka and Tanjung Taruna act as different villages, and while they are geographically separate, they are officially part of Taruna Jaya (see Figure 5.6 in Chapter 5). This increased coding may also result from greater fishing pressures in the Kahayan River or fishing declines that present more of a threat to livelihoods and human survival for residents in this location. The role of *adat* is reportedly greater in Taruna Jaya than Kereng Bangkirai, and in both locations it predominantly consists of respecting other's fishing locations and traps.

In Taruna Jaya both outsiders and locals are said to use electricity and poison (TJ4M, interview, 16/02/2016), and according to participant TJ19, potentially up to half of the inhabitants of the village uses electric fishing methods. Equipment for this could be seen in the village (Figure 7.3). Interestingly, in Taruna Jaya, when electricity or poison are used for fishing, people are either unwilling to get involved or they do not want to report to the police:

> "*It is actually illegal but this is their job. It is very difficult to say "stop electricity" because if you call police, one [whole] village will be involved. This is common in all villages*" (TJ2F, interview, 11/02/16)

Newer members of the community, like TJ6M, feel that they cannot forbid people to use electricity because they themselves are newcomers even if, like TJ6M, they have lived in Taruna Jaya for 30 years. They therefore do not have sufficient 'social capital' to uphold fishing rules against using electricity (Riley, 2017). The adherence to rules and the punishment of rule-breaking is therefore dependent on the origins of the participants and the composition of their village; i.e., the properties of the villagers themselves such as where they are originally from dictates their capacity to enforce local rules.

Figure 7.3: Batteries and equipment for electric fishing seen in Taruna Jaya (placed next to the boat, klotok, on the boardwalk)

These issues of harmful fishing and punishment for rule-breaking relate to the coding and territorialisation of the assemblage (Chapter 3). A highly coded and territorialised assemblage would be expected to have minimal rule breaking, or the components of the assemblage would be enforcing punishments for the rule-breaking (such as social stigmatisation or embarrassment). A highly coded and territorialised assemblage homogenises behaviour and in turn is stabilised by this behaviour and therefore in a more territorialised community one would expect less intracommunity conflict (DeLanda, 2006; Chapter, 3.2.2). Following this IAA understanding, Taruna Jaya shows symptoms of a more heterogeneous community compared to Kereng Bangkirai, with newcomers adding to this heterogeneity in Taruna Jaya (as discussed in Chapter 6). In Taruna Jaya, there is also less self-regulation between community members to adhere to rules and less pressure from social fall-out if rules are not obeyed (e.g. newcomers are less inclined to report the use of harmful fishing methods). There are potentially further implications arising from the less territorialised nature of Taruna Jaya: for example decreased resilience. This is due to the increased potential for intracommunity conflict and decrease in the inclination of community members to help each other out during difficult times.

Here, through an analysis of the coding and territorialisation of the assemblage and how this relates to the human and fish communities, a deeper understanding can be built of the differences between the two human communities, Taruna Jaya and Kereng Bangkirai, and their experiences. When fishing, it is important to understand the rules and coding of fishing and what is considered appropriate, e.g. not disturbing other's fishing tools to not face reprisal for wrongdoing. Another important aspect of being a fisher in the Sabangau area, is being able to successfully catch fish. This requires learning the skills of a fisher; building and acquiring local knowledge (or 'cultural capital' according to Riley (2017)), as described in the following section (Section 7.2.2). Throughout Sections 7.2.2 and 7.2.3, various forms of knowledges will be considered together to form an interdisciplinary analysis and understanding of the human-fish entanglements.

7.2.2. Ways of learning 'watercraft'

In both Kereng Bangkirai and Taruna Jaya, both female and male participants learned how to fish from their parents and from a young age. Some learnt from their grandparents or spouses, particularly if their parents did not work as fishers (e.g. KB8F). Participants were brought to the river by their family members and learned by joining and watching them fish:

> "*I learnt from grandparents, not directly, I often see [them fish] and I was brought by my parents and understood by myself*" (KB1M, 15/01/16)

Skills are thereby given down through generations through vertical cultural transmission; across generations through sensory education (Ingold, 2000).

Participants in both study locations also spoke of '*learning by doing*' and '*learning from nature*'. Using trial and error of different methods and locations, they familiarise themselves with the environment and learn which methods are useful for catching fish under which circumstances (KB11M, KB13F). Participant KB10M, explained that to be a successful fisher it is necessary to think in certain ways and be 'smart'. This mirrors the skills used by UK anglers where, as described by Bear and Eden (2011), they try to 'think like a fish' to decide on fishing locations, based on considering various environmental factors and their experiences of fishing in the past. Just as in the UK, fishers in Sabangau discussed a need to be able to read the environment ("*membaca alam*") and know which methods are appropriate to use in which season:

> *"Fishermen are smart people, it means they can read the environment, can read the situation, and situation of fish. If you read wrong situation there will be no fish. So, every weather, every season they already anticipate, 'oh, this the tool'"* (KB10M, interview, 20/01/16)

Male and female participants explained that they sometimes rely on 'feeling' to choose fishing locations which is based on their accumulative knowledge formed through fishing experiences. In this way, their local knowledge is gained through apprenticeship rather than formal education, through a gradual process of engaging with the environment, tools, fish, water, etc. (Ohmagari and Berkes, 1997; Berkes *et al.*, 2000; Olsson and Folke, 2001; Williams and Hardison, 2013). This is not an experience specific to Kereng Bangkirai and Taruna Jaya fishers, as Scheer (2016: 169) describes the process of boys learning to fish in Katingan, Central Kalimantan;

> *"By following…others in their daily routine, the boys observe, listen, smell, and feel fish; they learn how to handle tools, and how to read the signs of the waterscape. Prompted by their "teachers", they practice themselves, thereby receiving instructions and explanations. It is through a fully sensory experience with the water, fish, and tools that they learn how to fish."*

This sensitivity and the use of 'feeling' used by Sabangau and Katingan fishers is comparable to Ingold's (2000: 25) discussion of intuition and sentient ecology:

> *"Intuitive understanding…rests in perceptual skills that emerge, for each and every being, through a process of development in a historically specific environment."*

The knowledge that Sabangau, Kahayan, Katingan and UK fishers have is encoded in the landscape, and it consists of the ability of situating information and understanding its meaning within a direct engagement with the environment (Ingold, 2000). A need to know fish behaviour and to have knowledge of environmental situations to choose suitable fishing locations and methods in the Sabangau also mirrors Berkes' (1977) findings during his time with the Cree fishing communities and Santha's (2008) findings in Indian fishing communities, where these types of knowledge were prerequisites to successful fishing. These fisher-fish-water assemblages, and the analysis of these assemblages are therefore transferable beyond the Sabangau area.

The Sabangau fishers may or may not have a high level of formal education, but they have acquired specialised skills that are embedded within their environment. Their local knowledge, their intuition as Ingold (2000) terms it, is what, especially in Taruna Jaya, their livelihoods depend on and this knowledge is formed through many years of an ever-changing relationship between them, the fish communities, the waters, the rain, the fish bait etc. This local fishing knowledge is formed through a combination of trial-and-error, and cultural transmission inter-generationally or from partners, with the details of this dependent on the individual. The act of fishing is indeed the expression of this knowledge and this complex assemblage relationship: it is an expression of the assemblage entanglements. It furthermore describes a relationship that is in flux with the assemblage as a whole: undergoing de- and re-territorialisations as new unexpected experiences are had and whereby capacities are tested: as Bear and Eden (2011: 344) write, humans, like fish, "*adapt and develop with environmental conditions, in order to match the fish's own time-spaces*". The next section deals in greater detail with the choice of methods and the need for reading the environment for successful fish catches.

7.2.3. Choosing fishing methods and reading the environment

Fishing in the Sabangau area involves the use of several different methods; rods, nets, traps and electricity to name a few (Smith, 2002). One of the most popular choices of fishing tool is a trap such as the *tampirai* used for this study (results from the questionnaires and in accordance with Smith, 2002; WWF, 2012). In Katingan, Central Kalimantan, 41 different methods have been documented as being used in 1938, with 25 methods still in use today (Schreer, 2016). Schreer (2016) found that according to discussions with local elders, the discontinuation of some methods was due to the amount of time needed to prepare and make the traps. Participant KB2M also reported that fishing methods have changed due to there being an increased number of canals in the area (interview, 15/01/2016). Fishing methods change with the environment, over time and with technology, and are territorialised through discourses of 'traditionally used' designs using materials such as rattan (as found in interviews and focus groups; e.g. KB2M, KB4M, TJ12F, TJ18F) and reterritorialized through new ones (e.g. using more wire traps): they are "*inextricably linked to a dynamic waterscape*" (Schreer, 2016: 167). As seen in Section 7.2.1, a discourse surround 'appropriate' fishing methods can also lead to a territorialisation of fishing locations.

Fishing methods are as dynamic as the local knowledge and practice with these furthermore interwoven with the environmental and 'socio-cultural' context (Schreer, 2016) such as the rules of fishing (Section 7.2.1). Just as for UK anglers, fishers in Sabangau learn to read their environment; reading the water surface for signs, understanding what lies beneath the water surface and thereby knowing, without seeing, the underwater terrain: in sum, as Burton (2008) calls it: 'watercraft'. As Bear and Eden (2011) write, fish are actively relating to human societies, being both affected and affective. The fish and human assemblages are intertwined, entangled, and are changing and affected by the same worldly pulses and rhythms.

In the human-fish relationship, they are not the sole assemblage elements. Just as Bennet (2005: 446) includes "*powerful nonhumans*" in her analysis of their assemblage such as "*electrons, trees, wind, electromagnetic fields*", so the assemblage also includes the rain and the water. Fishers need to negotiate the relationship they have with fish, further considering the complex relationship between the fish and other assemblage elements and their ever-changing properties and capacities. The 'condition' of the water was one aspect that fishers considered when choosing trap locations (e.g. TJ4M, TJ6M). This is done through visual assessment, with water 'condition' indicators including water depth, temperature, dissolved oxygen and turbidity. This is further explored in the following paragraphs, further drawing on data from the water and fish surveys to better elucidate the human-fish relationships.

7.2.3.1. Water depth: *"You cannot catch fish in the air"*

Deep waters are perceived as favourable for fish catches by some of the fishers interviewed in both Kereng Bangkirai and Taruna Jaya (e.g KB2M, KB16F, TJ3M, TJ10M). Participant KB2M offered the quote for the title of this subsection, explaining that when the water is deeper, it is better to catch fish. Depth influences fish assemblages in streams (Harvey and Stewart, 1991; Matthews, 1998; Carvalho and Tejerina-Garro, 2014; Marion *et al.,* 2015) as deep water is related to environmental stability (e.g. damping temperature variation) and allowing greater vertical separation of fish species microhabitats (e.g. Baker and Ross, 1981; Gorman, 1988a, 1988b; Jackson *et al.*, 2001b). Increased habitat stability favours higher species richness and abundance (Schlosser, 1987; Winemiller *et al.*, 2000; Grenouillet *et al.*, 2004; Jardine *et al.*, 2015); thus, water depth can play a significant role in determining habitat diversity and consequently fish assemblage structure and species diversity (Sheldon, 1968; Evans and Noble, 1979; Schlosser 1982; Jackson *et al.,* 2001), thereby also determining fish catches.

Considering the data collected from fish surveys can further elucidate these relationships between fish and their water environment. Table 7.3 illustrates the average water depths measured in the river and the forest, the average width of the waterbody in each habitat along with minimum and maximum depths and widths. The river was deeper than the waterbodies in the forest and the average width of the river also greater than the forest waterbodies (pools/canals). As proposed in Chapter 6.3.5, with greater volumes of water, the river potentially has a greater number of niches available than the forest, leading to the higher species richness that was found (and predicted) in the river compared to the forest (see Chapter 6). Indeed, at least for a temperate river, Grenouillet *et al.* (2004) also found that stream size had implications for the structure of stream fish assemblages and increased stream size potentially increases fish species richness (Gorman and Karr, 1978; Taylor and Warren, 2001). Waterbody dimensions are likely to also play a role in the 'catchability' of the traps in the two locations which is likely to cause the difference in catch sizes and species richness (Chapter 5.3.). As mentioned in Chapter 3; diversity and scale are related, with species richness often increasing with spatial area.

Table 7.3: Average water depth (m) and water body width (m) in the river and the forest, with maximum and minimum measured. Standard deviation indicated in brackets.

Location	**Av. water depth**	Min	Max	**Av. WB width**	Min	Max
River	5.4 (±1.48)	1.5	8.7	30.0 (± 18.73)	3.3	130.0
Forest	0.4 (± 0.17)	0.1	0.9	2.4 (± 1.68)	0.3	12.5

Taking each habitat seperately and looking at the impact of changing water depth on the number of species trapped, in the forest there is a statistically significant weak positive correlation between the depth of the water body and species richness (Spearman's rho, r_s = 0.391, n=560, p<0.001). In the river, there was an even weaker, but still statistically significant positive correlation between the depth of the river and species richness (r_s =0.179, n=233, p=0.006). The forest probably shows a stronger relationship between water depth and species richness as in the forest the water depth was one of the largest limiting factors for our traps and was also highly variable over short time frames: Table 7.3 shows that the water depth in the forest decreased to a minimum of 5 cm where traps were still just able to be set. In the river, on the other hand, the water depth was not a limiting factor, and the minimum depth encountered was 1.50 m: far greater than the minimum depth for trapping.

In the forest, the deeper the water, the higher the water flow (r_s = 0.604, n=560, p=0.000). Greater water flow increases dissolved oxygen (DO) levels through more mixing of the water (r_s between DO and water flow = 0.447, n=382, p<0.001). This in turn creates more favourable conditions for fish and thereby a higher species richness with greater water flow (r_s between species richness and water flow = 0.473, n=560, p<0.001). Indeed, high water flow was another important aspect considered for trap locations by Sabangau fishers in both case study locations (e.g. TJ17W, KB9M), as well as DO levels, as further elaborated on in the next section (7.2.3.2).

7.2.3.2. Dissolved Oxygen

Oxygen levels in the water are also considered by Sabangau fishers, with Dudin often referring to this aspect during our fish surveys when explaining catches (pers. comm.; 15.10.2014, 17.10.2014, 07.03.15) or seeing many small fish such as *Osteochilus spilurus* at the surface of the river due to low oxygen levels (15.10.14). This furthermore illustrates how fishers can interpret the presence and location of a certain fish species to understand the properties of the water.

When considering the fish survey data; there were greater fluctuations in DO levels in the river compared to the forest (Figure 7.4). The forest values fluctuate between 1.2 and 1.7 mg/L (difference of 0.5mg/L), with the river values fluctuating between 2.9 and 3.6 mg/L (difference of 0.7mg/L) in the same months. Across all months, the river experienced its lowest average DO level in October 2014 (0.8 mg/L) and the highest average levels between December 2014 and June 2015 (maximum of 3.6 mg/L in December). The higher DO levels during these months correspond with the wet season, which ran from January to April/May, with an increase in rainfall leading to higher river DO levels (r_s between rainfall and DO levels for all months= 0.718, p=0.006, n=13). Of course, DO levels will also depend on mixing of the water caused by turbulence and water flow, but this study was unable to collect data on these. Further sampling of these environmental variables is therefore highly recommended for future research to allow for a more complete evaluation of the river environment.

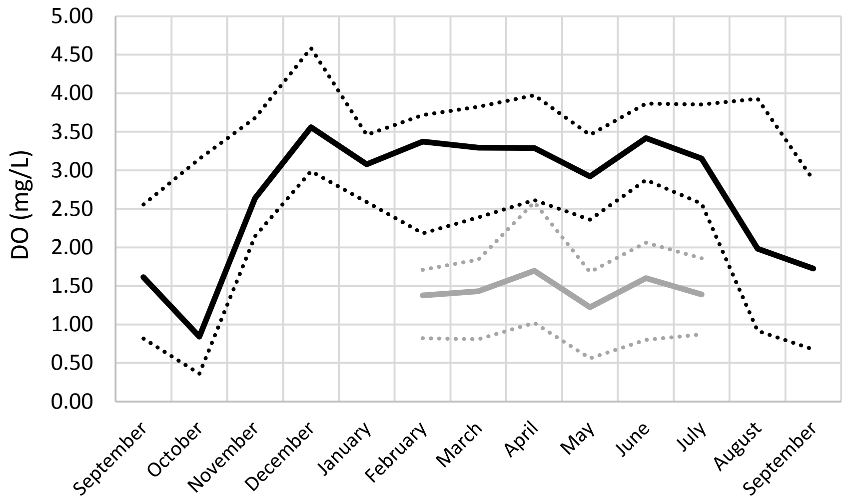


Figure 7.4: Average (bold line), minimum (dashed) and maximum (dashed) Dissolved Oxygen (mg/L) levels in the Sabangau River (black) and Forest (grey) from September 2014 - September 2015. DO measured at 30cm depth.

There is a statistically significant negative correlation between average monthly river water temperature and average monthly DO levels (PPC r= -0.589, n=13, p=0.034). However, while the forest had lower water temperatures in general compared to the river, there was not a corresponding higher DO level in the forest. When considering average monthly DO levels and average water temperatures in the forest (r_s = 0.371, n=6, p=0.468), as well as average daily DO levels and water temperatures in the forest (r_s = -0.238, n=30, p=0.242), no significant correlation was found. This is probably due to the nature of the TPSF, with DO levels kept low due to the high amount of tannins in the water, lack of water flow (especially in the standing water pools) and an accumulation of decaying organic matter that depletes oxygen, along with a lack of photosynthesis. These characteristics keeps the DO levels low regardless of the lower surface water temperatures (Yule and Gomez, 2009). The DO levels are an emergent property of the complex interactions between the water, peat, plants and bacteria. The property of the water being low in DO is not only constituted and contingent on the specific properties of the TPSF, it is also what leads to the TPSF forming through limiting the action of bacteria to break down the organic material of the peat. Thereby, the peat-water-plant-bacteria-other assemblage illustrates once more the downward causality of assemblages where upon their formation they also act as a source of limitations and opportunities for their elements (DeLanda, 2016), in this case through limiting DO levels in the water. While fishers in the Sabangau will not be focussing on aspects such as the bacterial component of the assemblage, they will consider, as previously mentioned, the behaviour of fish such as schooling and gaping at the surface of the water to understand potential DO conditions to inform their fishing approaches. They will also be familiar with DO trends in various habitats across the seasons through trial and error, as discussed in Section 7.2.2.

While the pH data (Figure 7.5) show slightly lower average pH in forest compared to water (which would support a hypothesis of higher tannin content/organic material content in the forest), additional data collection using methods to analyse differences in the water quality in the forest and river (e.g. tannin quantities), will further elucidate these correlations. As low concentrations of DO can make the water uninhabitable for certain species (Kramer, 1987; Alabaster and Lloyd, 2013), meaning that the forest is a more challenging environment to survive in compared to the river. This is likely to push species richness down in the forest with fewer species adapted to deal its more extreme environment (Adams, 2010), again illustrating the downward causality of assemblages.

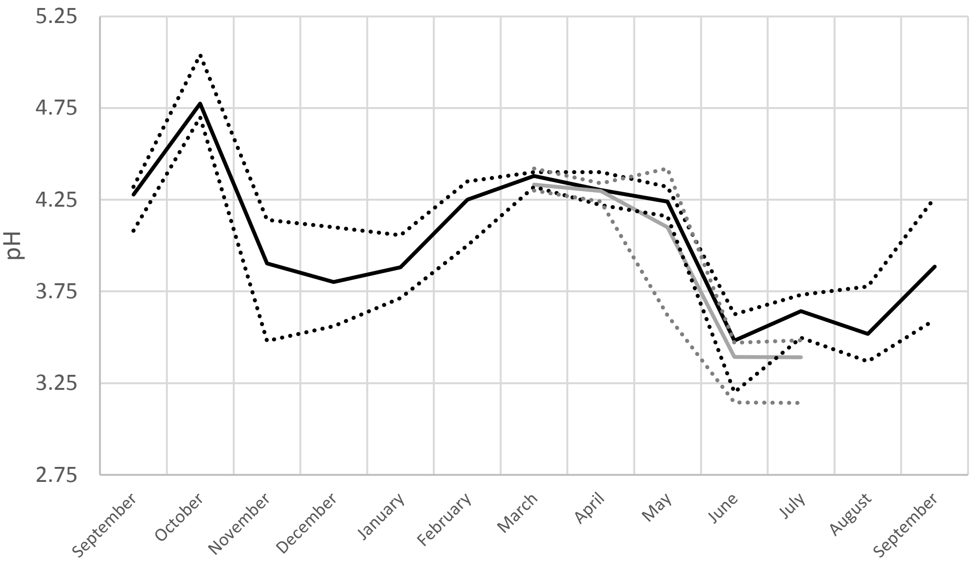


Figure 7.5: Average (bold line), minimum (dashed) and maximum (dashed) monthly pH in the Sabangau Forest (grey) and River (black), September 2014-September 2015

For the river, percentage fish mortality was calculated for each month of trapping (Figure 7.6). In October 2014, the maximum level of fish mortality occurred, reaching 50%. This then dropped to less than 10% for much of the wet season when DO levels were also higher. There is an increasing trend of mortality rates after July (with the onset of the dry season) with a corresponding decrease in DO levels. There was a strong negative correlation between average DO (mg/L) and death rate (PPC $r = -0.754$, $n=13$, $p=0.003$). Typically, DO concentrations of less than 5.0 mg/L put fish under stress, and sustained DO concentrations between 1.0 and 2.0 mg/L can result in fish kills (Kentucky Water Watch, 2016). Of course, this is dependent on species; TPSF fish are often specially adapted to live in hypoxic conditions, such as *Clarias* species which can breathe atmospheric air. However, Figure 7.6 indicates that this study did observe high levels of mortality once DO levels dropped below 2 mg/L.

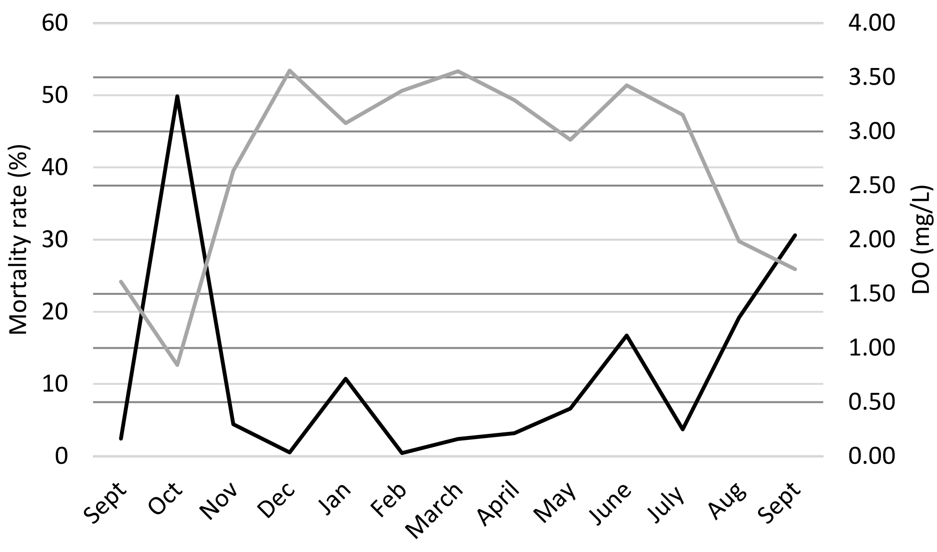


Figure 7.6: Monthly mortality rate [black] (%) and dissolved oxygen levels [grey] (mg/L) in the Sabangau river

Mortality rate showed no correlation to any other environmental variables that were measured. Therefore, as also concluded by Worthington (2015), it seems that low DO concentrations during the study period were the main determinant of the high rates of fish mortality. While setting traps with Dudin in October 2014, he told me that usually people would not set traps as the oxygen levels were low since this would likely lead to all the fish dying in the traps. It was obvious to him when we had the highest mortality rate of the fish surveys, illustrating another choice made by fishers.

Based on the correlation between surface water DO levels, any future monitoring of the river, including fish surveys, should take this into consideration by doing preliminary measurements of DO of the surface water levels to determine if it is appropriate to set traps. From the data presented here, the best months for reducing mortality in the fish surveys were between November and July (mortality rate of 0-17%). Between these months DO levels were above 1.98 mg/L. Care should therefore be taken when DO levels fall below this value, and if fish surveys are resulting in high mortalities they should be discontinued. This aspect is not only important for the fishers of Sabangau to consider for their fish catches, but also for 'scientific' researchers in the future.

In August 2015, near the start of the intense ENSO-driven dry season of that year, there was an increase in mortality rates and Dudin explained once more:

> *"The oxygen is not good now, therefore there are many dead [fish]. This is because the water is murky, the water is not good"* (pers. comm., 08/08/15)

DO levels are not the only property of 'water condition' that fishers use to read the environment, the murkiness, or the turbidity, is another important aspect. This is discussed in the next section.

7.2.3.3. Turbidity

As described in Chapter 5, increased water turbidity can have significant impacts on aquatic ecology, can impair visibility for fish and thereby their ability to feed, and can cause harm to the respiratory system of fish (Kennedy *et al.,* 2004). With increasing difficulties in finding food, fish are likely to either move away from the impacted area, or will prioritise processes other than feeding to survive. It would therefore be expected that increasing turbidity (as indicated by decreasing Secchi disk depths) would lead to lower catch per unit effort (CPUE). However, the results of this study indicate the complete opposite, with increasing turbidity (decreasing Secchi disk depth) leading to greater CPUE, with the daily CPUE showing a moderate negative correlation with average daily secchi disk depth (r_s = -0.479, p=0.002, n=38). Therefore, the greater the turbidity, the higher the fish catch.

As turbidity changes are dependent on both suspended sediments and organic materials as well as algae in the water, the higher fish catches could be due to there being higher levels of small food items for the fish in the water. Additionally, this correlation between turbidity and CPUE is likely due to the type of fish species being caught. The fish traps are selective against bigger fish, which are likely to be the bigger carnivorous species. Lower trophic level species are mainly being caught by the traps (which are more likely to be planktivorous/algivorous species), which are vulnerable to predation in clearer waters and therefore catches increase during periods of higher turbidity. Therefore, during times of lower water turbidity, prey fish may tend to stay close to vegetated areas and 'safer' locations or indeed they may face greater predation risk (i.e. they are not being caught because they are staying in safe locations and are not moving into the traps, or because they are being eaten). Turbidity therefore has species-specific impacts and will influence the trophic signature (Chapter 6).

There are times of the year when seasonal and significant changes occur, impacting a wide variety of environmental variables together. The following section now discusses these seasonal changes that are another key aspect of the fishing experience in the Sabangau area.

7.2.3.4. Fishing seasons: combination of water depth and precipitation changes

> *"The dry season is starting, so there is a lot of puyau [Osteochilus spilurus], but no saluang [*usually *Rasbora spp.*] *yet"* (Dudin, 10.04.2015), my additions in brackets.

The changing of fishing seasons is a clear example of environmental fluctuations that are usually predictable as well as complex, involving a multitude of factors such as water depth, precipitation, DO levels, water temperature etc. As Perez (2010:101) writes; people's "*livelihood repertoire (...) is extricable from the environment, just as the rhythms of everyday life are intertwined with the rhythms of natural seasons*". Figure 7.7 illustrates the CPUE for each month from September 2014 to September 2015 in the Sabangau River and from February to July 2015 in the forest. In the river, the two increases in CPUE in December and July can be related to the changing of the seasons from dry season to wet season (November-December) and wet season to dry season (June-July). During these two months, large changes in environmental conditions occurred, e.g. an increase in rainfall resulting in an increase in water depth.

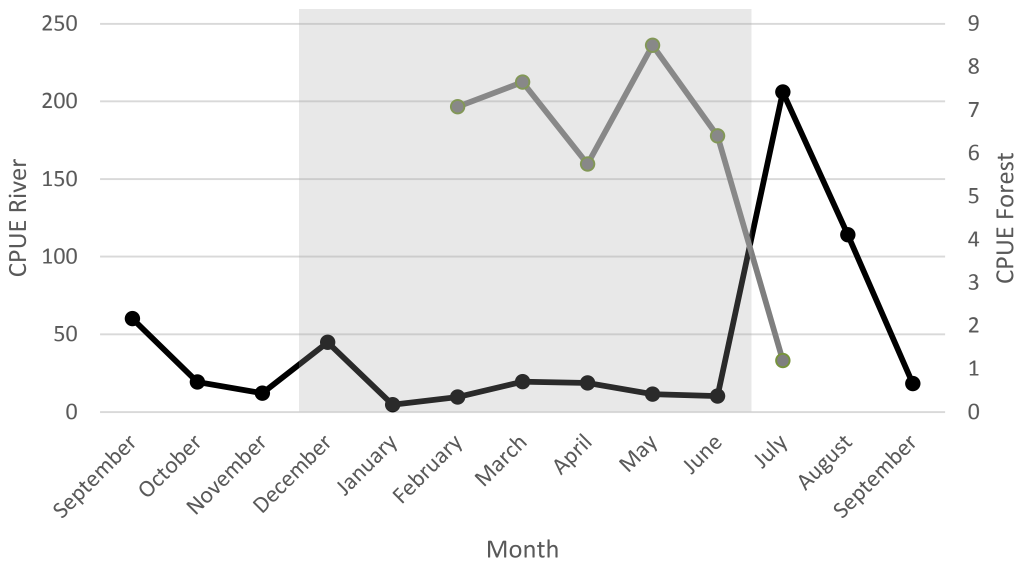


Figure 7.7: Monthly Catch per Unit Effort (CPUE) in the Sabangau River (black) and Forest (grey), from September 2014 to September 2015. Grey box indicating wet season.

The period of change that occurs around the end of the wet season and the beginning of the dry season also signifies the main fishing season in the Sabangau human communities (also found by WWF, 2012). This was reflected in the river data, with the CPUE in the river being negatively correlated to the average river depth (r_s = -0.571, n=13, p= 0.041) due the higher fish catches in the dry season compared to the wet season. CPUE or FTL in the river were not correlated with any other environmental variables (see Appendix VI). This may be surprising, as CPUE and FTL could be expected to correlate with DO levels, rainfall, temperature or pH, but instead illustrates the difficulty of trying to untangle the complex relationships between fish behaviour and the varied habitat factors (this study only gathered data from the river surface, for example). Nevertheless, the environmental measurements collected illustrate some aspects of fishers' decision making, provide a baseline for future monitoring of water quality variables, and highlight that future research is needed on the various survival strategies and behaviour of different fish species in the Sabangau to develop a better understanding of the relationships between fish and their abiotic environment in TPSF.

With the higher CPUE in the river during the dry season compared to the wet season, there was also a striking increase in the number of fishers on the river (pers.

obs. July 2015) during the beginning of the dry season. This was further supported by the results of the questionnaire surveys, with 67% of fisher respondents reporting that they mainly fished at the beginning of the dry season, with 62% of fisher respondents reporting that they caught the most number of fish at this time (n=50). This is a season for taking advantage of the favourable fish catches, and was also the time when the women in Kereng Bangkirai were reported to join the men in fishing activities, as described in Chapter 6.1.4.

Figure 7.8 illustrates that, based on the trap data, the river fish assemblage was very different in the wet season compared to the dry season. The dry season had a more diverse assemblage regardless of the wet season being longer, while the wet season catches were mainly dominated by *O. spilurus*. This illustrates how the dominant fish species of an assemblage changes not only between habitats, but also with seasons: there are geographic and temporal changes and heterogeneity within the assemblage. This is likely another reason why the dry season is the preferred fishing season, as fishers are likely to catch a wider variety of fish species.

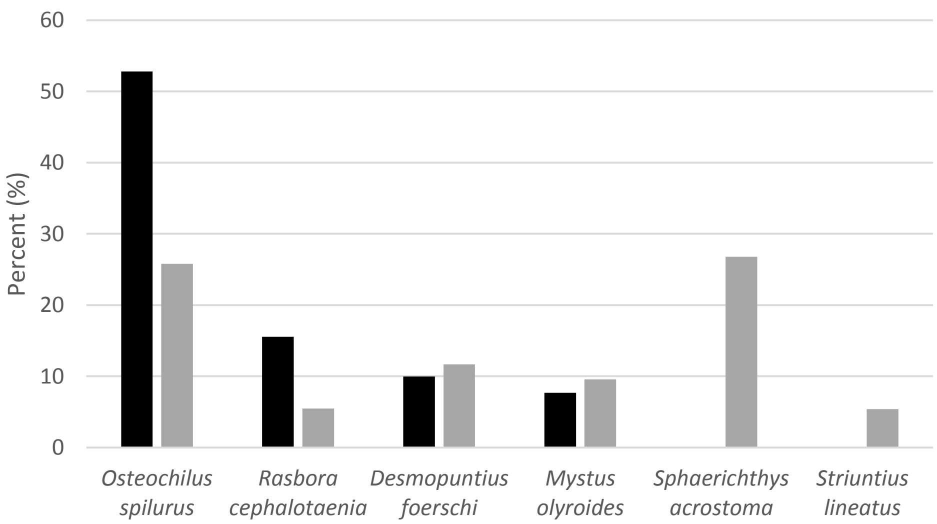


Figure 7.8: Percentage of total catch of each species (only included those representing over 5% of total catches) in the river, comparing wet season (in black; Nov 2014-Jun 2015, n=13,125) and dry season (in grey; Sep-Oct 2014, Jul-Sept 2015, n=36,422)

After the fishing season passes, fishers face a significant drop in catches (Figure 7.7). This brings with it a time of greater insecurity as catches are less consistent and income from fishing is less certain. To deal with these risks and uncertainties, there is therefore a tendency to move towards occupational pluralism or 'pluriactivity' (McCay, 1978; McGoodwin, 2001; Coulthard and Britton, 2015; Schreer, 2016). This is certainly the case in Kereng Bangkirai where a greater variety of job opportunities allows fishers to alternate between fishing and other jobs such as logging, building, farming, swift nest farming, gold mining and working on oil palm plantations. Eriksen (2016) also found in the Katingan area (close to Sabangau), that occupational pluralism was common, as one income was seldom enough and yields from most jobs varied. However, as Chapter 6 illustrated, Taruna Jaya fishers have fewer options for alternative sources of income, therefore less of an ability to achieve occupational pluralism and fishers are more likely to face difficulties during seasons when catches are naturally lower. Occupational pluralism is an important strategy that allows people to adjust to and cope with environmental change and uncertainty: it is vital for resilience. Other options include diversification and intensification of fishing, all of which will be discussed in Chapter 8.

Here, the changing of the seasons, and the various environmental changes impact the water, the fish and the fishers. These changes are yearly rhythms, and fishers expect these to occur, and depend on their ability to read the water and the environment to understand when they are in a process of flux between seasons. Problems occur when these rhythms are disrupted, as climate change and other deterritorialising forces can do, as will be discussed in Chapter 8. Reading the environment successfully for some fishers may however not be sufficient to ensure favourable fish catches. For those who believe in spiritual beings as being a part of the Sabangau area, this requires an additional relationship to be managed, with offerings sometimes needed. This is now discussed in the following section.

7.2.4. Gestures to the spirits

As seen with the taboos related to eating certain fish species, human actions can also be coded by the existence of non-humans such as *hantu.* These interactions include the use of offerings and gestures. Perez (2010: 119) describes that in everyday life it is common for Ngaju Dayaks to make small gestures to spirits that live in the environment, for example:

> "*When entering the mouth of a river for the first time or after a long absence, the Ngaju scoop water in one hand and rinse their faces as a way of greeting the spirits and warding off any danger of illness*."

Schreer (2016) draws on work from Dove and Kammen (1997) who write that this interaction constitutes a 'moral ecology' that is a "*morality governing the resource exchange between humans and the non-human*" (Schreer, 2016: 120). In fishing, this exchange can take the form of offerings for fish catches. Offerings are given to ask for permission from spirits, the fish or the river (TJ2W, Dayak, Christian; TJ14M, Dayak, Muslim) during fishing or other activities (Perez, 2010). Offerings are given to the river so that more fish come to their traps and other nonhumans do not interfere with the fishing locations (KB18F, Dayak, Muslim; KB19F, Dayak, Christian). Offerings can also include placing a yellow flag on the riverbank (KB19F, Dayak, Muslim) and this is a commonly observed practice in Central Kalimantan (Perez, 2010).

In Sabangau, for both case study locations, not all those who believe in spirits will use offerings, illustrating again the heterogeneity of interactions within the assemblage. Those that did give offerings were both Dayaks and Banjarese, Christians and Muslims. In Kereng Bankirai four female Muslim participants, who were both Javanese and Dayak reported that they used rituals and/or offerings. In Taruna Jaya one male, Dayak and Muslim participant reported giving offerings or using rituals. TJ1F (Dayak, Muslim) explained that offerings were given more in the past, and that nowadays only older people use this ritual. These are the same participants who had beliefs around taboo fish to consume, except for two participants in Kereng Bangkirai (KB19 and KB20) who reported there being no *pali* fish for them (as previously discussed, taboos around eating certain fish species are not necessarily linked to spiritual beliefs, and can be due to a variety of other reasons as detailed in Table 7.2). Indeed, in Kereng Bangkirai the participants who gave offerings were between 43-69 years old; in Taruna Jaya the male participant who gave offerings was 37 years old. Age or generation is likely not the only determining aspect, with others reported not using offerings anymore as it was not seen as compatible with their religion (e.g. TJ12F, Dayak, Christian). Some see it as only done by certain religions (TJ16F), while this study found that both Christians and Muslims reported using offerings, with the quote below coming from a Muslim participant:

> "*he is the richest prophet, all property, forest, river including fish, and all of them are belong to Sulaiman. Then, people believe if they give offering to him, they will get lots of fish…Suleiman had children and for one of them should protect the river area and anything to do with water. You give offerings to the child of Suleiman to ask permission to fish, and you say your name when you give your offering and ask permission. People who give offerings catch more fish. This is still done a lot, but mainly by muslims. For other religions you can use same methods but you would pray to someone else – not one of the prophets.*" (KB10M, interview, 20/01/16)

Participant KB8F also explained that offerings may not be used as much anymore as fishing methods have become more 'modern', more effective, and thereby offerings are not as needed anymore:

> *"In the past yes, they used to give offerings in the wet season. Now they don't anymore because of the change in methods. Because in the past they used traditional methods, now they use more modern methods so it's easier to catch fish."* (Interview, 18/01/16)

The reasons behind using or not using offerings are therefore likely to be very heterogeneous, personal and subject to temporal change.

Yellow flags are also used to mark spiritual sites at the mouths of rivers or at specific locations on river banks and these sites cannot be disturbed (Purnama *et al.*, 2012), as further explained by interviewee KB13F (Javanese, Muslim):

> "*This is because spirits have a home, and the yellow flags show that there are guardians which protect the area, so you put the flag there so that they don't get bothered.*" (Interview, 25/01/16)

Interviewees reported placing flags by the river's edge to warn other people against crocodiles, snakes and "*strange*" things (KB11M; Banjar, Muslim, interview, 25/01/16) or alternatively to "*thank God*" if fish catches had been good (KB12W; Banjar, Muslim, interview, 25/01/16).

Offerings and yellow flags are another example of interaction between humans and spirits that can be beneficial or non-beneficial to humans (also supported by Taylor, 1995). This section has shown how offerings may differ in what they are made up of, or who they give the offering to, but this is regardless of religion and provides another example of how the relations between humans and nonhumans are coded in the Sabangau area. This property of the human communities, namely spiritual beliefs and/or religion, can impact how people understand their assemblage and relate to other assemblage elements. As Chapter 6 discussed, religious beliefs and identities can therefore be a territorialising force through their stabilisation of communities and identities (DeLanda, 2006). Saying this, as introduced in Chapter 6, and further illustrated in this chapter, religious and ethnic identities have fluidity in the Sabangau: the conception of taboos as well as spirits, and the act of giving offerings to spirits are not specific to ethnicities or religions in the Sabangau area. They are the enactments of these fluid and constantly changing religious and ethnic identities with the ephemeral assemblage itself. This territorialising capacity of religion and ethnicity, yet their deterritorialised enactment within the Sabangau, illustrates that the co-existing territorialising and de-territorialising forces are in constant disharmony, "*releasing unexpected mutations and variations*" (Frosh and Pinchevski, 2014: 602). Using the IAA, these unexpected variations can be given appropriate space for consideration and discussion, including the heterogeneity and fluidity of spiritual beliefs, and their connection to religion and ethnicity in Sabangau.

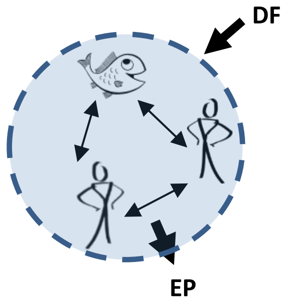
7.3. Chapter conclusion

This chapter explored the most prominent relationships between the human, fish and spirit communities along with other elements of the assemblage. From these relationships, the wider assemblage in the Sabangau area emerges. This chapter has illustrated, through for example the seasonal aspect of fishing that relationships within the assemblage are in constant flux and change. Chapter 6 illustrated how the spirit communities were considered by some in the Sabangau as having agency, and this chapter showed how the spirit and human communities can interact through gestures and ancestral links, with the latter determining for some people which species of fish are suitable for consumption (and thereby coding this human-fish relationship). Assemblage coding has been considered in terms of fishing practices and rules, and religious and spiritual coding and practices. There are coded rules that are to be followed relating to the use of fishing methods (e.g. harmful methods such as electric fishing) and the locations in which people can fish. The latter can be dependent on where the fisher is from, and their relationship to, for example, the river holder or the 'owner' of a certain lake: their properties determine their interactions within the assemblage. Lastly, to fish in Sabangau there is a necessity, as for most fishers, to understand the environment and to thereby make appropriate decisions for fishing methods and locations. The data collected by this study were used to elucidate some of these relationships between fish and the water, including depth, dissolved oxygen (DO), turbidity and seasonal changes that involve an interaction of these various water properties. This not only supports an enhanced understanding of how Sabangau fishers look to the water conditions to understand and predict their fish catches, but also provides useful details to inform future ecological fish surveys.

CHAPTER 8

STEP 3:

Deterritorialising Forces and Emergent Properties



Chapter 6 and 7 have allowed an understanding of the assemblage elements and prominent relationships between these elements that form the assemblage in the Sabangau area. In this chapter, in Section 8.1, I discuss and provide examples of forces of deterritorialisation that have acted, continue to act, and potentially could act on the ephemeral assemblage. A deterritorialising force recombines or replaces various components and roles within the assemblage, leading to the assemblage's dissipation or reformulation: it opens the assemblage up for change (DeLanda, 2006; 2016; Frosh and Pinchevsky, 2014). As Dovey and Fisher (2014: 50) write, deterritorialisation is "*the movement by which territories are eroded as new assemblages are formed*". Social mobility is an example of a process that leads to deterritorialisation as it decreases the density of assemblage elements through geographical dispersion (DeLanda, 2016: 30). Deterritorialising forces can also decode the structure, functioning and identity of assemblage elements, and thereby their relations to other elements (Dark, 2014). This chapter uses the following examples of deterritorialising forces: population growth, changes in national laws and regulations, climate change and the introduction of projects or conservation management actions through external and internal initiation. I discuss the consequences of these deterritorialising forces for the assemblage, its elements and their properties. After each deterritorialising force is introduced, I follow this with a discussion on the responses to these deterritorialising force, which in some cases are examples of territorialising forces (e.g. the Outsider Narrative). As previously explained in Chapter 2, territorialising forces maintain the components and inter-component relationships in an assemblage (and thus the identity and the durability of the assemblage) (DeLanda, 2006; Frosh and Pinchevski, 2014). In earlier chapters, examples have been provided of territorialising forces such as linguistic and religious coding, traditions and socio-cultural heritage (e.g. the passing down of fishing knowledge over generations), ideas of 'Dayakness' versus 'otherness' and thereby compartmentalisation of identity and right to resources. Deterritorialising and territorialising forces continuously act on the assemblage, and as previously explained they do not act in a way to cancel or balance each other out and can lead to unexpected variations. Therefore, the use of the IAA allows these forces and their impacts on assemblage interactions to be considered, along with novel patterns of association which may have been previously obscured (Frosh and Pinchevsky, 2014). One example of this that I discuss in this chapter is the link between the fish and bird declines in the Sabangau.

Section 8.2 then discusses three prominent emergent properties of the assemblage in the Sabangau that are notable for the functioning of the assemblage and its elements and that should be considered for future biocultural conservation projects. Through a tension between territorialising and deterritorialising forces, all in relation to assemblage elements and their own properties and capacities which have already been explored and delineated in previous chapters (6 and 7), the assemblage acquires certain emergent properties. As Chapter 3 discussed, emergent properties lead to assemblages being more than the mere sum of their parts. This also leads to emergent properties being contingent: if interactions between assemblage elements cease to take place the emergent properties cease to exist (DeLanda, 2016: 12). Emergent properties of an assemblage can constrain or help a community (Bazzul and Kayumova, 2015) through downward causality as already encountered (DeLanda, 2016: 21). In addition to discussion of deterritorialising forces, therefore, this chapter also discusses three main emergent properties of the assemblage in the Sabangau, all of which relate to and are created by the interaction between assemblage elements, deterritorialising and territorialising forces. Specifically these emergent properties are that i) it is fire-prone, ii) prone to overfishing, and iii) has certain resilient and non-resilient aspects. Of course, the assemblage has many other emergent properties, and these are used only as examples of how the IAA can be employed as a framework to support the approaches and aims of this thesis. The emergent properties discussed are also those most prominent resulting from the surveys of the human and fish communities in this study. As it is important to first understand some of the key deterritorialising forces before moving on to the emergent properties, I thereby organise this chapter in that order.

The assemblage in the Sabangau area is a historically individuated entity (DeLanda, 2016: 13): historical events have shaped the assemblage, and therefore past events and deterritorialising forces will be discussed as they cause the assemblage to be what it is now and have the emergent properties it has today. I will also use the example of fish ponds in Section 8.1.5 to illustrate how the IAA can be used to understand and analyse past deterritorialising forces, but also consider potential future deterritorialising forces.

8.1. Deterritorialising Forces

Deterritorialising forces that I will discuss in the coming sections include instrinsic population growth, population increases from immigration/transmigration, changes in national laws and regulations, and global forces such as climate change. Therefore, I am also dealing here with forces that are acting on a variety of geographic scales. Deterritorialising forces can cause chain-reactions to occur, including resistance in the form of territorialising forces. This chapter illustrates how certain deterritorialising forces lead to the 'Outsider Narrative' in the Sabangau area, which is an example of a territorialising force. Specifically, I argue that the Outsider Narrative has resulted from a loss of 'control' that human communities are feeling through their experience of change and transformation enacted on the assemblage; this builds on discussions from Chapters 6 and 7. However, I can only discuss the 'Outsider Narrative' and its significance in the Sabangau area once some of the key deterritorialising forces such as increasing human populations, which are linked to this 'Outsider Narrative', have been discussed. This will become clearer in Section 8.1.1.1. The following section begins now with the intrinsic and extrinsic human population growth as one of the key deterritorialising forces being experienced at the case study sites in Sabangau.

8.1.1. Increasing human populations

In Central Kalimantan there has been a recent increase in the human population due to natural population growth, plus transmigration of people from other parts of Kalimantan and Indonesia to the province, which has led to a perception of 'outsiders' encroaching on fishing villages as found through this study (see also Chapters 6 and 7). As discussed in Chapter 4, by 2000, transmigrants constituted 21% of the population in Central Kalimantan (Rautner *et al.*, 2005). The transmigration scheme caused villages along the Sabangau River to grow substantially in size, such as Kereng Bangkirai, which experienced a population growth from the low hundreds during the mid 20th Century to over five thousand today (Graham, 2013). This increase in populations, along with the influx of logging, the Mega Rice Project (MRP) and the cessation of these industries has had significant impacts on the Sabangau area and the relationships between its elements, as I will expand on in Section 8.1.3.

What I wish to highlight here is that the rapid influx of people into Kalimantan with little regard for *adat* laws, along with changing land-use behaviours, resulted in the transmigration programme ultimately fuelling increased experiences of marginalisation, tensions between ethnic groups, increased land pressures and poverty levels in locations unable to support the larger populations (O'Connor, 2004). Past population increases in Central Kalimantan have therefore helped form the assemblage as it is today. Population increases have led to a chain of events that have and continue to impact assemblage elements, their properties, and their relationships in the Sabangau. From interviews, an increase in the number of people fishing was reported as a main cause of fish declines in both Taruna Jaya (7 out of 20 participants; the others focussed on other issues such as electricity and fire as a cause of fish declines) and Kereng Bangkirai (16 out of 20 participants, with others focusing on fishing methods such as catching smaller fish, using electricity and fire as the causes of fish declines). For example, participant KB1M reported when asked how he perceived the future of fishing in the Sabangau:

> *"Not really good. Every day the number of people is increasing. The city is increasing and more people are fishing. The number of fish is unbalanced [with the number of people fishing]. People are catching fish when they are still small."* (Interview, 15/01/2016)

I will further discuss the other causes of fish declines in coming sections, but it is clear that the increasing human population is a key deterritorialising force acting upon the Sabangau area.

Human population growth can also be the result of intrinsic population growth, but this is difficult to unpick from provincial growth statistics and is likely to contribute increasingly less to population growth figures. This is due to ongoing government efforts to improve family planning programs and health services which have led to decreasing birth rates in the province: in 1971, women had between 6 and 7 children, compared to 2013, when most women have between 2 and 3 children on average (DEPKES, 2014; BkkbN, 2015). Family sizes are therefore decreasing; illustrating another part of the flux and change in the Sabangau area over the years. In Central Kalimantan, the rate of annual average rural population growth declined from 1.69% in 1971-1980 to 0.79% in 1980-1990 (Sunderlin and Resosudarmo, 1999). While intrinsic population growth is still happening, the rate of growth in more remote villages such as Taruna Jaya has likely decreased from the past. Here, the population could instead begin to decrease, as participant TJ12F and TJ10M described:

> *"The number of people have decreased because it is difficult to find another job. Catching fish is becoming more difficult and therefore people want to find a job in another city."* (TJ12F, interview, 22/02/2016)
>
> *"The future is difficult because every year it is harder to catch fish and the main job of local people are fishermen. They can't do anything else. You can find other jobs if you go out of the area. For this moment, people can survive, but if the fish are gone then people will have to leave."* (TJ10M, interview, 18/02/2016).

Once more, human and fish population dynamics are tightly entangled in the assemblage, particularly in rural settings where there are few alternative income options, such as Taruna Jaya. A decrease in fish populations may therefore lead to a decrease in human populations as village members are forced to move to more urban areas in search of jobs. This is in addition to the decreasing birth rates as just described.

In contrast, Kereng Bangkirai is expanding as a village due to its proximity and high ease of access to the provincial capital of Palangka Raya, and its consequent increased opportunity and choice of jobs compared to Taruna Jaya (Chapter 6). The intrinsic population changes which also include immigration and emigration from/to the villages are therefore likely to be varied across geographical areas and between villages, and highly dependent on their proximity to urban centres, health services, access to markets and jobs. This illustrates how the impacts of deterritorialising forces can depend on the properties of a village and its community members. It will also depend on more complex desires of the community members to move or stay within a village.

With an increase in human populations, be it arising from intrinsic and/or extrinsic population growth, the fishing methods used in the past by community members and those used by outsiders are causing tensions, as participant KB4M explains:

> *"The number of fish has decreased because of outsiders coming to fish and the number of local people fishing has increased. It doesn't matter if outsiders come to Sabangau, but the methods that they use matters. They use electricity and poison."* (Interview, 18/03/16)

Both traditional and non-traditional fishing methods will have consequences due to the increased number of people fishing. When blame is primarily placed on 'outsiders' for the decrease in fish populations, this allows local community members to avoid considering their own contributions to these declines (von Helland and Clifton, 2015). As I will further explain and justify in the coming section (Section 8.1.1.1), this plays into narratives of legitimacy of resource use and ethnicities, along with responsibilities for ensuring sustainable fishing practices (von Helland and Clifton, 2015). This is not only manifested in response to the deterritorialising force of increasing populations, but also in relation to the methods and technologies that are now being used (e.g. discussion of changes in fishing methods over time; Chapter 7.2.3.) which themselves are also having a deterritorialising impact. This now brings me to what this thesis refers to as the 'Outsider Narrative'.

8.1.1.1. Response to growing populations: The "Outsider Narrative"

There has long been confrontation with the 'other' in Central Kalimantan, predominantly resulting from transmigration and spontaneous migration (Section 8.1.1) causing increased feelings of marginalisation within the Dayak population and a reconfiguration of local identities (Schreer, 2016). In recent years, this tension between local people and 'outsiders' has continued, particularly in the context of oil palm development (see Schreer, 2016) but also fishing, as discussed here. The deterritorialising force of increasing human populations, has led to a reponse of what I call the 'Outsider Narrative', which is an example of linguistic coding. As introduced in Chapter 3, coding can influence the level of (de)territorialisation of an assemblage. This narrative is being used to distinguish those who are deemed to belong or not to belong to a community, with those considered as outsiders having fewer rights to 'resources' such as fish.

Within the Sabangau area, perceptions of who the outsiders are has changed over time, as will be illustrated through the course of this chapter, and is summarised in Table 8.1. The definition of 'outsider' therefore experiences the same flux and temporality as the assemblage itself. For the assemblage in the Sabangau, I argue that this narrative is a reaction, a human expression in response to a deterritorialising force as communities (which themselves are ethnically and historically heterogenous, as explained in Chapter 6) sense loss of control and security due to a perceived decrease in fish and other resources. This 'Outsider Narrative', which was evident in both Taruna Jaya and Kereng Bangkirai, does not refer to people living within these communities, even those who came originally from other parts of Indonesia, but predominantly refers to people living outside the villages to fish in the area, often on a short-term and seasonal basis. The definition of 'outsider' is however flexible (Table 8.1) and this section will illustrate how the Outsider Narrative produces certain effects.

Table 8.1: Examples of the different conceptions of 'outsider' exemplified in this thesis		
Views held by	**Insider**	**Outsider**
Central Kalimantan Dayaks	Dayaks	Non-Dayaks (e.g. Madurese)
Taruna Jaya residents	Taruna Jaya residents	Those not residing in Taruna Jaya
Pusaka (Taruna Jaya) residents	Pusaka residents	Tanjung Taruna villagers
Kereng Bangkirai residents	Kereng Bangkirai residents	Those not residing in Kereng Bangkirai
Community members (like those in Kereng Bangkirai and Taruna Jaya) who previously worked in logging	Other community members	Conservation actors and/or the Government

This Outsider Narrative stems from historical experiences of Dayaks and the formation of Central Kalimantan. It thus illustrates how foreign influence has long been part of the history of Kalimantan, and how past forces have implications for how the assemblage is formed and functions today. One of the prominent experiences of Dayak exclusion and marginalisation occurred under President Suharto's New Order from 1966-1998 (McCarthy, 2004; Smith, 2005; see Chapter 6.1.1.). During this time, the transmigration scheme that was bringing people from Java, Madura and other over-populated areas of Indonesia to Central Kalimantan was at its peak. In the Sabangau region, an ethnic division rapidly emerged; those with the 'social' and 'economic capital' needed to open and operate timber concessions tended to be Javanese and ethnic Chinese elites (McCarthy, 2004). Dayak elites also benefited from the system through gaining privileged political positions during the New Order (McCarthy, 2004). However for most rural people in the Sabangau and across Central Kalimantan a centrally (Jakartan) controlled process of resource exploitation brought very few benefits, and instead left them dealing with the environmental consequences, creating increased marginalisation and resentment (McCarthy, 2004). According to Smith (2005), the Dayaks began to feel squeezed by outsiders through the loss of land and, with plantation companies preferring to hire migrant workers over Dayaks (Chapter 6.1.1.), there was an increased feeling of inferiority and marginalisation as access to an improved economic situation was seen as being unfairly limited. In Kalimantan, the New

Order left a "*heritage of bitterness*" toward Jakarta and the Javanese-dominated bureaucracy (McCarthy, 2004: 1202).

It is necessary here to recall that Central Kalimantan was formed in 1957 as fundamentally a Dayak stronghold with ethnicity therefore "*woven into the fabric*" of the province (van Klinken, 2006: 27). I discussed ethnicity in Chapter 6, and here it is relevant once more to understand the Outsider Narrative. Following the fall of Suharto in 1998, Dayak elites used the growing resentment towards Jakarta to highlight an ethnic and social division between the outsiders who had profited from the New Order system, and the marginalised 'Children of the Region' or *Putra Daerah* (McCarthy, 2004). This discourse aimed to territorialise the access and sense of entitlement of local ethnic groups to many areas of life including government positions and natural resources (McCarthy, 2004). It was the *Putra Daerah* discourse that also catalysed the ethnic cleansing of the Madurese populations in Sampit and other parts of Central Kalimantan in 2001 (McCarthy, 2004). With the Sampit conflict, the use of violence became legitimised through the discourse of 'self-defense'; it was turned into a 'war' to defend Dayaks and Central Kalimantan, calling for 'warriors' from both rural and urban communities (Smith, 2005). This is an example of the extreme territorialising reactions that can occur in response to a deterritorialising force.

Nowadays, the historic Dayak tolerance of immigrant groups has shifted to only include those that show a willingness to integrate or at least to not offend Dayak customs, as Smith (2005: 8) quotes a Government Official in Palangkaraya:

> *"Traditionally, Dayak are very welcoming to outsiders…But there was a long accumulation of bad behavior by the Madurese. They do not want to assimilate. They always bring their pure Madurese culture and don't respect the Dayak culture. Dayak were offended by Madurese behavior. It was a time-bomb waiting to go off."*

In this way, under the IAA I argue that the Outsider Narrative is completely a physical manifestation and act of (re)territorialisation for the wider assemblage across Central Kalimantan, including the assemblage in the Sabangau (as these are not in isolation from each other). The Outsider Narrative was already created and embedded by the historical experiences that I outline above.

However, the definition of who qualifies as an 'outsider' is fluid, and in Kereng Bangkirai and Taruna Jaya, it was less an issue of Dayak versus non-Dayak, and more an issue of those who live in the village versus those coming in temporarily (e.g. seasonally from other villages, or even more short term, such as for the day) (Table 8.1). Male and female participants, both Dayak and Banjarese, in both Kereng Bangkirai and Taruna Jaya reported problematic experiences with outsiders coming into the village to fish. Notably, there seemed to be a greater focus on outsiders being a main cause of fish declines in Kereng Bangkirai compared to Taruna Jaya, as interviewee KB9M expressed:

> *"They can't control people from the outside, from South Kalimantan like Banjarmasin…They are just thinking about the catches, and the place they are destroying is not their own place. So it is the local fishermen are the victims of what they are doing."* (KB9M; interview, 20/01/16)

In Taruna Jaya, no participants blamed outsiders solely for the decrease in fish, with TJ4M, TJ7M, TJ14M saying that the cause of fish declines was due to an increasing number of people, both locals and outsiders, who were fishing. Therefore, referring back to Section 8.1.1; both extrinsic and intrinsic human population growth are seen as deterritorialising forces in Taruna Jaya along with fire, and the changing and different fishing methods used (Chapter 7.2.3). Infringement of outsiders is therefore a deterritorialising force, with the Outsider Narrative reacting as a territorialising force as it delineates identity and entitlements to 'resources'. These forces are in tension with each other, again illustrating how deterritorialising and territorialising forces are acting together and reacting to each other in the assemblage.

To understand the Outsider Narrative more fully, I now consider the perceptions which participants had of outsiders in the two case study locations. In both villages, outsiders are seen by both male and female participants to bring with them fire and harmful fishing techniques such as poison and electricity, although less strongly so in Taruna Jaya as aforementioned. Particularly in Kereng Bangkirai, outsiders are seen as not caring about the local environment as it is not their home and so they do not suffer the direct consequences of environmental degradation:

> *"People from the outside bring poison and electric fishing. While local people don't think it's good for their income or lives so they think twice, outsiders don't care*." (KB13W; interview, 25/01/16)

I discussed electric fishing in Section 7.2.1 in regards to the rules of fishing, but now I focus on the connections made specifically between outsiders and harmful fishing methods, and why these perceptions matter. It is perceived in Kereng Bangkirai that outsiders do not understand the environment or fish and therefore they are ignorant and negligent to the implications of harming the environment using fire (supported by Graham, 2013):

> *"People from the outside do not realise that the location of the burning was the location where the fish stay. People from Palangka Raya who fish in the area don't realise that the fire will mean the fish is gone."* (KB4M; interview, 18/01/16).

Participant KB13W links outsiders with harmful fishing methods as they do not care about the environmental consequences, while participant KB4M perceives this more as an issue of outsiders being ignorant and perhaps not being 'good fishers' (as discussed in Section 7.2.2). Regardless of the reason, there is a clear delineation being drawn between 'locals' and 'outsiders'.

A loss of fish leads to a clear yearning to regain control in both Kereng Bangirai and Taruna Jaya. It makes community members feel as though they need to make regulations against outsiders who do not reside within the community (e.g. KB13F) to limit their access to fishing resources. However, since fishing is an open resource (Chapter 6), this is almost impossible to achieve as KB14F explains:

> *"But you can't stop people from outside as it's free for all to fish in the area. They should just realise the consequences, as you can't keep an eye on people 24 hours a day."* (Interview, 25/01/16)

The only control villagers do have is trying to catch people using harmful fishing methods as seen with the example of Kereng Bangkirai villagers breaking the boat of an outsider who used electricity in Section 7.2.1 (in Taruna Jaya electric fishing was more tolerated as discussed in Section 7.2.1). Through attempting to enforce local fishing rules (coding in the IAA, as discussed in Chapter 7), the villagers in Kereng Bangkirai are trying to (re)territorialise the assemblage. However, this is often done in vain, which leads to a further sense of frustration amongst residents of Kereng Bangkirai. In contrast, Taruna Jaya experiences intra-village territorialisation (predominantly due to the geographic spread and historical experiences of the village as discussed in Section 7.2.1) while Kereng Bangkirai is experiencing territorialisation of itself against any 'other', including Palangka Raya and other villages in the area.

In areas such as Taruna Jaya, where outsiders are not identified as a threat to the same extent compared to other locations such as Kereng Bangkirai, the Outsider Narrative is less strong. I argue that to understand the reasons for this difference, the element properties such as ethnicity need to be considered. Regardless of Taruna Jaya having fewer alternative income options than Kereng Bangkirai, which one could hypothesise would lead to a stronger Outsider Narrative with the decreasing fish populations having more severe impacts, I did not find any evidence that this was the case. On the contrary, the Outsider Narrative seemed more prominent in Kereng Bangkirai, and I suggest that this is due to the history of the village itself. As discussed in Chapter 6, Taruna Jaya occupants included a higher percentage of Banjarese people than in Kereng Bangkirai. Overall, Taruna Jaya has a higher proportion of villagers who have come from other areas in Central Kalimantan. Its status as a newer village (Chapter 5) may explain why the 'Outsider Narrative' is not as prominent as inhabitants have a less strong sense of entitlement to the area's 'resources' (which also leads to the increased toleration of harmful fishing methods in Taruna Jaya as discussed in Section 7.2.1.).

This section has illustrated why the interaction between deterritorialising and territorialising forces matters, and how they can impact the assemblage, its elements, and the relationships between the elements. With the increasing population in Central Kalimantan (a deterritorialising force), the encroachment of outsiders is causing tensions in and between local fishing communities. Outsiders cause a sense of loss of control over land and river resources amongst resident communities, with outsiders often seen to be uncaring and ignorant of the environment and its functioning and thereby the impacts they have on the assemblage. Being unable to control this encroachment due to the public nature of the river and the fish has caused increased insecurity for fishers in Taruna Jaya, but particularly in Kereng Bangkirai. The Outsider Narrative is an expression of marginalisation and feeling powerless and comes into being as an attempt to reterritorialise the assemblage. As the following sections (8.1.3. and 8.1.4.) of this chapter will illustrate, it usually points to problematic enactments of power between various assemblage elements. Therefore, the Outsider Narrative is of particular pertinence in Central Kalimantan; it is strongly linked to the history of the province and its formation, and to the changing and strengthening of local identities. Overall and in relation to population growth and the 'Outsider Narrative', it is evident that territorialising and deterritorialising forces are acting together and reacting to each other in the assemblage.

There is another cause for a loss of control and an increased insecurity for fishers in the Sabangau area, and that is climate change. The following section discusses this aspect that is not only impacting those in the Sabangau, but also fishers globally. The specific implication of climate change for the Sabangau area is the topic of focus.

8.1.2. Global Climate Change and the El Niño Southern Oscillation

Environmental change, such as that attributable to global climate change, is another deterritorialising force acting on the assemblage. Deterritorialising forces can act at various scales, and this is an example of a global deterritorialising force. The Sabangau area is part of wider and larger assemblages, and as climate change impacts the fisheries of South America (Defeo *et al.*, 2013), so will it impact the fish and fishing communities in the Sabangau. Participant KB6F and KB8F described changes in climate as one of the causes of fish declines in the Sabangau, and therefore it is another notable deterritorialising force to consider:

> *"In the past there were a lot of fish, and now the number of fish has decreased... This has changed because of the dry season, change in nature and the climate."* (KB6F, interview, 18/01/2016)
>
> *"I have seen many changes, the number of fish is decreasing because there are many people who are fishing. It's also because the climate is changing, as well as canals."* (KB8F, interview, 18/01/2016)

The exact response which fish and human communities have to changes in the climate are dependent on a wide variety of factors, including their adaptability to changing environments. Section 8.1.2.1 now discusses the environmental (i.e., increased intensity and frequency of El Niño Southern Oscillation events), human and fish responses to this deterritorialising force in greater detail.

8.1.2.1. Environmental, human and fish responses to climate changes

Ecological systems that support fisheries are already known to be sensitive to climate variability, with risks to aquatic systems from climate change including alterations to the distribution and timing of fresh water flows, extreme weather events, changes in precipitation and run-off (Daw *et al.*, 2009). Climate change is expected to drive shifts in geographic ranges of species including fish (Colwell *et al.*, 2008; Chen *et al.*, 2011; Scriven *et al.*, 2015). Accompanying changes in rainfall are also likely to affect the responses of species to climate change (Colwell *et al.*, 2008), impacting also the rivers, their waters and the condition of these waters (Chapter 7). Dry season flows of many rivers in South and South-East Asia are expected to decline with climate change, and changes to hydrological regimes along with the risk of drought may create further incentives to invest in projects like hydropower dams and irrigation schemes, which are likely to have complex and often negative impacts on aquatic ecosystems (Daw *et al.*, 2009). Climate change may also greatly exacerbate the ongoing impacts of the current land-cover change driven by oil palm and timber plantation development, amongst other causes, on terrestrial fauna across Borneo (Struebig *et al.*, 2015). The impacts of this deterritorialising force are far-reaching and complex, and are also notable specifically for the Sabangau area. For the Sabangau, elements such as fish species will respond to these changes by either expressing previously unknown capacities (if they are able to adapt to climate change), or will cease to exist (if they are unable to adapt). Each of these potentialities will lead to the assemblage in the Sabangau area changing as a whole.

Severe droughts in Borneo are often associated with the El Niño phase of the El Niño Southern Oscillation (ENSO) (Harrison, 2001; Brodie *et al.*, 2012; Power *et al.*, 2013). While the ENSO phenomenon is probably at least 100,000 years old (Hughen *et al.*, 1999), there is growing evidence that the intensity and frequence of ENSO events have increased in recent decades, likely as a consequence of climate change (Salafsky, 1998; Hughen *et al.*, 1999; Harrison, 2001). In the context of the Sabangau this has particular relevance to the incidence of fire, with wildfires escalating with increased drought episodes (Harrison *et al.,* 2009; Marlier *et al.*, 2013; Brodie *et al.*, 2012). The increasing frequency and severity of fire in Indonesia is also linked to changing land cover and land use and therefore the complexity is even greater (e.g. Harrison *et al.,* 2009; Page and Hooijer, 2016). Climate change and increasing intensity and severity of ENSO events lead to another cascade of changes in the Sabangau area, including fire, resultant land degradation and negative impacts on fish habitats and human livelihoods. The issue of fire will be further elaborated on towards the end of this chapter (Section 8.2.2).

As discussed in Chapter 7.2.3, fishers in Sabangau have learnt to read and understand the environment in order to inform their own fishing practices. However, in both case study locations there were reports of the fish catches and the peak time of fishing recently becoming unpredictable (e.g. KB12F, interview, 25/01/16; TJ9M, interview, 18/02/16). This unpredictability could also be related to the changes in the fish assemblage caused by over-fishing, thus exact causes of unpredictability are difficult to untangle without long-term fish population data.

Participant TJ9M explained that an unpredictable environment was making it hard to calculate fish harvesting times:

> *"In the past 10 years, people can't predict environment, when harvest time. For this month, people can't predict."* (Interview, 18/02/2016)

Environmental unpredictability is therefore another example of a driver of insecurity in the Sabangau (Agarwala *et al.,* 2014; Schreer, 2016). Participant KB15M had a slightly different approach to this difficulty, emphasising that dealing with the (un)predictable is part of the skills required of fishing:

> *"The main challenge that fish and fishing faces in the area, apart from there being too many people is that the climate is changing. You cant't predict the weather. However this is the art of fishing."* (Interview, 26/01/2016)

He thereby stresses that as the climate and environment changes, so must the knowledge of a fisher adapt.

Additionally, the responses of fish species to climate change such as changing geographic ranges, along with environmental tipping points such as fish stock collapse, can have serious consequences for human wellbeing through the loss of provisioning and regulating services and livelihoods (Pinsky *et al.,* 2011; Pollnac and Poggie, 2008). In this way, the deterritorialising force of climate change has serious implications for both the human and nonhuman communities of the Sabangau. From this large-scale deterritorialising force of climate change, the following section now focusses on an example of a more local change, coming from national and provincial changes in laws and regulations that led to the formation of the Sebangau National Park, and the prohibition of logging in the area. This caused another chain of events that continues to have implications for the Sabangau area to this day.

8.1.3. Changes in laws and regulations: The logging example

As discussed in Chapter 4, legal logging concessions previously operated in Sabangau. While the creation of the Sebangau National Park in 2004 does not prevent people from accessing the area for fishing or harvesting of non-timber forest products, it does prevent them from legally harvesting timber (WWF, 2012). During the periods of legal logging, most villagers joined the logging operations, with few fishing at that time (KB11M, interview, 25/01/16). After concession logging was ended following the formation of the National Park, 90% of people in Kereng Bangkirai were dependent on logging for their main source of livelihood and income (Graham, 2013) and illegal logging continued in the immediate vicinity of Kereng Bangkirai until 2004. As law enforcement became more stringent, many were forced to stop illegally logging and move into fishing as a fall-back occupation (Graham, 2013). This experience was also found by Schreer (2016) for people in the lower Katingan (on the western side of the Sabangau Forest) and Medrilzam *et al.* (2014) for the ex-MRP area. As more people turned from logging to fishing, the pressures on the fish populations increased, as was supported by participants in both case study locations:

> *"In the past, nature was still good... That time people worked with logging in the forest, because the price was more than from fishing. Then the logging concession closed and people then people became fishermen...Now there are many fishermen so the number of fish are decreasing."* (KB10M, interview, 20/01/16)

> *"In 1995 logging was legal. Not as many people were fishing then. In 2001 logging stopped and therefore all people started fishing, and this has caused a large decrease in fish. Now there are a lot of people fishing."* (TJ11M, interview, 22/02/16)

Following Shreer (2016) and Medrilzam *et al.* (2014), this relationship between logging, law enforcement and intensified fishing pressures seems to be a common experience across the Sabangau area and likely even the wider Central Kalimantan Assemblage. This deterritorialising force is caused by national policies, as determined by the Indonesian Government, with a prominent involvement of international conservation organisations. This is an example of how assemblages can be structured through various power relations and resource control (Brenner *et al.*, 2011). In this case, the central government and conservation organisations are seen to be enforcing a change in the relation between the local communities and other elements of their assemblage, deterritorialising the assemblage.

Section 8.1.3.1 now discusses the responses of the human community to this cessation of most logging activities in the Sabangau due to a change of laws and regulations. This includes the perceptions of the local community towards those seen as controlling natural resources (government and NGOs), community experiences of 'logging nostalgia' and sensing a loss of control.

8.1.3.1. Response to the end of logging: human perceptions and nostalgia

The experience of legal and illegal logging coming to an end, and needing to find income elsewhere (predominantly in fishing) has implications for local community perceptions of this deterritorialisation, with many yearning for the "*time of prosperity*" of the logging years (Graham, 2013: 243). This leads to the 'logging nostalgia' that is experienced by human communities surrounding the Sabangau Forest as documented by both Graham (2013) and Schreer (2016). Logging nostalgia has increased the sense of a loss of control of natural resources, as well as resentment to those seen as controlling natural resources including the National Park authority, WWF and the Indonesian Government. The following is an excerpt from my diary concerning an informal discussion with a research participant:

> *"Talking about WWF, [he] is very clear about his opinion. He doesn't trust them and feels that their involvement with the community is false and they don't follow up on their promises. [He] talks about the local members who work with WWF as being corrupt and keeping any money meant for the community for themselves…[He] explains that many people are angry with the WWF"* (Pers. comm. with participant, 08/08/2014)

This negative perception towards WWF was also expressed by participant KB6F (interview, 18/01/16) who felt that the conservation organisation only gave limited job opportunities following the formation of the National Park. Participant KB4M expanded:

> *"I want people from CIMTROP and the government to support us more to have more opportunities and to have a good life… At the moment I don't feeling supported by these groups…The wellbeing of local people should be their priority…"* (Interview, 18/01/16)

This sentiment plays into and emboldens the Outsider Narrative with now the role of 'outsiders' being played by international and local conservation actors along with the Indonesian Government (see Table 8.1). This illustrates how the narrative is also changing with and through deterritorialising forces. With regards to the biocultural approach to conservation which I argue for in this thesis, the need to consider the Outsider Narrative is clear as it can determine the relationship between various stakeholders in or adjacent to a protected area. It is therefore important to understand how this narrative functions (as I described in Section 8.1.1.1), with the fluidity of what is considered an 'outsider' meaning that this narrative can become a potential barrier to any conservation actions that are enacted by the Government or other organisations. This is regardless of whether the conservation actions are being done by, arguably, 'local' people or not.

'Logging nostalgia' also has an impact on fishing practices, with fishers wanting to reach the same standard of income and living that they experienced in the past through logging. The only way to do this is to increase fishing effort and intensity through, for example, using nets with smaller mesh sizes, as participant KB9M explained:

> *"The cause of this decrease in the number of fish is that more people are fishing now and there are people who are catching the fish when they are still small and therefore cannot become big. Before they used nets with bigger holes."* (Interview, 10/01/16)

As discussed in Chapter 7.2.3., fishing methods change over time and technology. A changing narrative of 'appropriate' or 'allowed' fishing methods can lead to a territorialisation of fishing locations, with some methods coded as not being allowed in an area (such as electric fishing). The Outsider Narrative can act together with this territorialisation of fishing locations (e.g. Tanjung Taruna residents not allowed to fish in the Pusaka area), further contributing to a delineation of *who* is allowed to fish *where* using *which* methods. Territorialising forces can therefore act together and potentially amplify each other.

In conclusion, the banning of logging following designation of the Sebangau National Park is an example of how a change in coding (in this case, rules and regulations) has caused a deterritorialising force as it alters available income sources for local human communities. In this way, it changes the human communities' relationship to the forest and the fish resources. By switching to fishing as a main livelihood, the number of fishers has increased, and in turn this has led to greater pressures on the local fish populations. Fishing methods have also undergone intensification as people want to earn the same level of income as they did during the logging years. Fish populations are therefore further threatened, and as is easy to imagine, a negative feedback loop ensues. The past changes and deterritorialising experiences are thereby still impacting the assemblage today.

8.1.4. Introduced conservation objectives and projects: The damming example

As was seen with the creation of the National Park, any 'introduced' conservation or livelihood project can potentially be a deterritorialising force, as it will in one way or another alter certain relationships between and/or properties of the assemblage elements, sometimes with unintended or suprising consequences (see Polasky, 2006; Skogen, 2015; Larossa *et al.*, 2016; Lim *et al.*, 2017). Furthermore, if a project does not take into account local situations, it can have unforeseen implications for existing assemblages, causing tensions if it is perceived as negatively impacting communities' wellbeing (fuelled by and fuelling the Outsider Narrative). On the other hand, 'introduced' conservation and management actions can also have beneficial implications for the local community if local perceptions are listened to and respected, the role of the conservation action is clear and if there is a beneficial link made to improving community wellbeing, through effective biocultural conservation (e.g. Campos-Silva and Peres, 2016). I will explore these aspects further in the next example of a deterritorialising force: the building of dams by conservation organisations.

As previously described in Chapter 4, one of the main actions for peatland conservation in the area has been canal blocking through dam construction. Dams are built to slow down the water flow draining from the peatlands and to raise the water table, which is needed to reduce peat degradation and fire risk (Wösten *et al.,* 2008; Ritzema, *et al.,* 2014). The scientific community (e.g. BNF and other conservation scientists working in the Sabangau) is aware of the goals as well as the limitations of damming canals. However as I will illustrate, issues can arise when local communities are not aware of these, especially if dams are instead perceived as having negative impacts on local livelihoods. There are therefore issues here of knowledge (e.g. how dams work) and power (who is building the dams, and who this impacts). Section 8.1.4.1 will now discuss in greater detail the response, primarily of the human communities, to the deterritorialising force of dam construction in Taruna Jaya and Kereng Bangkirai.

8.1.4.1. Response to dam construction

Dams were reported to contribute to fish declines by both male and female participants, with all but three interviewees in Kereng Bangkirai viewing them unfavourably. The perception in both Kereng Bangkirai and Taruna Jaya is that during the wet season fish enter the canals and forest, and as the water levels decrease with the onset of the dry season, fish get stuck behind the dams and many die. To my knowledge there has been no collection of empirical evidence to support this. Regardless, dams are therefore seen by both male and female participants in both case study areas to be harming the fish populations and thereby local human livelihoods. As participant KB4M explained:

> *"The dam is not useful. When there are two dams, there are a lot of fish caught in between the dams. When the water level decreases in the dry season then many fish die. I heard this from people who saw it in a canal nearby. This is the effect of the dams – many fish die in the dry season. People say that dam is collect the water in the dry season, but in fact the water dries up, so I don't think the dams are useful."* (Interview, 18/01/16)

In Taruna Jaya, there were generally more positive responses to dams than in Kereng Bankgirai. In both locations, positive impacts reported by both male and female, Dayak and Banjar participants on fish and fishing included that dams make it easier to catch fish by trapping, they cause the area to flood more easily and to hold water and therefore can be helpful to prevent and fight fires. Male (Dayak and one Dayak/Banjar) participants in both locations explained that as they help to hold water, this also can create places for fish to breed and thrive as participant KB9M elaborated:

> *"If people place traps in the canals then it is easier to catch fish than in the rivers as the fish are more concentrated. Maybe with dams, the water in the forest is still there and then the fish can thrive in the forest. Because the dams, there are more than one, far into the forest. Maybe there in the forest they make small lakes and fish can breed there in the forest."* (Interview, 20/01/16)

In Taruna Jaya dams were occasionally seen as beneficial for agriculture by male participants (both Dayak and Banjar). Lastly, when working in the forest, e.g. hunting birds, another reported benefit by male and female participants (Dayak and Banjar) in both locations included that people can use dammed canals to drink from and to wash in. These results highlight again the heterogeneity of perceptions and experiences, but no significant difference between male and female participants or ethnicities was found.

Some participants did not know why dams had been built (e.g. KB2M) with the only participant, KB9M, who knew accurate and detailed rationale for dam building only having this knowledge due to his previous work with UPT LLG CIMTROP UPR on the damming project. UPT LLG CIMTROP UPR takes community involvement very seriously for its dam building projects, while other organisations which are operating in the Sabangau area are perceived as needing to improve their participatory approach, as Kris explained (24.11.2015; excerpt from field notebook):

> *"…Kris explained that community involvement was central to UPT LLG CIMTROP UPR's approach. He explained how the Patrol Team would use local people to build the dams. In this way, they can use the time building to explain he benefits and reasons behind the dams, while also involving those men in the building process (therefore, they are more likely to be protective of their work). These men then hopefully share what they learned with their friends and family. This is important to gain support from the local communities, as dam breakage is often caused by deliberate breaking by people. I asked if other organisations like WWF take this approach. He said no, they just come in with people, build the dams and leave."*

Saying this, according to WWF (2012: i), their damming project also had extensive community consultation and involvement:

> *"Communities, especially the fishermen who fish intensively in the area, were consulted on the design of dams… Communities are also involved in the construction and maintenance of dams."*

However, Christel (2015) also conducted interviews in Kereng Bangkirai regarding the experiences of dams, and found that while riverholders granted permission for the WWF dams to be built they were unaware of the potential impacts on the fish populations that might result, and were frustrated and disappointed as they perceived dams to be harming their primary source of income: fishing. Christel (2015) reports experiences of betrayal felt by villagers as they were promised that income generating activities would be introduced in the area, which never seemed to materialise. A perceived failure of one organisation to properly involve local communities may negatively impact local perceptions of damming projects as a whole, regardless of who is managing them. It needs to be kept in mind that with the CPT present (Kris and Karno), people may not have been willing to criticise UPT LLG CIMTROP UPR during our interviews. What this section does illustrate is how the Outsider Narrative has been shifted once more, framing WWF as the 'outsiders' due to perceptions of unequal power distribution.

There was also confusion surrounding the exact role of the dams. While participants from each village understood that dams were built to hold water, they were considered useless as they still dried up in the dry season (while the scientific community is aware that this will happen). Some participants furthermore felt that they were not useful, as if the canals were left they expected them to close naturally, i.e. there would be a build-up of soil and leaves that would cause the canals to close over time (e.g. KB2M and KB5M). Others thought they were built to fight fires, and again felt they were useless as the canals would not hold water in the dry season:

> "*last year they didn't help because of the distance of the dams to the fire. They are not useful because they are not big enough. In Bakung, when there was fire, people could take water from the dam. The dams from WWF are too small, they build many dams, but there was still fire. Even the tall trees caught on fire*." (KB10M; interview, 20/01/16)

The gap between expectations and reality of the functions of dams is causing disappointment, a sense that they are not working effectively, and perceptions of uselessness by both male and female participants in both case study locations. This can fuel distrust between conservation organisations and community members who are becoming wary of the motives behind dam building projects as was expressed by participant KB15M:

> *... Dams are built because of money – to take the money of these projects [he thinks that the people who build the dams, this is a way to keep money for themselves]. There are no benefits for people here [from dams] and for peatlands they are also not useful. For fires, you should use bores instead of dams to get water to fight them. You also need someone who keeps a better eye on fires. The water in the dams dries*

up in the dry season, therefore building dams for fires is not useful. (Interview, 26/01/16)

This represents a misunderstanding – i.e. that dams are built primarily for fighting fires (which the participant correctly identifies bores as being for) rather than to keep the peat wet and reduce fire risk through restoring the hydrological functioning of the peat-swamp. On the other hand, participant KB9M who had been involved in the UPT LLG CIMTROP UPR damming project, was very supportive of the dam project but also commented that there is some misunderstanding of why dams are built:

"*But sometimes people don't agree because the dams will bother them if they want to place fishing equipment there. Before, people therefore broke dams. Maybe more work from the government should explain to people why dams are built*" (Interview, 20/01/16)

This highlights the need for further participatory approaches, shared learning experiences and knowledge transfer to clarify the role of dams. It is clear that unmet expectations due to a lack of understanding can lead to resistance and distrust by villagers. This is also amplified by the Outsider Narrative and historical experiences (Chapter 8.1.1.1).

There are clear negative and positive perceptions about dams, with differences observed between Kereng Bangkirai and Taruna Jaya due to their locations, their experience with dams, and their expectations as to why dams were built. In both locations participants reported advantages and disadvantages, with the perceived negative impacts of dams for fish and fishing causing tensions that could have potentially significant implications for future dam projects: "*without the dams the forest is lost, but with the dams the fish is lost*" (KB13F; interview, 25/01/16). One of the main causes of dam breakage is by people (Morrogh-Bernard, 2011). I suggest that this will not change unless these negative perceptions which people have of the dams are taken seriously and dealt with appropriately through further involvement and discussion with local community members to clarify the role of dams for peatland restoration.

The relevance of dam construction to local livelihoods and wellbeing has to be a central focus. Local priorities need to be considered, and the trade-offs more carefully analysed with the involvement of the local community through participatory approaches. While this was clearly part of the approach attempted by both UPT LLG CIMTROP UPR and WWF, dams are are still perceived negatively, particularly in Kereng Bangkirai. This could be exacerbated by the experiences that the village has had in terms of the logging ban following establishment of the National Park, adding to existing perceptions of limited access to natural resources and problematic power dynamics. In addition to this, with evidence of the Outsider Narrative being more prominent in Kereng Bangkirai, the village is likely to be particularly sensitive to experiences and perceptions of a loss of control of resources and access. This also illustrates why historical experiences need to be considered when, especially 'outsider' researchers and projects, are introducing changes in the area.

8.1.5. Introduced conservation objectives and projects: The fish pond example

The construction of fish ponds is another example of an 'introduced' project. Fish ponds have been used in the past and are therefore already a part of the assemblage in the Sabangau. While these are considered more 'modern' ponds, they were designed by people who are arguably from the Sabangau (UPT LLG CIMTROP UPR and the Community Patrol Team). As discussed in Chapter 5, the fish pond (*beje*) pilot project was envisioned by UPT LLG CIMTROP UPR /BNF as a source of additional income for local villagers, as well as incentivising them to guard the area from fires and other harmful activities. The difference with the fish ponds and other examples given above is that they are more of a potential future deterritorialising force, rather than one that has already acted upon the assemblage. This section focuses on the potential future implications of fish ponds for the Sabangau area with an assessment of if/how they could be a deterritorialising force.

This study has already demonstrated that the majority of participants, both male and female, in both case study locations were interested in owning a fish pond as a means of fishing diversification. People perceive that fish ponds make it easier to catch fish, especially in the dry season once the fishing season on the river has largely passed (see Chapter 6). In Taruna Jaya, in particular, fish ponds are seen to provide additional benefits such as growing crops on the fish pond walls (e.g. TJ1F). One participant, TJ14M, already planted fruit such as mango, rambutan, orange, soursop and chilli along with local vegetables including peanuts and aubergines on the walls of his fish pond. These have been planted for personal consumption, but there is a potential for selling these later if the crops prove successful, providing another opportunity for income diversification. Fish ponds were also perceived to provide water during the dry season to fight fires and water crops (e.g. KB2F). Therefore, they are seen as having beneficial impacts on local livelihoods and for fire protection.

To provide greater information regarding the functioning of the fish ponds, the four fish ponds built on the edge of the Sabangau Forest were monitored, as outlined in Chapter 5. The fish were harvested in September 2015, and Appendix VII shows the summary fish data from each of the ponds including fish weight and standard length data. For the fish ponds to be a viable source of livelihood, they need to provide sufficient income compared to the costs of their construction and maintenance. Table 8.2 shows the total weight harvested of each of the species, the current estimated market value for each of these species (per kg), with the calculated total values for the catches across all fish ponds. No market value was available for *Macrognathus maculatus* as this is not a popular fish for consumption (e.g. being a *pali* species, as discussed in Chapter 7). The estimated market values are for December 2015 in Kereng Bangkirai. However, these prices can vary between the dry and wet seasons, with a wet season price likely to be an overestimation of the actual prices likely to occur at the time of fish pond harvesting (end of dry season).

Table 8.2: Total weight harvested for each species and their estimated current market value (all fish ponds combined).

	Total harvest (kg)	Current market price (IDR/kg)	Market value of fish caught (IDR)
Channa pleurophthalmus	9.763	(25,000)	244,075
Clarias sp.	1.066	(20,000)	21,320
Wallago leeri	4.594	(75,000)*	344,550
Channa micropeltes	33.80	(40,000)	1,352,000
Cyclocheilichthys janthochir	0.00158	(12,500)	19.75
Channa gachua	0.12272	(32,500)	3988.4
*Only if dried		**SUM**	**IDR 1,965,953.15**

The harvest from the four fish ponds had a total value of approximately IDR 1,965,953.15 which is equal to about GBP 121. Fish pond 1 contributed to approximately 65% of this value (see Appendix VII). This value of GBP 121 would take 119 years to break even with the costs of building the fish ponds (Chapter 4). Taking just the first fish pond closest to the river, this cost about GBP 3,515 to construct, and therefore would still take 46 years to break even. Given these figures, the economic viability of the fish ponds using current methods is questionable. However, comparing these results to the income derived from existing fish ponds in Taruna Jaya, which are smaller and simpler structures, provides a more positive assessment. Participant TJ16 has 3 fish ponds that can earn about USD 227 from harvests each year (these smaller fish ponds cost about USD 379-454 to build). The Taruna Jaya figures indicate a break-even in about two years and suggests that it would be worthwhile trialling the pilot project in Kereng Bangkirai again to improve the design and harvests, plus potentially decreasing construction costs, and therefore enhancing economic viability. Cost is therefore a significant barrier for the fish ponds to become a deterritorialising force in the Sabangau area.

A consideration of the fish catch data from the monthly monitoring also supports a retrial. These data were collected between February 2015 and the point of harvest in September 2015 and provide an indication that the low fish harvests could be due to the harvests happening too late in the year. The data indicate that there were more fish in the fish ponds a couple of months earlier (Figure 8.1), with peaks in fish catches occurring in June for ponds 2, 3 and 4 and in July for pond 1. This can be explained by pond 1 being the closest to the river and mirroring the July peak of the river catch trend (Chapter 7). Furthermore, by the time the harvests happened, the outer part of the fish ponds had dried up completely and any fish in these outer rings would have died and/or been eaten by scavengers (bird prints are visible in Figure 8.2). This suggests that the fish ponds were indeed harvested too late and that in any retrial, fish harvest should occur before water levels become too low. This would allow a more accurate idea of the economic viability of the fish ponds to be generated, and thereby the future use of the 'modern' fish ponds in the Sabangau area.

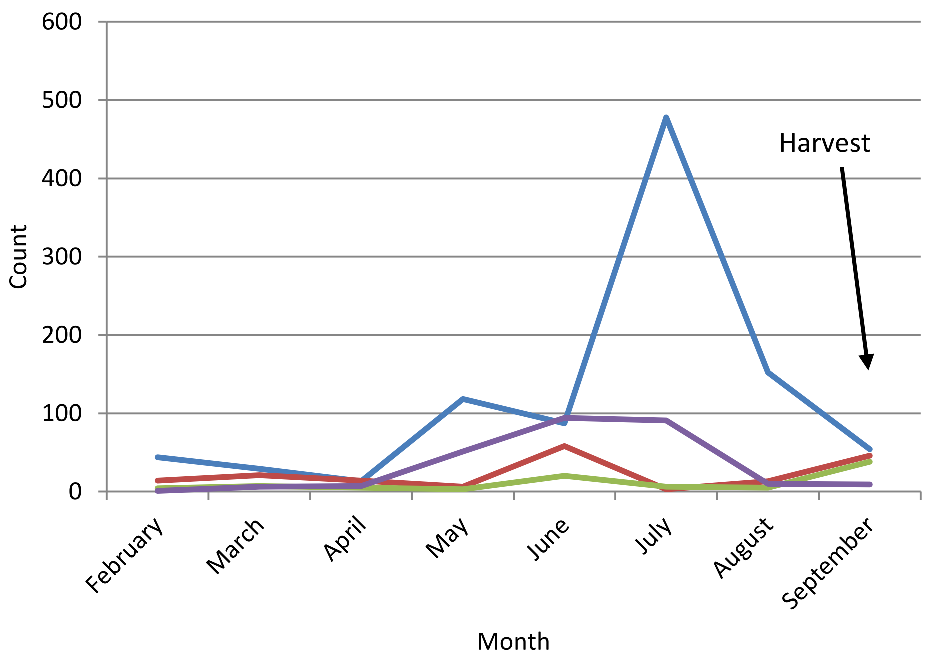


Figure 8.1: Number of fish trapped (count) in each fish pond between February 2015 to Harvest. Fish pond 1 (blue), 2 (red), 3 (green) and 4 (purple).

Figure 8.2: Outer rings of the fish ponds had dried up, with bird prints in the remaining mud. Photo taken in September 2015 during harvesting of the fish ponds.

From interviews and focus groups, several barriers to owning a fish pond were identified, which indicates that until these are resolved; fish ponds are unlikely to be a deterritorialising force in the future:

1. **High costs**: they are expensive to build and maintain. Cost was the most common reason that male and female respondents, in both case study locations, gave for not owning one already. (The cost of building the Sabangau fish ponds was predominantly funded by BNF). Further fish pond construction of the design as it stands would have to be funded by 'outside' organisations, and would not be affordable for local community members to fund themselves.
2. **Land**: some participants did not have suitable land on which to build a fish pond (e.g. KB14F, KB19F, TJ2F)
3. **Security issues:** participants reported several security issues with fish ponds, including that outsiders can enter them during the night and use poison to capture fish (e.g. TJ1F) and there are fears that crocodiles will enter the fish ponds:

   > "*Furthermore, other people can harvest from your beje before you have the chance to. Using beje has a risk. The fish can be taken before harvest time, because the location is far away from local residents so, it cannot be monitored*." (Male participant, Kereng Bangkirai, focus group, 02/08/15)

There are therefore still key barriers that need to be addressed before fish ponds can be a serious additional income option for villagers. Due to the high costs and the need for land to build the fish ponds, this would likely require investment and aid from external organisations or funding bodies (i.e. the government or NGOs). Only once these barriers are overcome would fish pond construction be a deterritorialising force on the assemblage in the Sabangau. However, if wide-scale fish pond construction were to occur, there are considerable impacts that are likely to occur. Section 8.1.5.1 will now consider some of these, including political and environmental responses.

8.1.5.1. Potential responses and implications to future wide-scale fish pond construction

If fish ponds were to be built on a larger scale in the Sabangau area, there are potential political and environmental responses that are likely to occur. Drawing on the experiences of the villager who has a fish pond in Taruna Jaya, there are potential local political implications for building these ponds. TJ4M found himself in conflict with local community members after his *beje* was built following UPT LLG CIMTROP UPR/Japanese collaboration:

> *"People always say inappropriate words to me about my beje. Losing trust is easy…I got protest from locals because my beje is narrowing their space in searching fish. People got angry because they have no land or money to build beje. The head of village called me because I never asked permission to build it. However this land belongs to me…I really understands why people forbid me, it's all about money…"* (Interview, 16/02/16)

There can therefore be significant social implications and responses following the introduction of fish ponds, further illustrating how these can be a deterritorialising force which can change not only the relationship between humans and fish, but also between human community members.

There are also potential negative environmental implications that need to be further addressed and researched, particularly concerning the current condition of the river and the likelihood that fish populations are experiencing overfishing. The fish ponds are stocked with fish from the river during the flooding of the wet season. The fish ponds are another form of fishing diversification and thereby their use could increase pressure on fish populations in the river. This is notable as according to some interview responses, harvesting would not be done selectively (KB1M, KB3M, TJ16F). Breeding in the fish ponds is also unlikely if using similar designs to the pilot ponds, as they dried up towards the end of the dry season (Figure 8.2). Fish are therefore unlikely to survive through the year and those trapped in the fish ponds are either harvested or eaten by nonhumans. This also makes it unlikely for the smaller fish to be caught and emptied from the ponds to reduce their impact on river stocks, especially as human community members are likely to eat anything they do trap. Despite their original design intentions as discussed in Chapter 5, by which it was hoped fish left over in ponds would re-mix and breed with river fish when water levels rose back up at the start of the wet season, in their current form fish ponds cannot play a role in the recovery of fish stocks. This is a critical issue to address in future fish pond design with a need to better understand the potential implications of fishponds should they become a deterritorialising force in the future.

The use of the IAA can thereby support the consideration of both past and potential future deterritorialising forces. Lastly, in light of the Outsider Narrative, any potential negative implications of the fish ponds on the fish populations in the Sabangau may have serious impacts on the perception that local community members have towards UPT LLG CIMTROP UPR/BNF. The fish ponds could be a new (or at least 'upgraded', recalling Chapter 5) fishing method in the Sabangau. However, this fishing method will only become part of the norm if it is suited to the properties and needs of the assemblage elements (i.e., the barriers as discussed in this section are overcome). Using an interdisciplinary approach can thereby allow a more holistic understanding of how an introduced livelihood project is likely to succeed, along with associated potential unforeseen implications (such as tensions caused by the Outsider Narrative) if the project were to negatively impact access to local 'natural resources'.

8.1.6. Conclusion on Deterritorialising Forces

This first part of Chapter 7 has focussed on providing examples of deterritorialising forces: each having its own impact on the assemblage, but also all linked to each other, and at times amplifying each other. These include changes in climate, population increases, changes in laws and the introduction of new projects or management approaches. They are not the only deterritorialising forces that have acted and continue to act on the Sabangau area; others include the building of canals and the drainage of peatlands, which have also changed the way human communities conduct traditional agriculture and other livelihood activities. I have also illustrated how these deterritorialising forces can produce territorialising forces in response. These territorialising forces have included narratives and characteristics which delineate the assemblage such as religion, occupation and ethnicity of people or communities (predominantly discussed in Chapter 6), with this chapter focusing on fishing methods and locations, as well as the 'Outsider Narrative'. The latter is particularly important in understanding local perpectives and reactions to deterritorialising events. However, these examples of territorialising and deterritorialising forces illustrate how complex and interacting changes in the assemblage can be discussed, analysed and better understood using the IAA. They further demonstrate some other important aspects that need to be considered when dealing with the Sabangau area, such as changing local identities and how historical experiences are likely still impacting on experiences of more recent and even future deterritorialising forces. An assemblage undergoes constant change, from within and from external deterritorialising forces. From the interactions occurring within the assemblage and following deterritorialising forces, emergent properties of the Sabangau area are established, as I will now explore.

8.2. Emergent Properties

The interactions between assemblage elements, both nonhuman and human, are shaped by their properties and capacities. In turn, it is resulting human-nonhuman relationships that lead to the emergent properties of the assemblage, which are also influenced by territorialising and deterritorialising forces, as previously discussed. A couple of examples of emergent properties of assemblages within the Sabangau area have already been given: the degree of 'closeness' of a human community (Chapter 7.2.1.) as well as the dissolved oxygen levels in the TPSF assemblage (Chapter 7.2.3.1.1). This section now focuses on the emergent properties of the wider Sabangau area: a) a fire-prone landscape, b) an overfishing-prone landscape and c) the resilience of the assemblage. These are emergent properties as they depend on the particular properties of the assemblage components as discussed in Chapter 6, the relationships between these components as discussed in Chapter 7, and as I will illustrate in the coming sections are distinct from deterritorialising or territorialising forces. They are properties that determine what the Sabangau is today, and why biocultural conservation is needed that is adaptive, open to complexity and appropriate to local contexts and historical experiences.

8.2.1. Fire-prone Assemblage

It is in the properties of the human communities; the (continued) use of fire due to occupations such as fishing and farming (Chapter 6), local perceptions and actions against or for fire (e.g. the enforcement of rules, as seen with fishing in Chapter 7), along with the properties of the nonhuman communities and elements (e.g. the specific properties of drained peatlands, seasonal changes in rainfall and drought events) that in combination lead to the emergent property of the Sabangau area being prone to fire. I illustrate this in Figure 8.3.

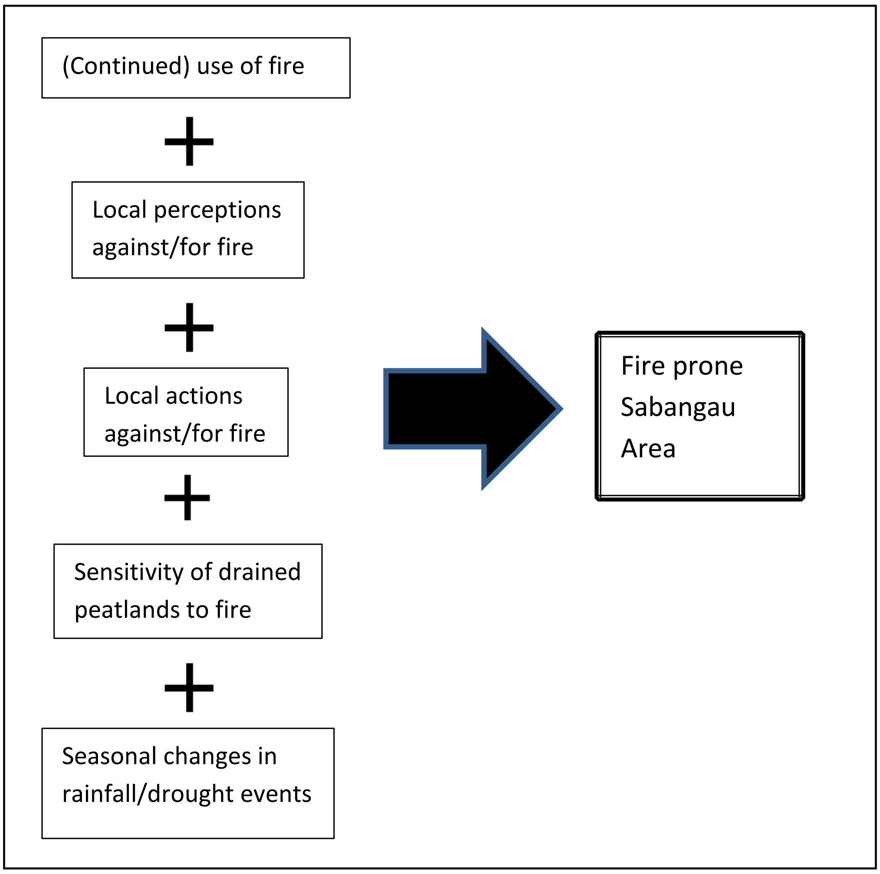


Figure 8.3: examples of how characteristics of the Sabangau area make it have the emergent property of being fire-prone

Deterritorialising forces such as transmigration, climate change and ENSO events further exacerbate the fire-prone nature of the assemblage. In both case study locations, fire was discussed as another main cause of fish declines in the Sabangau (e.g. KB9M, KB10M, KB11M, TJ1F, TJ4M, TJ10M, TJ12F, TJ13M, TJ17F, TJ20F) and as I will discuss in this section it can also be a deterritorialising force (e.g. changing soil and water properties). However, I do not see it as only a deterritorialising force, but part of something more complex and emergent from the assemblage. In this section I will further explain why I am considering the assemblage being fire-prone as an emergent property, along with the impacts which fire has on the human and fish communities in the Sabangau area.

As described in this section, the responsibility for those starting fires is highly contested, resulting in a 'chain of finger-pointing' (Cattau *et al.*, 2016). There is much evidence suggesting small- and medium-scale farmers outside of large concessions are the main contributors to fire (Marlier *et al.*, 2013; Cattau *et al.*, 2016). From the interview and focus group data, participants in both case study locations reported that fires were started both deliberately and accidentally (also supported by Cattau *et al.*, 2016). The most common accidental cause reported in both case study locations, by both male and female interviewees, was lit cigarettes being left on the ground and wind causing a small fire to grow and spread. This is supported by similar findings by Eriksen (2016).

As discussed in Chapter 4.1.3. slash and burn techniques have a long history in Southeast Asia (MacKinnon *et al.*, 1996), and the livelihoods of many small-scale farmers still use fire as the only affordable way to rapidly clear land (Cochrane, 2003; Rieley and Page, 2005; Page and Hooijer, 2016). The causes of fire are therefore numerous and multifaceted (see Cattau *et al.*, 2016). The CPT report fishermen setting fire to the *rasau* (*Pandanus* sp.) on the riverbank, as burnt tips and new shoots are believed to attract fish, while the thick build-up of *rasau* makes it harder to set fishing nets (BNF OuTrop, 2015: 5). This use of fire was reported in both Kereng Bangkirai and Taruna Jaya, by male and female participants (also supported by Graham, 2013).

> *"For fire, the main reasons which people use fire to clean the area: for access. They also use fire… to prepare the area for this [fishing] tool"* (KB6F, interview, 18/01/16)

> *"It happened by deliberate, when tourist fish… Because the rasau has many spines, and therefore they burn to open the area…They bake fish and leave it. They are cooking the fish and the fire spreads. Also for fishing in the night they need fire to keep the mosquitos away and then they leave the fire and it spreads"* (KB1M, interview, 15/01/16)

This aspect of fire use for fishing is important as – at least in Sabangau – it is clear that the fire issue is not only one of plantations and other forms of agriculture, but also one related to fishing and increasing access to fishing locations. Further research is needed to establish if this is as significant a source of fire in other areas, though this may be expected, given the high reliance of many rural forest-edge communities on fishing. Especially for the Sabangau area, with rivers on both side of the Sabangau Forest, this is of notable concern, as the fires started through fishing activities can spread into the forested areas as reported by two male participants in Kereng Bangkirai. The causes of fire are therefore numerous and multifaceted (see Cattau *et al.*, 2016) and also connected to fishing activities. This section has illustrated how occupations (e.g. fishing) play a role in the fire issue, laws play a role in the fire issue (through illustrating that land is in 'use', this is furthermore an example of coding), the properties of riverside vegetation (being spiny) play a role in the fire issue, and inter/intra-community conflict plays a role in the fire issue, etc. Therefore, assemblage element properties interact and lead to the emergent property of the Sabangau area being prone to fire.

Fires are often blamed on outsiders in both case study locations by both male and female participants, as was also found by Graham (2013) which further links to the Outsider Narrative. Participant TJ11M reported that fires are sometimes started by outsiders from other villages, and that most fires are started further away, and by the time they have spread nearby they are too large and local firefighters are unable to control them. He furthermore reported that the attitudes of those starting fires is another issue with people thinking "*this is just forest*" and they leave it – there is therefore an element of them not caring, as discussed in Chapter 7.1.2, and "*they don't think about the future*" (TJ1M, interview, 22/02/16). Participant KB4M echoed this perception of outsiders using fire as they are not impacted by the consequences:

> *"So the main cause is outsiders…There are some locations that they burn because that's the location of the fish…People from the outside do not realise that the location of the burning was the location where the fish stay. People from Palangka Raya who fish in the area don't realise that the fire will mean the fish is gone."* (Interview, 18/01/16)

Again, not all participants perceived outsiders to be the main cause of fires with, for example, participant KB20F saying that fires are caused by both locals and outsiders (Interview, 02/02/16). The Outsider Narrative is therefore not only relevant to fishing, conservation, and interactions with the government, but also to the fire issue in the Sabangau area.

The fires of 2015 were described by some participants as the worst they had ever seen. Fires and their resulting haze now occur during most dry seasons in lowland Central Kalimantan and have done so periodically since the 1980s (Wooster *et al.,* 2012; Field *et al.,* 2016). Fire causes severe negative health impacts locally with some human residents needing hospitalisation due to breathing problems and asthma caused by smoke inhalation and the resulting haze (e.g. TJ4M, TJ6F). Many houses in Kereng Bangkirai and all in Taruna Jaya are wooden structures, making it impossible to keep the smoke from entering inside the home. The haze forces villagers to stay at home, making them unable to work or attend school and thereby impacting incomes and livelihoods. Thereby, fishing activities can lead to fire with fire either enabling or completely inhibiting fishing activities (another example of downward causality where the assemblage begins to act on its components: the way in which the assemblage responds to the fire either enables or inhibits the human components of the assemblage to engage in fishing). Johnston *et al.* (2012) found that peat fire emissions contain a cocktail of carbonaceous volatile organic compounds such as benzene, formaldehyde etc. and small particulates, all of which are harmful to human health. Johnston *et al.* (2012) estimated that the inhalation of smoke haze particulates may lead to 110,000 additional deaths per year, particularly impacting children, the elderly and those with pre-existing conditions. Indeed, recent research on the impacts of the 2015 fires and haze suggests that 69 million people were exposed to unhealthy air quality conditions (Crippa *et al.,* 2016), resulting in an estimated 100,300 premature deaths across Indonesia, Malaysia and Singapore (Koplitz *et al.*, 2016). Peat smoke contains many carcinogenic gases including hydrogen cyanide, ammonia and benzene (Page and Hooijer, 2016), and as peat fires are now an annual occurrence in Central Kalimantan, the long-term health impacts of repeated exposure are likely incremental and severe. Fire therefore has serious negative implications for the health and overall wellbeing of human communities in and beyond Central Kalimantan. This emergent property, and the downward causality leads to the negative impacts on human communities as herein described, is thereby likely to continue to impact the Sabangau area for years to come.

Considering the impacts of fire on nonhuman communities, there is very sparse information on fire impacts on fish, and almost none related to TPSF fish. Temperate and some tropical studies have shown that intense fires can cause environmental responses such as decreased stream channel stability, and increased water discharge, turbidity from large sediment pulses and debris flow, and increased water temperatures which all may lead directly or indirectly to increased fish mortality (Rieman and Clayton, 1997; St-Onge and Magnan, 2000; Dunham *et al.*, 2003; Lyon and O'Connor, 2008;). The effects of fire on fish are highly dependent on a variety of factors such as their intensity, location, timing, and the characteristics of the aquatic and terrestrial ecosystems that are affected (Dunham *et al.,* 2003); i.e. the impacts of fire are dependent on the assemblage elements and their properties. Participants in both case study areas, both men and women, reported that fire causes a decrease in fish populations by opening up the forest and leading to a loss in fish habitat, feeding areas and breeding areas. Fires do cause a loss of riverside vegetation as seen along the upper reaches of the Sabangau in the fires of 2015, Figure 8.4. Thereby, fire can change the properties of the fish environment and thereby the assemblage.

Fire can cause direct fish mortality (reported by participants KB2M, TJ2F), but these cases have usually been in small isolated water-ways and impacting only small numbers of fish (Cushing and Olson, 1963; McMahon and de Calesta, 1990). In larger interconnected systems such as the Sabangau River, fish populations are likely more resilient to the effects of fire due to greater connectivity to other adjacent unburned streams and sites (Dunham, 2003). In concurrence, participants KB18F and KB19F said fire has no impact on fish, as fish can move away from the area and seek refuge under vegetation and in large holes in the peat left from fallen trees (Interviews, 01/03/16). The impacts of fire are therefore heterogeneous. This however likely only leads to short-term resilience, as any compression effects will eventually lead to negative impacts on fish populations.

Figure 8.4: Burning of the riverside vegetation during the 2015 fire season (left, photo by Marta Bina) and resulting post-burn condition (right)

There was a greater discussion of the indirect effects of fire on water quality and thereby fish health. Both male and female participants in both villages reported that fires cause water pollution from the ash that settles on the water with the water becoming 'poisoned' following fire and this furthermore causes fish to move away from the immediate area due to a decrease in water quality: "*The fish get "drunk" and they try to find a place where the water is still clean and therefore they move far from here*" (TJ13M; interview, 25/02/16). This is a deterritorialising force as it leads to geographic dispersion of the assemblage elements (as discussed in the introduction to this chapter).

Fires can also significantly increase sediment loads in peatland rivers following heavy rainfall, which would increase turbidity (Maltby, *et al.,* 1990; Brown *et al.,* 2015). As Chapter 6 illustrated, increased turbidity will have an impact on both fish and fishing with some authors identifying increased turbidity as the greatest threat to aquatic fauna (Beschta, 1990; Beaty, 1994; Rieman *et al.*, 1997; Benda *et al.*, 2003; Meyer and Pierce, 2003). However the data from this study showed no significant changes in water turbidity following the 2015 fires. This could be due to measurements being taken once there had been a significant amount of rainfall clearing the air of haze, which likely cleared the upper reaches of the Sabangau River of much of its sediment load. Indeed, Holden *et al.* (2012) found post-fire organic carbon loss occurs very rapidly after fire (within a few weeks), while Moore *et al.* (unpublished data) found an immediate post-fire enhancement of DOC losses from tropical peatlands. With carbon loss directly linked to sediment transport (Grieve and Gilvear, 2008; Shuttleworth *et al.*, 2014), it is likely that by the time the post-fire measurements were made in the wet season, the sediment loss, and thereby the increase in turbidity following the fire were no longer apparent.

The resilience of fish also depends on their habitat specificity and their life histories: species with more generalist habitat requirements should be more resilient along with those with simpler life histories that do not require multiple habitats (Rieman and Clayton, 1997; Dunham *et al.*, 2003). As seen in Chapter 5, some fish species are location specific. To better understand the impact of fire on fish in Sabangau and other TPSF areas, further research on fish life histories and habitat specificity is needed. This relates to their capacities to adapt to environmental change. Furthermore, effects of fire are likely to have greater impacts in smaller streams and rivers where the smaller volume of water reduces the ability of the system to absorb changes in water temperature and chemistry (Lyon and O'Connor, 2008). Following the information presented in Chapter 6 on the size of the waterbodies, the river is likely to be more resilient than the forest. The properties of the assemblages relate to the impact of the affect which, as an emergent property, can exercise an effect on the smaller-scale assemblages and their elements, through downward causality. Emergent properties themselves promote further change and potential de- and re-territorialisations.

Two participants (KB2M and KB19W, interviews, 15/01/16 and 02/02/16 respectively) commented on the taste of the water changing, becoming more sour and bitter after the fires. In concurrence, the water quality measurements indicated a decrease in the river pH from a pre-fire mean of 3.88 (n=100) to 3.20 (n=60) immediately after the fires (Figure 8.5). This pH change corresponds to an almost five-fold increase in acidity of the Sabangau River post-fire. This decrease in pH could be due to the fire damaging the soil structure and burning organic matter (Lyon and O'Connor, 2008; Brown *et al.*, 2014) leading to a release of organic acids and other low-pH substances (Page *et al.*, 2002; Holden *et al.*, 2012; Moore *et al.*, 2013; Jauhiainen *et al.*, 2016).

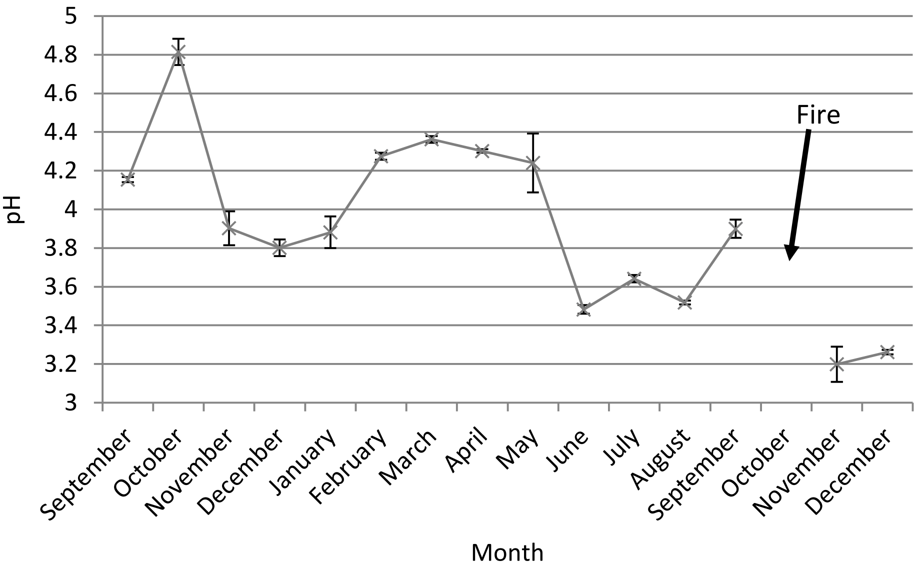


Figure 8.5: Average pH of the Sabagau River from September 2014 to December 2015, with error bars showing standard deviation

Thus fire is playing a deterritorialising role through changing the properties of the soil and the river which causes a decrease in the water pH. Likewise, after high precipitation events, it has been observed that the pH of temperate stream waters can decrease to as low as 3 as organic acids are flushed out of the peats (Rothwell *et al.,* 2005). A decrease in river pH is likely to cause changes in fish behaviour and potentially survival depending on their capacities, as pH changes affect the ion and acid-base regulatory mechanisms at the gills of fish as well as mucous secretion and gill structure (McDonald, 1983; Laurent and Perry, 1991; Kwong *et al.,* 2014). There was a corresponding decrease in fish CPUE from 18.21 to 4.02

after the fires, which is in agreement with reports that post-fire fish catches were extremely poor for many fishers in the Sabangau River (pers. comm., Dudin, 14/12/2015). Huan (2015) also writes that following the fires there could be an increase in the acidity of rainwater across South-east Asia and Borneo (caused by dissolved carbon-based particles from the smoke haze), which could be a further reason for the drop in the surface water of the river (also supported by Crutzen and Andreae, 1990). Further research is needed to understand the exact mechanisms behind the pH decrease, but the available evidence strongly suggests that post-fire increases in river acidity negatively impact local fish catches, which in turn will have negative implications for human livelihoods and wellbeing.

When discussing the impacts of fire with the human communities, it was notable that there was no complete consensus that fire was wholly negative for fish. Participant TJ14M said that fire was positive for fish as fire will open up spawning areas (interview, 25/02/16). Others said there was no impact of fire on water quality (e.g. TJ2F and TJ6M; interviews, 11/02/16 and 16/02/16 respectively), and therefore no negative consequences for fish. Due to higher water temperatures, participants (TJ5F, TJ7M; interviews, 16/02/16) also reported that fire causes fish to spawn earlier, leading to increased fish catches and earlier harvests. This was seen as both a positive for fish catches but a negative for fish populations. Impacts of fire (as a deterritorialising force) can be difficult to predict and can vary over time (see Rieman and Clayton, 1997; Gresswell, 1999) which also likely leads to the heterogeneity of human perceptions of fire impacts on the fish populations in the Sabangau.

When considering the IAA, I illustrate here how fire is a deterritorialising force. However, the wider issue of the assemblage being fire-prone is an emergent property. Viewing it through this lens allows for a more nuanced understanding of how the assemblage is functioning and the complexity of the fire issue. It is only through an understanding of this complexity that realistic solutions can be built using biocultural approaches to conservation.

8.2.2. Overfishing-prone Assemblage

Just as fire can be a deterritorialising force, yet understanding the assemblage as having the emergent property of being fire-prone allows for a more complex view of the situation, so fish declines are another deterritorialising force, but with the assemblage as a whole also having the emergent property of being overfishing-prone. This allows, once more, for helpful analysis and a more nuanced understanding of the situation. It also explains why the solutions to the fish declines, like the fire problem, are not straightforward or simple in the Sabangau area and I will explain why the assemblage has this emergent property in the coming paragraphs.

There are not only short-term or seasonal changes in the numbers and catches of fish (as described in Chapter 7). From the interview and focus group data, participants reported long-term fish declines which is in line with previous studies. For example, Lyons (2003) reported that 80% of those fishing in Sabangau reported a decline in their harvests over the previous 10 year period, and 99% of all the respondents reported a decline in fish size within individual species caught, with large fish being caught less frequently. Christel (2015) reported that all fishermen interviewed in Kereng Bangkirai said there was a decrease in their fishing yields over the past 10 years, and Schreer (2016) writes that discussions with elders revealed that local fish stocks in Katingan had drastically declined over the last three decades and were expected to continue to decline in the future. This section now outlines some of the likely causes for the Sabangau being prone to and experiencing overfishing.

In both village locations, decreases in fish catches were attributed to there being more people fishing:

> "*The number of fish has decreased. In the past the size of the fish were larger. Now many people are catching them and therefore the size has decreased*" (TJ5F; interview, 16/02/16)

Schreer (2016) also found that the declining fish stocks in the Katingan was due to a combination of water pollution, forest degradation and habitat loss, as well as overexploitation and unsustainable fishing practices. Market prices and volumes can effectively be used to indicate wildlife declines, with increasing market prices and declining volumes indicative of severely declining species (Harris *et al.*, 2015). In the past, fishing for one day would reportedly yield catches of 5-10 kg of fish during the dry season (TJ18F, interview, 01/03/16). Now, using the same method during the same time of year, TJ18F only harvested 1 kg of fish. KB10M also explained how in the past even 10,000 kg of fish was 'easy' to catch, while now just reaching 10 kg is difficult with fish prices also increasing:

> *"In the past the price of fish was low because there were so many fish. Now the price is high because the number of fish has decreased in the river. For example, Kapar, now you can get IDR 40,000/kg. Before you would get IDR 10,000/kg. This was only 4-5 years ago."* (KB10M; interview, 20/01/16)

While almost all interviewees reported a decrease in the number of fish they were catching, this perception of declining fish catches was certainly not homogeneous across all fishers. Taking the questionnaire results, out of 50 fishers participating, 26 fishers perceived that fish catches had remained constant (compared to 21 who reported a decrease in catches). This is statistically not significant (X^2=0.53, n=50, df= 1, p=0.47). It is also curious in comparison with the 40 fishers interviewed, where almost all reported a decrease in fish catches, a conclusion further supported by Lyons (2003), Graham (2013), Christel (2015) and Schreer (2016). When comparing the questionnaire results to age, gender and fishing experience (amount of years of fishing experience), this study was unable to clarify potential reasons for this irregularity. This highlights that not all villagers perceive a decrease in fish catches, whilst on the whole the majority of the participants in this study, if one includes the in-depth interviews, do perceive a decrease in fish catches. This illustrates the heterogeneity of fishing experiences in the Sabangau, and further research targeting the reasons behind this difference in experience would be valuable.

Despite this heterogeneous response, overall, it does appear that a decrease in fish populations has led to decreasing and less reliable catches, which in turn is causing a decrease in the security of fishers who depend on fishing for their livelihoods. McCay (1978) writes of two adaptive strategies which fishers use to cope with this decrease in security, and which were also observed in the Sabangau: fishing diversification and intensification. Ultimately, if fishing intensification and diversification fail to re-equilibrate the system, people will be forced to change occupation and even leave the area (McCay, 1978), or switch to using electricity or poison. Changing methods are also part of the fishers' strategies to cope with a changing and unpredictable environment, as discussed in Chapter 7.2.3.

Due to their higher dependence on fishing, electric fishing is considered common in Taruna Jaya (as discussed in Chapter 7.2.1.), and was reported as another of the main causes of fish declines. People are aware that poison and electricity methods are harmful and are causing increased pressure on the fish populations, especially compared to more traditional fishing techniques: "*If you use tampirai then the number of fish would not change. But you don't catch much. With poison, you can catch many fish but the populations are impacted.*" (TJ20F, interview, 01/03/16). Despite knowing the consequences, these harmful methods are still in continued use. Participant KB9M explained the situation saying that people fish at this increased intensity because they need income (interview, 20/01/16). If they find manual methods are not working as well, they will switch to using electricity. However, this in turn causes fish populations to decrease, and therefore there is a negative feedback loop:

> "*You have to think about the future, not just think about your needs. The people have their own reasons. They also need other job options which are still related with fishing but not using electricity*." (KB9M, interview, 20/01/16)

Intensification in fishing includes using a greater amount of fishing traps or nets (increasing fishing effort), and catching a larger variety of fish and fish sizes by changing trap and net design as discussed in Chapter 7.2.3 and 8.1.3.1. There has been a decrease in the selectivity of fish sizes in Sabangau, where both local community members and outsiders are harvesting smaller fish (partly due to ‘logging nostalgia’ as well as decreasing fish populations), as participant KB3 explained:

> “*In the past you wouldn’t do that, but now you have to take what you get and people don’t think as much about the ecosystem. People are also using nets with smaller holes in it, and therefore they catch the smaller fish…People just think how to catch fish as many as they can. It doesn’t matter how the impact will happen.*” (Interview, 18/01/16)

This was also found by Schreer (2016) who writes that compared to the past, fishermen in Katingan now own more equipment, including nets with smaller mesh size to deal with declining yields through also targeting smaller fish. In this way, ‘ecosystem overfishing’, is indeed likely occurring as the fish community assemblage is fished down as mentioned in Chapter 6.3.3 (Allan *et al.*, 2005).

Regardless of knowing that increased intensity and diversification of fishing is causing further declines in fish populations, which in turn require even higher efforts to catch the same amount of fish, people are driven to race for the declining resources for short-term income gains. This leads to what Hardin (1968) first termed as the “*tragedy of the commons*”. In Taruna Jaya this furthermore leads to the response of territorialising fishing locations between the Pusaka and Tanjung Taruna residents (seen with the limiting of Tanjung Taruna fishing in the Pusaka area), as previously discussed in Chapter 7.2.1. While there are rules for fishing (Chapter 7.2.1), they are not succeeding in protecting fish stocks due to the multitude of deterritorialising forces, and the complex emergent properties that are now determining the assemblage and its functioning. Fish declines will likely continue unless new coordinated management strategies that follow biocultural approaches to fish conservation are introduced or the fish stocks experience a complete collapse. Only further long-term monitoring of the fish populations, using methods such as those proposed and used herein, will allow for effective monitoring to determine any potential future fisheries collapse in the Sabangau area.

While fishers can have strong views and opinions regarding conservation and the need for environmental protection, this does not mean they put these into practice (McGoodwin, 2001: 40). Furthermore, local knowledge does not necessarily lead to sustainable fishing practices. Most small-scale fisher's knowledge is concerned with helping them to catch fish, rather than constraining fishing effort (McGoodwin, 2001). An intimate knowledge of fish behaviour, along with changing value systems and resource situations may actually be detrimental to sustainable resource management, as Santha (2008: 432) gives an example:

> *"…fishermen in this village are proficient in recognising fish movements and habitat characteristics. However, with mounting resource scarcity…active fishermen and young people have resorted to using herbal poisons and chemicals such as copper sulphate for catching fish."*

Potential reasons for why previously sustainable fishing actions become unsustainable include external influences such as the introduction of modern and more intensive fishing techniques and increases in human populations which I have shown to deterritorialise and destabilise the assemblage. The traditional means of community-based management strategies that perhaps used to control overfishing under former levels of human populations, such as limiting access to fishing spaces, etiquette and observation of ritual behaviour and taboos (McGoodwin, 2001; and as discussed in Chapter 7) are now failing in the Sabangau. As I previously mentioned, they are unable to keep the assemblage territorialised against large and powerful deterritorialising forces such as climate change and increasing human populations, changing laws, changing occupations, an increasing frequency and continued use of fire.

Overall, it is clear that these deterritorialising forces are increasing pressures on fish(ing) populations (supported by Schreer, 2016). Along with other potential deterritorialising forces such as dam construction, fish ponds, plus fishers' reactions to fishing declines such as intensification and diversification, Sabangau emerges as an overfishing-prone assemblage. The problem persists as, due to a multitude of factors, fishers' 'choices' are being made primarily based upon considerations of their own short-term wellbeing, desires and survival. This is due to issues of resilience and flexibility (such as diversification of income activities in Chapter 6.1.4) that a consequence of historic events including transmigration, past environmental degradation (e.g. MRP) and poor access to markets and other souces of income. Taruna Jaya and Kereng Bangkirai are going through different experiences when it comes to finding alternative jobs or moving out of the area, with Taruna Jaya experiencing a lower employment potential beyond the present main occupation of fishing (as discussed in Chapters 5 and 6; Lyons, 2003). This aspect of flexibility and resilience is further discussed in the following section, 8.2.3.

8.2.3. Assemblage resilience

As discussed in Chapter 3, the UK National Ecosystem Assessment (NEA; 2012) described ecosystems having emergent properties and used ecosystem resilience as an example. To reiterate from Section 3.2.4, resilience refers to the ability of a system to "*withstand or to recover from a stress or perturbation and adapt to future stresses and perturbations*" (Tuler *et al.*, 2008: 173). For the Sabangau area, adapting to a fire-prone and over-fishing prone landscape in the face of deterritorialising forces is necessary for the wellbeing of the human and nonhuman communities. The ability of the assemblage to withstand or recover from stresses from deterritorialising forces depends on the capacities and interactions between assemblage elements. The communities in the Sabangau, if fishing intensification and diversification fail to support them, have the choice of a) finding other income sources, and if this fails, b) moving to where there are other job opportunities (at which point the community assemblage is threatened with dissipation if all community members leave). A resilient assemblage can be a highly territorialised one (e.g. a close-knit community that helps each other in times of stress), or alternatively one which undergoes deterritorialisation but not to the point of the assemblage falling apart, as it is composed of elements with capacities that allow them to successfully adapt to a perturbation (e.g. fish species that are capable of adapting to higher water temperatures in the face of climate change).

In Kereng Bankirai, the majority of participants, both men and women, reported that while it is necessary for fishers to in general have side jobs, there were good work opportunities in the area, although many of them still said that they hoped for more work opportunities to be created. Tourism was often mentioned, with some participants hopeful that this would increase job opportunities and improve local economies (e.g. KB8F, KB10M). Women wanted more job opportunities based on 'home industry'; making things such as roofing materials, handicrafts such as rattan bags and mats or cooking (e.g. KB11M). Thus, there are potentially differing needs and desires between genders for additional livelihood options. Another occupation which people in Kereng Bangkirai hope to diversify into is farming, but serious barriers include not having the land to farm, and it being too costly for villagers to purchase land as participant KB2M explained:

> *"The future is very difficult because I would like to farm... I want to plant fruit, vegetables and rubber and rice for example. I don't have the land to do this though. There is no long-term job that is good...For the future I therefore want to farm, if I have the money. But I need money to buy the land for farming"* (Interview, 15/01/2016)

Side jobs such as *jelutong* (*Dyera polyphylla*) collection, bat and pig hunting used to be notable in Kereng Bangkirai in the past, but seem to have declined in recent years (comparing Lyons, 2003 with Graham, 2013; pers. comm. Harrison, 2017). One side job that is gaining popularity in the area is bird trapping. This is illegal for nationally protected species and is prohibited in areas such as the National Park and therefore many participants were likely to not want to discuss this. Some did though, which allowed insight into this occupation.

For decades, Indonesians and in particular Javanese have kept birds as a status symbol and a signifier of peace of mind and a balanced life (Jepson and Ladle, 2009; Jacobson, 2015). In Indonesia, at least 300 bird species are traded, and 22% of households own pet birds (Harris *et al.*, 2015). In the Sabangau area, there has been an increase in the past few years in bird trafficking in and around the Sabangau Forest (Christel, 2015). Sellers can earn between IDR 200,000 (GBP 12) (female) and IDR 400,000 (GBP 24) (male) for a single bird. Popular species in Sabangau are the lesser green leafbird (*Chloropsis cyanopogon*), *cucak hijau* (as mentioned in Chapter 6) and white rumped shama, *burung murai* (Christel, 2015). As Christel (2015) reports, I found that those reporting to be involved in bird hunting were also fishers who switch trades between seasons, such as participant KB3M and KB9M explained:

> *"Now I also work as a bird hunter in the Sabangau because the cost of my nets are very high…I earn as much from the bird hunting as I do from fishing…I switch between the jobs, sometimes I work as a fisherman, sometimes as a bird hunter. It depends on the season"* (KB3M, interview, 18/01/2016)

> "*Because of the number of decreasing fish, fishermen change their professions to builders and other jobs…There is also palm oil, bird hunting… there is a motivation to hunt for birds, there is income there. This is because the income from fishing is not certain*" (KB9M, interview, 20/01/2016)

Bird hunters reported a decrease in bird catches in recent years due to birds "*having become aware of humans as a threat*" (Christel, 2015: 9; pers. comm. CPT member, 22/03/2015), illustrating the agency of these nonhumans with the birds modulating their behaviour following an awareness of being hunted. As a response, some hunters therefore have started venturing further into the Katingan area (Christel, 2015). A decline in forest bird populations is a previously unforeseen consequence of fish population declines and illustrates how the IAA can elucidate previously obscured relationships and chain of events.

Chapters 6 and 7 illustrated the importance of side-jobs and job opportunities in the Sabangau. Taruna Jaya faces lower opportunities in terms of access to education and job opportunities and therefore in Taruna Jaya only 9 of the 20 participants (male and female) reported that they had side jobs. Only six participants out of 20 (both male and female) reported that there were 'good work opportunities' but these were always considered limited (compared to 17 out of 20 participants in Kereng Bangkirai reporting that there were good work opportunities). All others perceived the work opportunities to be poor in the area with there being few other options apart from fishing (Chapter 6). Furthermore, the current population in Taruna Jaya is facing noticibly scarcer resources and therefore, as described in Section 8.1.1, villagers are beginning to consider moving closer to Palangka Raya. In this over-fishing prone assemblage, the lack of sufficient alternative side jobs increases the insecurity of fishers in the area and makes it more likely that they may have to leave the village in search of other jobs. This threatens the resilience of Taruna Jaya Assemblage.

Another important aspect in the ability to adapt to environmental changes, is poverty. As I discussed in Section 7.1.1, there is a high expenditure on food in the Sabangau area, which suggests high local poverty levels. Supporting this, in their study of villages in the ex-MRP area (where Taruna Jaya is located), Medrilzam *et al.* (2014) found that almost 50% of the population live below the international poverty line (citing unpublished KFCP data, 2009). Furthermore, while forest degradation and canal construction in the ex-MRP had opened up land for use by local communities, Medrilzam *et al.* (2014) found that the improved land access was not enough to compensate for the loss of the original livelihoods that were in place before the MRP (traditional farming practices such as shifting cultivation and rubber collection). The authors write that this has led to increased poverty, which in turn increases the likelihood of the community engaging in illegal fishing and gold mining, as was observed in Taruna Jaya. Poverty is therefore linked to environmental degradation through the 'downward spiral' theory between poverty and environment (Medrilzam *et al.,* 2014). As Medrilzam (2014) discusses in terms of the ex-MRP project, poverty leads to communities pursuing short-term gains regardless of the impacts these have on the environment. I have reported similar findings in this thesis with regards to the prolific and unchallenged use of harmful fishing methods in Taruna Jaya (Sections 7.2.1, 8.1.1. and 8.1.1.1). This 'immediate return society', along with the sense of insecurity and lack of job opportunities leads to communities taking advantage of any opportunity to earn more income, and thereby promotes a fire-prone and over-fishing prone environment. This symptomises a non-resilient assemblage and illustrates how the properties of components of the assemblage (i.e. poverty levels) in turn determine the relationship between other properties (i.e. downward spiral between poverty and environment) which likewise determines the emergent unresilient properties of the Sabangau area.

Poverty also causes increased vulnerability to climate change, with it being the vulnerable members of society who face the greatest barriers to adapting to environmental changes. These vulnerable members of society include those living under the poverty line and who depend on natural resources such as fishing because they have few alternative income sources (Daw *et al.,* 2009) such as in Taruna Jaya. Poverty can be directly related to marginalisation and lack of access to resources, which is critical when faced with environmental changes and risks that threaten livelihoods (Adger and McKelly, 1999). Poverty can affect the ability of people to cope with and recover from extreme events (deterritorialising forces) by constraining opportunities (Adger and McKelly, 1999). Therefore, along with education and available job opportunities (Chapter 6), poverty is a key consideration for the resilience in Sabangau. All of these properties lead to Taruna Jaya facing particularly difficult circumstances compared to Kereng Bangkirai.

As Chapter 7.2.1 already argued, Taruna Jaya shows signs of being a less territorialised assemblage than Kereng Bangkirai, and there are indications that the resilience of this community is also lower. External government support, rather than internal community support, is therefore seen by male and female participants in both case study locations as the key to not only improving local livelihoods through training, and financial aid for fishing and farming, but also to protect the environment, to stop fire and stop the use of electric fishing. In other words, to counter the emergent unresilient properties of the Sabangau area and to promote its resilience. This hope, and expectation for government help and intervention was expressed more in Taruna Jaya during interviews (16 out of 20 participants), than in Kereng Bangkirai (5 out of 20 participants), and the narrative was illustrated by participants TJ7M and TJ8M.

> *"The government needs to help with funds and training. But still I hope for breeding animals and beje. The government help should be targeting animal breeding and bejes, by teaching people how to do this and this focusses on local incomes."* (TJ7M, interview, 16/02/2016)

> *"I don't know who starts the fires and why. Burning land is not good because of the negative health impacts… The solutions to the fire is that the government should make a team to keep an eye for fires, guard and prevent them."* (TJ8M, interview, 18/02/2016)

Once more, the two case study locations are having very different experiences, likewise with the level of resilience in the face of changing 'environments' and other deterritorialising forces. Furthermore, the residents of Taruna Jaya are expressing that they predominantly view the Government as being responsible for initiating positive change. They do not view themselves as having the power to do so. However, instead of seeing the 'other' as negatively impacting them (as with the Outsider Narrative), residents in Taruna Jaya now view the 'other' as their only hope for improved lives.

Understanding the properties and capacities of fish communities is vital, particularly in TPSF environments where species are likely confined to small niches and are thereby habitat specific. Certain species may be temperature sensitive and less able to adapt; increasing their susceptibility to deterritorialising forces including climate change and changing water temperatures. Changing water temperatures will also impact the amount of oxygen that the water can hold, and being already a low-oxygen environment, fish species may face increased stress in blackwater environments. Considering the river fish catches (average monthly CPUE), species such as *Leiocassis micropogon* had a negative correlation with maximum temperature (r_s= -0.792, n=13, p=0.001) and *Kryptopterus sp.* had a negative correlation with average temperature (r_s:-0.588, n=13, p=0.035,). This could suggest that these species are sensitive to increasing temperatures, which relates to their capacities and resilience to environmental change.

Furthermore, the TPSF habitat as a whole is facing increasing and continued risks. For the forest-specific fish species (Chapter 6), forest loss through conversion to oil-palm and timber plantations and other agricultural uses will likely lead to the loss of these species (Giam *et al.*, 2012). Likewise, for the river-specific species, further changes in the river water quality through pollution and the building of canals, and consequent disruption of river sediments, is also expected to have severe negative consequences (Giam *et al.*, 2012). The threats are not isolated just as the assemblages are not isolated, with any change in forest health likely also impacting the river fish species (see Chapter 6). Further peatland drainage, coupled with increased occurrence of strong ENSO events associated with global climate change, is likely to impact the hydrology of the forest. As I reported in Section 7.2.3, there were correlations between fish catches and water depth in the forest, with water depth in turn impacting water flow and thereby dissolved oxygen levels. These deterritorialising forces are likely to have negative implications for the fish species of Sabangau, and further research on their potential to tolerate or adapt to these changes is needed (Giam *et al.*, 2012). This has implications for the fish assemblages, and through the entanglement of the human-fish assemblages this will also impact the Sabangau area as a whole.

In this way, the resilience of the Sabangau area can be seen as being constituted of the capacity of the fish and human assemblages to adapt to certain forces. If these smaller assemblages are unable to adapt, they may cease to exist or change so dramatically that the wider assemblage of the Sabangau area itself will become increasingly unrecognisable as a tipping point occurs (see Chapter 3.2.4).

8.3. Chapter conclusion

This chapter illustrates how the IAA can be used to examine deterritorialising forces that have and continue to act on the Sabangau area, with the IAA allowing me to consider some of the important emergent properties that characterise the assemblage as a whole. The IAA used in this thesis provides the space for both human and nonhuman communities and their interactions to be considered, and the discussion in this chapter provides a few examples of the complex interconnected forces and reactions that these communities are experiencing.

This chapter has again highlighted the heterogeneity of experiences between and within case study locations: not all participants perceived fire as being negative for fish populations, not all perceived outsiders as being the only cause of fire, not all perceived the fish populations as decreasing or outsiders as the only ones using electric fishing. This illustrates the complexity of the system, but also illustrates that the IAA can deal with this complexity and allows for its consideration in order to provide a more realistic, a more holistic appreciation of the assemblage.

To conclude, for human communities, a sense of security is vital for social life and wellbeing, and intensification and diversification of fishing methods can occur in response to a lack of secturity. This was also found by Eriksen (2016) who writes that the adaptations seen with fishing methods as well as income diversification illustrate a way of trying to regain a sense of security in a continuously changing environment over which local human communities feel they have little or no control. Fishing intensification, diversification, as well as income diversification and the ability to achieve these (considering obstacles of poverty, and potentially exacerbating deterritorialising factors such as climate change), determine the resilience of the human communities in the Sabangau area. Because the human and fish community assemblages are intertwined, the reactions of the human community to deterritorialising forces will also impact the fish communities. In combination, increased frequency and intensity of ENSO events and the negative implications of these for the wider assemblage across Central Kalimantan, continued use of fire in peat landscapes and the geographic specificity of fish species, have the potential for severe impacts on TPSF fish extinctions and thereby the wellbeing and livelihoods of local human communities. Both short- and long-term changes in climate have direct implications for social and ecological resilience which determines the stability of these assemblages. The respective capacities of the human and fish communities to adapt not only to deterritorialising forces but also to each other will determine their long-term resilience. This is why it is vital to understand the complexity of the Sabangau area, the complex interwined relations, and how these change with shifting and dynamic environments. Only then is it possible to anticipate the consequences of current and future environmental and social changes and to plan more effective and appropriate biocultural approaches to conservation in the region.

CHAPTER 9

Conclusions, future directions and recommendations

While the links between human health and a thriving environment have long been known, it is also clear that finding solutions to environmental problems is frequently challenging, due to the complexity of 'socio-ecological' systems (SES). In this thesis, I laid out the argument that complex human motivations need to be considered and assessed in order to understand environmental degradation, and furthermore outlined some of the critiques and shortfalls of the Ecosystem Service (ES) paradigm and the economic valuation of ES (see Chapter 2). I furthermore argued for the need for interdisciplinary approaches to conservation, as a way to better understand the SES's that we are dealing with which requires approaches from both the 'social' and 'natural' sciences. But this has often been easier said than done, with interdisciplinary approaches facing multiple barriers, including those of language, disciplinary divides within academia and a difficulty in publishing.

In recognition of this, I explicitly avoided separating the 'social' and 'ecological' between chapters, which necessitated a novel framework to bring these together and challenge their dichotomy. The proposed framework, which I called an Interdisciplinary Assemblage Approach (IAA), took five main theoretical steps:

1. Marrying DeLandian Assemblage Theory (AT) and ecological understandings of 'assemblages', highlighting their commonalities and differences.
2. Widening ecological assemblage thinking through Step 1 to allow not only communities of organisms, but also individuals to be considered as assemblages.

3. Taking DeLandian AT and drawing on More-than-Human Geography (MTHG) approaches to challenge the nature-culture dichotomy perpetuated through the DeLanda's language.
4. Tackling the anthropocentricity of the ES approach by drawing on MTHG approaches to better include nonhuman elements in the assemblage. This eventually led me to discard the vocabulary of the ES approach and replace it with that of the IAA.
5. Taking a more progressive interdisciplinary approach that considers experiences of interdisciplinarity within oneself, including within myself as a researcher through challenging personal beliefs and biases, plus considering different worldviews and knowledges. This determined the research methods and approaches. The IAA framework allowed me to report information resulting from various forms of knowledges and without any hierarchy imposed on these.

I then used my within-individual approach to interdisciplinarity and my proposed IAA to structure an analysis of the assemblage and how it functions (Fig 1.1. in Chapter 1). This then allows me to answer my three research questions:

1. How do we develop an approach to interdisciplinarity that challenges biases from within and accepts different worldviews and knowledge systems?
2. Can assemblage theory provide a non-dualistic way of understanding people-environmental relations, thereby avoiding some of limitations of ecosystem service perspectives?
3. How can an interdisciplinary assemblage theory help to explain the importance of fish and fishing to local human communities in Sabangau, Indonesia?

To answer these questions, I focussed on the relationships between fish and humans and other relevant elements of the assemblage. I used case studies of human and nonhuman fish and spirit communities in the Sabangau in Central Kalimantan, Indonesia. Chapter 5 outlined the methods used, which combined 'ecological' and 'social' science techniques to explore the fish and human communities in the Sabangau area.

Chapter 6 identified elements of the Sabangau area by first considering how the assemblage looks according to the human communities (de-centring my world-view as an outsider). Drawing on results from focus groups, interviews and questionnaires this chapter identified and discussed properties of the human, fish and spirit communities, which facilitated understanding of the relationships and differences between these assemblages in later chapters. Through this, 55 species of fish were identified in the Sabangau area, and there were two distinct assemblages between the river and the forest, with 41 species trapped and documented for the river and 29 for the forest (17 species were not assemblage specific). I demonstrated that locally available trapping methods can be used to monitor the fish of the Sabangau specifically and tropical peatland-river ecosystems in general. These constituted the first in-depth water and fish surveys in the area, providing an important baseline for future fish monitoring and conservation management.

In Chapter 6, I also discussed characteristics of the human assemblages including ethnicity, religion, occupation and formal education. There was a greater proportion of Banjarese in Taruna Jaya compared to Kereng Bangkirai. Both villages had a Muslim majority, with Taruna Jaya having a higher representation of Christians compared to Kereng Bangkirai. This chapter built on the links between religion and ethnicity in the Sabangau area, the fluidity of Dayak and local identities and the role this plays as a territorialising force. Fishing was shown to be often complemented by other income sources, and gender differences in the two villages were identified. Notably, for both men and women, there was a higher dependence on fishing as a source of income in Taruna Jaya compared to Kereng Bangkirai. This chapter illustrated through interview data the link between fishing as a job and low education levels.

Lastly, the spirit community was considered through information gathered from focus groups, in-depth interviews and personal communication. A belief in spirits is still important for some of the human community members, and this belief can determine the relationship which human community members have to other assemblage elements. Spirits were shown to be able to take various forms, inhabiting the river and forest, with specific examples identified. The spiritual nonhumans, fish nonhumans and human elements were found to be both entangled and co-shaping with each other.

Chapter 7 explored some of the main relationships between elements of the Sabangau area, focussing on those between human communities and forest nonhuman species, human communities and fish communities, and the interactions between fish, human and spirit communities. These relationships include the importance of fish for human livelihoods, fish as a food source for human communities, the taboos that can be associated with eating or preparing fish in a certain way, the act of fishing itself and how 'watercraft' is learned, along with the 'environmental' aspects that fishers need to consider for successful fishing. For human community members that believe in spirits, gestures or offerings are sometimes required to be made to spirits or other nonhumans for successful fish catches. This allowed for a greater understanding of the variety of relations between humans and nonhumans in the Sabangau, drawing on MTHGs to consider agency, co-shaping and entanglements.

Key findings of Chapter 7 included that there is still a high dependency on fish and fishing as a source of livelihood in the Sabangau area and that fish are considered the most relevant to people's lives compared to other forest species, such as the flagship orangutan. Certain taboos associated with the consumption of specific fish species code the relationships which people have to these species and these are further linked to the territorialisation of 'Dayakness' and spiritual beliefs. Territorialisation and coding come from the assemblage framing, and can play a significant role in determining and structuring relationships between assemblage elements. I discussed local rules of fishing and how the territorialisation within Taruna Jaya along with the failure of Taruna Jaya residents to uphold rules related to electric fishing indicates a more heterogeneous, less territorialised assemblage in the latter with potential consequences for the resilience of this community within the Sabangau. I then considered the data from interviews and discussions with Dudin along with the fish surveys to discuss and elucidate the watercraft involved with being a successful fisher in the Sabangau. This illustrated the interwoven nature of fishing methods, local knowledge and practice, changing environments and requirements from spiritual relationships. The fish, human and spirit assemblages are thereby intertwined, entangled, and are changing and affected by the same worldly pulses and rhythms of local environmental (e.g. seasons) and global environmental changes (e.g. climate change) as other fishing communities across the world.

Chapter 8 illustrated how the IAA can be used to examine deterritorialising forces that have acted, continue to act, and potentially will act on the Sabangau area, with the IAA allowing me to consider some of the important emergent properties that now characterise the Sabangau area. This chapter considered population growth, changes in national laws and regulations, climate change and the introduction of projects or conservation management actions as key deterritorialising forces. All these forces are impacting the relationship between assemblage elements, causing them to change in certain ways. Each have their own impact, but all are also linked and at times amplify each other, such as human population increases and climate change leading to increased pressures on fish populations. These examples of deterritorialising forces, and some of the reactions to these forces such as the Outsider Narrative (which is an attempt by human community members to reterritorialise the assemblage), illustrate how complex and interacting changes in the assemblage can be discussed, analysed and better understood using the IAA.

Chapter 8 showed that through complex relations, and historical experiences, the emergent properties of the Sabangau area can be conceptualised as a) being prone to fire, b) being prone to overfishing and c) having (un)resilient properties. These are emergent properties: as it is the way assemblage elements are interacting with each other that cause these properties to become part of what characterises the Sabangau area. Considering these as emergent properties highlights the need to evaluate complex relationships and multiple assemblage components to find solutions and to understand the factors that cause these emergent properties to exist. In other words, to solve the over-fishing issue in Sabangau requires an understanding of the historical experiences of the local communities, their perspectives of, for example, harmful fishing methods, the barriers that lead to failed enforcement of rules and the challenges of finding alternative income sources. Using the IAA allows me to consider these aspects and perspectives with the embeddedness of the element properties, as described in Chapter 6, and the relationships, as discussed in Chapter 7, to build an understanding of a complex system that is in constant flux, change, acting and being acted upon.

Furthermore, I have tackled clear gaps in knowledge when it comes to the perspectives of local communities in Sabangau towards various changes in their environment, from fires to damming projects. This will be vital information for future biocultural conservation research and management projects in the area. Additional notable findings include the previously unforeseen link between fish and bird declines, with fishers changing to hunting birds as their incomes from fishing are decreasing. This is an example of how the IAA can elucidate surprising links within the assemblage. This chapter illustrated that in the Sabangau area, the fire issue is not only relevant to plantations and other forms of agriculture, but also to fishing, with its usage as a tool to increase access to fishing locations. Further research is needed to establish if this is as significant a source of fire in other areas, although this may be expected, given the high reliance of many of Kalimantan's rural forest-edge communities on fishing. Lastly, the majority of participants perceived a decrease in the fish populations, in line with other previous studies in other areas of Central Kalimantan. This indicates a clear necessity for future long-term fish population monitoring, especially since the results of this thesis also illustrate a high dependence on fish and fishing of human communities in the Sabangau. My results suggest that, compared to Kereng Bangkirai, more isolated villages such as Taruna Jaya are particularly sensitive to this decrease in fish resources, due to lower levels of education, higher dependence on fishing, lower levels of alternative income options apart from fishing and more difficult access to urban centres and associated markets. This leads to a prediction that more isolated villages such as Taruna Jaya are less resilient in the long-term if fish declines continue, and in the face of very limited alternative income options may result in outward migration of community members. The experience of this village is likely to be similar to others with the same characteristics, but further research in other case study locations would elucidate the applicability of these results elsewhere in Central Kalimantan.

Lastly, I now offer some reflections on how a TCK background provided personal experiences that may position a researcher to deal with interdisciplinary difficulties, such as ‘intellectual homelessness’. I suggest that my TCK background along with the paired familiarity of being an ‘outsider’ made me particularly drawn to interdisciplinary research. Aspects which can make it very daunting for some, such as the ‘intellectual homelessness’ was not a significant barrier for me. I may therefore have been more willing to take the plunge into ‘interdisciplinary waters’, but there was no saying whether I would be as or more capable of staying afloat than others. With my own experiences as a cultural marginal, adapting to different cultures and environments wherever I am, and an instinctive rejection of politics of polarity and categorisation, this naturally led to me taking the more personal approach to interdisciplinarity which I propose in this thesis. Resisting hierarchies, false dichotomies and oppressive attitudes is as much a part of myself and my aim as a way of life, as it is a part of my research. The IAA and the novel way that I approach interdisciplinarity allowed me to realise my own personal hopes and ideals, better than any other framework that I have come across so far. Other interdisciplinary researchers may find this approach similarly useful and worthy of consideration in their own work.

9.1. Contributions of the study to knowledge and theory

In this thesis, I have argued that i) there is a need to embrace the complexity of the world, to untangle the net of the assemblage and re-tangle it in order to understand ii) that various geographical scales need to be considered to understand local perspectives and how these respond to and tie into wider influences such as national movements of people and climate change; and iii) that there is a need to 'learn how to fish': to understand and consider different knowledges and to challenge the false 'dichotomy of knowledges'. All of this is needed to support conservation and environmental management. The IAA that this I propose in this thesis can be used as a framework to do this.

Building on previous uses and conceptions of 'assemblage', I have outlined and used examples to show how the IAA can challenge the nature-culture dichotomy and foster interdisciplinarity by allowing human and non-human elements and the interrelationships between these to be dealt with. The IAA framework and my proposed within-individual approach to interdisciplinarity also provides the opportunity to effectively incorporate different types of knowledges and challenge the dichotomy of 'local' and 'scientific' knowledge, which I expand on in the following section.

9.1.1. Critiques of the local-scientific knowledge dichotomy

It must be stressed that the IAA in this thesis is not used to test 'local' knowledge against 'scientific' knowledge or *vice versa*, it is instead a way to foster conversations between various forms of knowledge. In my discussion of, for example, dissolved oxygen levels and how these correlate with fish catches; Dudin's consideration of this variable when fishing is not included in this thesis to test or prove his knowledge (e.g. '*oh yes, he is aware of the importance of dissolved oxygen levels, so his local knowledge is accurate*'), but rather to illustrate the two forms of knowledge nodding in agreement with each other. The use of the IAA is thereby an act of building a bridge *not* a podium. As the introduction of this thesis discussed, the duality between 'local' or 'indigenous' and 'scientific' knowledge begins to break down when knowledge is understood as socially produced in all its forms, with 'scientific' knowledge also a particular, standardised form of local knowledge (Vermeylen *et al.*, 2008). In this way, 'scientific' and 'local' knowledge both provide tools, which may be different but complementary in helping to understand the world around us and how it functions.

'Local' knowledge is dynamic, location-specific (Sillitoe and Marzano, 2009; Gavin *et al.*, 2015) and as complex as the assemblage that it forms from (Reed, 2008; Silitoe and Marzano, 2009). To deal with these forms of knowledges along with, and in these complex SES, thereby requires a framework that can be as dynamic as the knowledge and assemblages themselves. The IAA allows for this complexity and dynamism as it fundamentally assumes fluidity and change. This is vital when considering shifting fishing practices, heterogeneous and fluid spiritual beliefs, religious and ethnic identities amongst other aspects of the human-nonhuman relationships in the Sabangau and elsewhere.

Notably, the IAA has allowed multiple types of knowledge to be dealt with in a way that can challenge the false knowledge dichotomies and hierarchies. The 'local' knowledge of my research assistants was vital for the collection of the 'scientific' data and, as discussed in Section 5.2.3, in practice the scientific/local knowledge dichotomy quickly disintegrates. The folk taxonomy was also very important to understand the assemblage and relationships between assemblage components through allowing basic documentation of the various names for different fish species. Folk taxonomies and local classifications are therefore worthy of attention for conservation efforts and to further our understanding of how people relate to their environment. In conclusion, and drawing on the IAA once more, the concept of what 'science' is needs to be re-imagined. Instead, different forms of knowledges should be placed on a continuum rather than at opposite ends of a pole to each other, in agreement with Agrawal (1995) and Vermeylen (2008) amongst others.

9.1.2. The applicability of the IAA to promote interdisciplinarity

The IAA that I propose in this thesis is a novel approach that is built on an interdisciplinary step itself: by marrying ecological and AT conceptions of 'assemblages'. It is through this interdisciplinary merging that new possibilities are found. The concept of what 'interdisciplinarity' is can be stretched to include more within-individual meanings of the word, thereby involving the challenging of biases, the incorporation of different worldviews and knowledges that are respectful to the beautiful complexity of the world. This link between ecological assemblages and AT assemblages, to my knowledge, has not been explicitly highlighted before. It is in these commonalities, the shared language and the joint embrace of complexity that a creative bridge can be built.

Without a framework to support interdisciplinarity, without a structure that resists the problematic tearing apart of the 'social' and 'natural', interdisciplinarity fails. This thesis has illustrated the possibility of using creative and theoretical frameworks such as the IAA to bridge the 'social' and the 'natural'. It is with the challenging of these false dichotomies (e.g. between 'social' and 'natural' sciences) through the subtle determination of the thesis' structure, that it thereby becomes a truly interdisciplinary thesis and project.

The IAA that I propose has allowed for the structure of the thesis to be built on themes, or 'steps' to build the assemblage with an understanding of some its main components, relationships, deterritorialising forces and emergent properties. Ultimately, in this thesis I focus on relationships rather than 'values'. It is in and from these relationships between system elements (humans and nonhumans, biotic and abiotic) that values and desires are formed, but by focusing on relations the anthropocentricity of the ES approach can be avoided. It is also in the attempt to understand certain relationships that the 'best available tool' can be chosen: when understanding the relationship between a person and another person certain tools can be used while others will be used when understanding relationships between a person and a fish. For the latter, being unable to talk to fish, a researcher instead has to depend on methods traditionally derived from the 'natural sciences' to get an insight into the fish's way of life. In this way, another novel contribution of this thesis is this re-imagination of disciplines: I illustrate the act of drawing on disciplines where necessary and using these as a toolbox rather than a set of instructions. I thereby suggest that if an approach to disciplines and their respective methods are viewed more like this 'toolbox of possibilities' with their underlying assumptions and limitations clear, interdisciplinary conservationists could choose accordingly the 'tools' appropriate for the aims of their project. Handling methods and data in this way can support the breaking down of disciplinary hierarchies.

The IAA that I propose in this thesis illustrates that there are certainly new approaches that can be taken to foster interdisciplinarity and that the 'natural' and 'social' sciences, however different they may be, can foster their similarities in concepts and approaches, such as assemblages, enabling cross-learning and more effective co-operation. This approach to research, interdisciplinarity and supporting framework of the IAA with its ability to deal with complexity, should be transferable to other sites and ecosystems and requires future trialling.

The act of writing this thesis has been an illustration of the challenges of interdisciplinary research. Language is one barrier (MacMynowski, 2007; Norgaard *et al.*, 2007; Donovan *et al.*, 2011; Collier *et al.*, 2011), and just as Graham (2013: 303) experienced during her writing with her supervisors, language was a challenge: "*writing in first-person, placing 'results' in the method chapter, switching between technical and common-use prose*". I certainly experienced these as well. By identifying similar experiences, interdisciplinary researchers would benefit from pooling these together to inform future interdisciplinary projects as well as to avoid repeating mistakes. Another barrier to interdisciplinary research is diverging theories, methods and analysis (Fry, 2001; Collier, 2011; Donovan *et al.*, 2011) and a lack of clear frameworks for integrating the 'social' and 'natural' sciences (Sievanen *et al.*, 2011). I tackled this barrier by using the IAA to bring together theories and analysis. Methods still tended to stem from 'ecological' or 'social' disciplines, and future work and innovative approaches to tackle these distinctions is necessary. Graham (2013) also discusses the lack of academic foundation to support the work as another barrier to interdisciplinary research (Fry, 2001; Donovan *et al.*, 2011). As Graham (2013) writes, without a supervisory team that was open to interdisciplinary research, and as willing to take the risks that I was, this study would not have been achievable. With researchers who are facing a less supportive environment, this could still pose a significant barrier.

More personally, what I consider as the main potential barrier was the risk associated with interdisciplinary research. Through the writing of this thesis I often felt I had to hold on to a blind faith that it would work out, or even just make sense. To write a thesis that deals with complexity in a coherent manner was challenging, and by definition could go on endlessly. Interdisciplinary research tries to be true to the beautiful complexities and imperfections of the world. It tries to make sense out of messiness, and it might not always be able to do this, and perhaps should not always have to. With a greater acceptance of this, the risks associated with venturing into interdisciplinary projects would be lessened.

The IAA is therefore not without its downsides: while allowing for complex and dynamic systems to be considered, with enough space to study various types of knowledge and worldviews, along with analysing deterritorialising forces and emergent properties and characterising communities to allow for comparisons: this makes delineating the area of study very difficult (and indeed a little paradoxical to the ethos of assemblages). The complexity can easily become overwhelming, and this is a potential barrier for this approach to be used more widely. Saying this, I suggest that it may be a matter of practice, pooling experiences and learning from them; and as researchers become more comfortable with dealing with complexity, approaches such as the IAA will also be refined over time.

9.2. Study limitations, management recommendations and future research directions

It is clear from the results of this thesis that villagers are experiencing uncertainty in their fishing, and this is causing an increased sense of insecurity. For the wellbeing of human communities in Sabangau, there is a need to support socially and culturally appropriate ‘safety nets’ to ensure food security. To identify these potential supports for food security, options must be properly evaluated in a holistic manner, with the entanglements, local perceptions and context at the forefront of analysis (Habel *et al.,* 2015). The entanglements between food security and biodiversity conservation in Sabangau needs further consideration beyond fish and fishing. As Glamann *et al.* (2015) write, research focusing on the issues of biodiversity conservation, food security and their interrelations is relatively new, but already seem to be veering into two major approaches: biophysical-technical and social-political. However, there is scope for bridging the gap between these two approaches, and to do so “*requires open and constructive dialog on both sides of this divide, and explicit regard of the often hidden assumptions and foundational analytical frames that underpin these two broad approaches*” (Glamann *et al.,* 2015: 9). The IAA proposed in this thesis could potentially support this.

As this thesis found regarding canal damming projects in Sabangau, expectations and perceptions are vital to understand how (local) people will perceive a conservation project and for the project’s success (Ite and Adams, 2000; Pomeroy and Douvere, 2008; Benson, 2012). Expectations need to be managed, and one productive way of doing so is maximising shared learning, experience and community involvement (McEwan *et al.,* 2014). This study concurs with McEwan *et al.* (2014) who found that the consideration of knowledge and different levels of knowledge is critical, as this leads to different levels of expectations. Local perceptions and expectations are key to projects failing or succeeding, and can have serious consequences for community trust in organisations and conservation groups in the future as well. I therefore recommend these local perceptions to be taken seriously for any TPSF conservation or restoration project/agency (see Chapter 4.1.6.). Any peatland restoration project that involves extensive dam blocking, needs to consider not only fish and fisher's role within the assemblage, but also more generally the past experiences of local communities and the prevalence of the Outsider Narrative that may turn into significant barriers to the success of any project, along with local perceptions of these projects on livelihoods. This requires appropriate participatory approaches to deal with asymmetries in power and knowledge within the assemblage. As Kumar (2014) writes, certain individuals or organisations have greater capacities to change trajectories in the assemblage through action or inaction. This power can take the form of political power, financial power, legal power and organisational capacities (Kumar, 2014). These power gradients require further analysis in the Sabangau area, and hopefully this thesis provides one stepping stone for this to be possible through providing an initial understanding of some key features and relationships within the assemblage.

This study highlights that links between fish (and other 'natural resources' of importance to local communities), the forest and the conservation of other species (e.g. orangutans) can and should be made more clearly. The entanglements between species and humans and nonhumans need to be further explored, used and communicated for the benefit of the whole assemblage; e.g. demonstrating how conservation of apes can benefit fish and *vice versa*, and how this can benefit local people. This study highlights the benefits that may be accrued through conservation organisations considering fish as an opportunity to make conservation research relevant for local communities and engage them with this research in an appropriate manner, following biocultural approaches to conservation. This could include projects that consider access to markets and exploring together with local communities ways to support alternative sources of income that promote (or at least do not compromise) TPSF conservation.

Furthermore, while fish and fishing are clearly important to the local communities of Sabangau, this importance should not be romanticised. This is a very practical importance, and therefore engaging local communities with environmental issues using fish and fishing needs to also keep this in mind. Otherwise, conservation organisations may risk seeming naïve to local realities and harming the engagement that is being attempted. These realities will also change temporally and spatially, requiring adaptive and flexible conservation projects.

A knee-jerk reaction to the fisheries declines that Sabangau seems to be facing is to suggest fishing quotas need to be introduced. However, the results of this study suggest that such a measure would be unlikely to succeed considering the nature of fishing as a livelihood that often supports the poorest and most vulnerable in society. Also, any attempt to introduce fishing quotas is likely unenforceable in the Sabangau, considering current/past experiences of continued use of electric fishing, logging and other harmful activities. Ultimately, the drivers of peatland degradation and deforestation need to be tackled for there to be any chance of conserving these vital environments. This requires a holistic, participatory approach that considers the worldviews of local communities, their needs and desires, and the historical experiences and context of the area. In agreement with Medrilzam (2017), this requires poverty, land-use practices and other causes of insecurity to be tackled. These are all complex and interwoven, but are vital considerations for the success of any conservation action.

It is clear that the causes of the overfishing-prone assemblage are multiple and complex, emerging from a situation of poverty, lack of alternative income sources, increasing human populations and pressure on fish populations, changing occupations and laws forcing communities into fishing, to name a few. To add to this complexity, this thesis has not been able to discuss all the aspects of the fish entanglements and causes for their declines, including for example water pollution from agriculture, household waste and illegal mining as suggested by Schreer (2016) and Eriksen (2016). There are therefore other notable aspects to the fisheries problems that are being faced in Sabangau, but are not considered here. This illustrates that to find solutions to the fish(ing) declines is even more complex, with future a more research needed to tackle some of these key knowledge gaps.

This research would benefit from also following a framework such as the IAA that has been shown to have the capacity to support a holistic view of the system, uncover unexpected or previously unknown relationships between assemblage elements, and allow for various geographic and temporal scales to be considered.

Further limitations of the study include that only two human communities were used as case studies. These communities showed some large differences between them, such as their histories and geographic locations. Whether the results from these two communities can be generalised to a larger assemblage needs to be further tested through considering a greater variety of human communities in future studies. Until then, care should be taken when attempting to generalise these results. For the human communities, future consideration and use of ethnographic approaches would allow issues of attitudinal fallacy to be considered, which interviews and focus groups are unable to do (see e.g. Jerolmack and Khan, 2014). However, this would not give the reasons as to why people are using their environment in one way or another, and the interviews used were relevant to understanding the motives behind environmental management and use of the river and fishing, although the ability to evaluate actual actions was limited (Jerolmack and Khan, 2014). This therefore leaves scope for ethnographic approaches in the area, which would likely provide important details and depth that may have been missed in this study. The research furthermore only considers a handful of deterritorialising forces and emergent properties: continued enquiry into local perceptions of 'environmental' changes including, for example, oil palm plantations and water pollution, will allow for a more complete understanding of the assemblage and will ensure that correct assumptions are drawn.

The ecological data collected in this study were used to elucidate some of the relationships between the fish and the water. This not only supports the understanding of how Sabangau fishers look to the water conditions to understand and predict their fish catches, but also provides useful details to inform future fish surveys to, for example, minimise fish mortality. This is important from an ethical standpoint, and to ensure that fish surveys are not seen to be negatively impacting local fish populations by local fishers, which would undoubtedly cause negative local perceptions.

More specifically, I recommend the following actions and future research considerations:

1. Long-term fish monitoring should be conducted in both the Sabangau and Kahayan rivers to collect information to support an assessment of potential fish(ing) trends and linked environmental variables, which may be compared to the baseline data described herein.
2. In concurrence with Giam *et al.,* (2012), more research on TPSF fish species is needed to understand fish behaviours, diets, functional traits, and their flexibility and resilience to changing environments; and to link this to human community wellbeing and resilience. This could involve research focussed on migration patterns of fish species, or/and laboratory studies considering the impact of changing environmental variables on their foraging behaviour and survival. This is vital for designing future conservation management actions and will allow a better understanding of catch and trophic level data.
3. Studies on the impact of peatland dams on fish populations are recommended. In particular, data are needed on the mortality of fish following dam construction, and the onset of the dry season and decreasing canal water levels, is suggested. Before-and-after fish surveys following dam construction would be useful to further elucidate the impacts of dams on local fish populations.
4. Further research is needed on the environmental impacts of fires on fish populations, the aquatic ecosystem of the Sabangau and other TPSF habitats. This includes consideration of both the short-term and long-term effects of fire, and could involve laboratory studies to investigate the impacts of fire on aquatic environmental variables. For field studies, data loggers, funding permitting, would allow for environmental variables such as water turbidity to be measured frequently and during times when data collection by humans is risky and inappropriate (e.g. when smoke haze

requires data collection by humans to be suspended). Further points to consider are that:

   a. Other methods of fish trapping are likely to add to the species list in the future. Any alternative methods need to be chosen appropriately, considering their impacts on fish and perceptions of local communities on researchers.
   b. Future fish surveys should measure dissolved oxygen levels prior to setting traps to minimise fish mortality.
   c. Further research is needed to establish if fishing is a significant source of fire in other areas apart from Sabangau, given the high reliance of many of Kalimantan's rural forest-edge communities on fishing.

5. Future research on and the use of participatory approaches, shared learning experiences and knowledge transfer is needed to better understand local perspectives in the area; e.g. clarify the role of dams for peatland conservation between relevant stakeholders.
6. Alternative fish pond designs/uses should be considered and tested to improve the economic, social and ecological sustainability of the current fish ponds. A re-trial of the fish pond design and harvesting in Kereng Bangkirai is also recommended. This would include altering the designs or locations of the fish ponds to ensure that they continue to be full of water throughout the dry season, thus allowing the fish to survive and re-enter the river system once flooding in the wet season occurred. Methods that encourage selective (sustainable) harvesting of fish also needs to be considered, to ensure that the fish ponds do not merely increase existing pressures on local fish populations.
7. Future research is needed to consider the prospects of future climatic change in conservation planning in the Sabangau area (in concurrence with Laurance, 2016). This relates to all the suggestions above; the fish-focused, human-focused and fire-focused research, but drawing these together to understand the wider consequences and potentialities of future climate

change. This is necessary to anticipate the consequences of current and future assemblage changes and resilience.

8. Further theoretical work is needed on the use of the IAA in considering and exploring flows and dynamics of agency, desire/emotion and power.

Taking a biocultural approach to conservation, specific management recommendations include:

1. Continued involvement of local community members is essential in the construction of dams in peatland areas. This provides an opportunity to gather information on local perceptions of dams, which is useful to inform future research on the impacts of dams, as aforementioned. Attempts need to be made to collect evidence of mass fish mortalities around dams, whether these are photographs or more organised fish surveys. For the human communities in the Sabangau, these concerns of fish mortalities related to dams must be shown to be taken seriously and acted upon.
2. More wide-scale construction of fish ponds should not occur until the economic, social and environmental impacts of these are better understood, once more following on the research recommendations as above (number 7).
3. Fish research, involving long-term and short-term studies is necessary in peatland areas. Where there is high human dependence on fish and fishing, fish are the clearest faunal link between human communities and the environment, and could provide a great opportunity to a) increase the relevance of conservation projects for local communities and b) support the engagement between local communities and conservation projects. Both are vital for successful peatland conservation and management.
    a. Considering the high dependence on fish for food in the Sabangau and thereby a need for continued supplies of fish, along with increasing human populations and generally declining ecosystem condition: other project options such as fish farming or aquaponics systems should be considered and evaluated in terms of their socio-cultural, economic and environmental viability.

This research does not end here, and dissemination of its findings particularly back to the human community case study sites in a culturally appropriate way needs to be done to ensure the research "*reaches the people who have helped make it*" (Smith, 2012:15). It is therefore a long-term commitment that does not end upon submission.

Just as this thesis has inspired me to keep challenging my own perceptions of the world, continue pushing the boundaries of the disciplines I find myself in, and continue to search for creative ways of approaching science and research; I hope that it provides a helpful contribution and step forward to others seeking to do the same.

APPENDIX I

Species lists and folk taxonomy

Table 1 lists the fish species (Actinopterygii) of the Sabangau area. Species have been highlighted in matching colours which are considered similar (generally in shape) or share names in the local taxonomical system (or 'folk taxa'). For example, *saluang* is a name given to small fish. Human community members may either just use *saluang*, or may add another word to further identify them, e.g. *saluang licin*, which literally means 'slippery *saluang'*. *Saluang kambe* (synonym of *saluang karing*) means 'ghost *saluang'*. Other main groups of fish include *sapat*, which are also small but distinct in shape from *saluang*. These are very popular locally to dry and eat. *Bilis* is another group, which are even smaller fish compared to *saluang* or *sapat* that are often not trapped due to their size but are often seen on the surface of the river. A white background indicates that no particular folk taxa grouping was identified.

Table 2 lists the fish species (Actinopterygii) of the Sabangau area, including the habitat it was sampled in, whether it is listed as an ornamental species in literature and any further notes.

Table 1: List of freshwater fish (Actinopterygii) species recorded in the NLPSF, Sabangau, including data from ad hoc observations and published accounts (Page et al., 1997; Ng and Tan, 2011; Schindler and Linke 2013). Colours indicate folk taxa groupings (except white colour, for which a folk taxa grouping was not determined)

Order	Family	Genus	Species	English name	BNF name	Dayak name	Banjar name	Indonesian name	Additional name (from interviews)
Beloniformes	**Zenarchopteridae**	*Hemirhamphodon*	*chrysopunctatus*		Janjulung kecil	Janjulung kurik	Janjulung halus		
		Hemirhamphodon	*tengah*		Janjulung kecil	Janjulung kurik	Janjulung halus		
Cypriniformes	**Cobitidae**	*Kottelatlimia*	*cf. pristes*						
	Cyprinidae	*Cyclocheilichthys*	*janthochir*		Puhing	Puhing	Puhing		
		Desmopuntius	*foerschi*	Foersch's fire barb	Renteng bening	Renteng	Renteng	Ikan garis	Babat, pinang
		Desmopuntius	*hexazona*	Six-banded tiger barb	Renteng merah	Renteng Bahandang	Renteng habang	Ikan garis merah	
		Desmopuntius	*johorensis*	Striped barb	Banta Besar	Saluang Baputi	Lambayut		
		Desmopuntius	*rhomboocellatus*	Snakeskin barb	Renteng merah 2/ Bandot	Renteng Bahandang	Renteng habang	Ikan garis merah	
		Eirmotus	sp.[1]	Eight-banded bard	Renteng bening	Renteng	Renteng	Renteng tipis	
		Osteochilus	*melanopleura*	Greater bony lipped barb	Kalabau	Kalawau	Kalabau	Kalabau	
		Osteochilus	*spilurus*		Puyau	Saluang licin	Puyau		
		Rasbora	*cephalotaenia*	Porthole rasbora	Saluang merah	Saluang bahandang	Saluang habang		Saluang kahui, Saluang like
		Rasbora	*dorcioceletta*	Eyespot rasbora	Bilis liar	Bilis	Bilis		
		Rasbora	*kalbarensis*	Kalbar rasbora	Bilis putih	Bilis pabuti	Bilis putih		
		Rasbora	*kalochroma*	Clown rasbora	Saluang karing	Saluang kambe	Saluang karing		
		Striuntius lineatus	*lineatus*	Lined barb	Banta	Saluang Baputi	Lambayut		
		Trigonopoma gracile	*gracile*	Blackstripe rasbora	Bilis merah	Bilis bahandang	Bilis habang		
Perciformes	**Anabantidae**	*Anabas*	*testudineus*	Climbing perch	Puyu	Puyu	Bapuyu	Puyu	

Order	Family	Genus	Species	English name	BNF name	Dayak name	Banjar name	Indonesian name	Additional name (from interviews)
Perciformes	**Channidae**	*Channa*	*bankanensis*	Bangka snakehead	Selentak	Selentak	Mihau	Mihau	
		Channa	*gachua*	Forest snakehead	Mihau	Mihau	Mihau	Mihau	
		Channa	*melanoptera*	Black finned snakehead	Kihung	Kihung	Kihung	Kihung	
		Channa	*micropeltes*	Giant snakehead	Toman	Toman	Toman	Toman	
		Channa	*pleurophthalmus*	Oscellated snakehead	Kerandang	Karandang	Karandang	Karandang	
		Channa	*striata*	Snakehead murrel	Gabus	Behau	Haruan	Gabus	
	Helostomatidae	*Helostoma*	*temminckii*	Kissing gourami	Biawan				
	Nandidae	*Nandus*	*nebulosus*	Bornean leaffish	Tawon	Tawon	Patung tanah	Ikan daun	Ikan bungul (Banjar), Tatawon, Patung batu, Tambubuk
	Osphronemidae	*Belontia*	*hasselti*	Malay combtail	Kapar	Kapar	Kapar	Kapar	
		Betta	*anabatoides*	Giant betta	Tampalah	Sambaling	Kalatau	Cupang	
		Betta	*foerschi*		Betta merah	Tampala	Kalatau	Cupang	
		Betta	*hendra*						
		Luciocephalus	*aura*	Peppermint pikehead	Janjulung bintik	Janjulung	Julung		
		Luciocephalus	*pulcher*	Giant pikehead	Janjulung	Janjulung kurik	Julung		
		Sphaerichthys	*acrostoma*	Giant chocolate gourami	Sapat trompet	Sapat rasau	Sapat hijau		Sapat layang
		Sphaerichthys	*osphromenoides*	Chocolate gourami	Sapat bagong	Sapat garis	Sapat garis		
		Trichopodus	*pectoralis*	Snakeskin gourami	Sapat siam	Sapat	Sapat siam	Sapat siam	
	Pristolepidae	*Pristolepis*	*grootii*	Indonesian leaffish	Patung	Patung	Patung		
Siluriformes	**Bagridae**	*Leiocassis*	*micropogon*	Bumblebee catfish	Puntin	Puntin	Puntin		

Order	Family	Genus	Species	English name	BNF name	Dayak name	Banjar name	Indonesian name	Additional name (from interviews)
Siluriformes	**Bagridae**	*Leiocassis*	sp.		Puntin hutan	Puntin	Puntin		
		Mystus	*nigriceps*	Twospot catfish	Sanggi	Sanggi	Sanggi		
		Mystus	*olyroides*		Pantik	Darap	Pantik		
		Mystus	sp.		Baung	Baung	Baung	Baung	
	Chacidae	*Chaca*	*bankanensis*	Angler catfish	Tabenkung	Tabenkung	Tabenkung		
	Clariidae	*Clarias*	*meladerma*	Blackskin catfish	Lele	Pentet	Pentet	Lele	
		Clarias	*nieuhofii*	Slender walking catfish	Lele	Pentet	Pentet	Lele	
		Clarias	*teijsmanni*	Airbreathing catfish	Lele	Pentet	Pentet	Lele	
		Encheloclarias	*tapeinopterus*		Lele hutan	Pentent	Pentet	Lele	
	Schilbeidae	*Pseudeutropius*	*moolenburghae*	Sun catfish	Riyu	Riyu	Rariyu		
	Siluridae	*Kryptopterus*	sp.	Striped glass catfish	Lais kecil	Lais sahep	Lais		
		Ompok	*leiacanthus*		Tapah	Tampahas	Tapah	Tapah	
		Silurichthys	*ligneolus*	Brown leaf catfish	Dadasai	Dadasai	Dadasai		
		Silurichthys	*phaiosoma*	Hasselt's leaf catfish	Dadasai	Dadasai	Dadasai		
		Wallago	*leeri*	Striped wallago catfish	Tapah besar	Tampahas	Tapah	Tapah	
Synbranchiformes	**Mastacembelidae**	*Macrognathus*	*aculeatus*	Lesser spiny eel	Jinjili 2	Janjili	Jili	Sili	
		Macrognathus	*maculatus*	Frecklefin eel	Jinjili 2	Janjili	Jili	Sili	
	Synbranchidae	*Monopterus*	*albus*	Asian swamp eel	Lindung				

1. Potentially new species based on inspection in the field and of photographs. Requires specimen for confirmation.

Table 2: List of freshwater fish (Actinopterygii) species recorded in the NLPSF, Sabangau, including location it was trapped in, mean standard length (SL), whether it is reported as an ornamental species in literature and notes. Grey colour indicates recorded by literature but not trapped in the surveys, Green indicates opportunistic trapping, Blue indicates not trapped by surveys but identified as present by local fishers.

Order	Family	Genus	Species	BNF name	Habitat	Mean SL (mm)	Trapped in forest	Trapped in river	Trapped in canal	Reported as ornamental species by author	Notes
Beloniformes	**Zenarchopteridae**	*Hemirhamphodon*	*chrysopunctatus*	Janjulung kecil	River/Forest	69.7	x	x			
		Hemirhamphodon	*tengah*	Janjulung kecil	Forest						Reported by Page *et al.* (1997) and trapped by Dr. Frank van Veen in 2016.
Cypriniformes	**Cobitidae**	*Kottelatlimia*	*cf. pristes*		Forest		x				Opportunistic trapping
	Cyprinidae	*Cyclocheilichthys*	*janthochir*	Puhing	River	84.2		x			
		Desmopuntius	*foerschi*	Renteng bening	River	30.3		x			
		Desmopuntius	*hexazona*	Renteng merah	River/ Forest	35.2	x	x		Sule *et al.*, 2016	
		Desmopuntius	*johorensis*	Banta Besar	River	58.4		x		Sule *et al.*, 2016	
		Desmopuntius	*rhomboocellatus*	Renteng merah 2/ Bandot	River	36.2		x			
		Eirmotus	sp.[1]	Renteng bening	River	30.3		x			
		Osteochilus	*melanopleura*	Kalabau	River	183.3		x			
		Osteochilus	*spilurus*	Puyau	River	50.5		x		Sule *et al.*, 2016	
		Rasbora	*cephalotaenia*	Saluang merah	River/ Forest	61.9	x	x		Sule *et al.*, 2016	
		Rasbora	*dorcioceletta*	Bilis liar	River	42.0		x		Sule *et al.*, 2016	
		Rasbora	*kalbarensis*	Bilis putih	River			x			Opportunistic trapping
		Rasbora	*kalochroma*	Saluang karing	Forest	45.7	x			Ng et al. (1994), Sule *et al.*, 2016	
		Striuntius lineatus	*lineatus*	Banta	River	43.3		x			

Order	Family	Genus	Species	BNF name	Habitat	Mean SL (mm)	Trapped in forest	Trapped in river	Trapped in canal	Reported as ornamental species by author	Notes
		Trigonopoma gracile	*gracile*	Bilis merah	River	28.8		x		Ng et al. (1994), Sule *et al.*, 2016	
Perciformes	**Anabantidae**	*Anabas*	*testudineus*	Puyu	Forest	70.0	x				
Perciformes	**Channidae**	*Channa*	*bankanensis*	Selentak	River/ Forest	128.2	x	x			
		Channa	*gachua*	Mihau	River/ Forest	167.7	x	x		Sule *et al.*, 2016	
		Channa	*melanoptera*	Kihung	River	134.0		x			
		Channa	*micropeltes*	Toman	River/ Forest	266.1	x	x			
		Channa	*pleurophthalmus*	Kerandang	River	205.5		x			
		Channa	*striata*	Gabus	River						Present according to local fishermen, photographic evidence available
	Helostomatidae	*Helostoma*	*temminckii*	Biawan	River	89.3		x		Sule *et al.*, 2016	
	Nandidae	*Nandus*	*nebulosus*	Tawon	River/ Forest	57.8	x	x			
	Osphronemidae	*Belontia*	*hasselti*	Kapar	Forest/ River	59.0	x	x		Sule *et al.*, 2016	
		Betta	*anabatoides*	Tampalah	Forest	64.5	x				
		Betta	*foerschi*	Betta merah	Forest	38.3	x				
		Betta	*hendra*								Schindler and Linke (2013)
		Luciocephalus	*aura*	Janjulung bintik	River	85.9		x			
		Luciocephalus	*pulcher*	Janjulung	Forest	86.8	x			Sule *et al.*, 2016	
		Sphaerichthys	*acrostoma*	Sapat trompet	River	42.4		x			

Order	Family	Genus	Species	BNF name	Habitat	Mean SL (mm)	Trapped in forest	Trapped in river	Trapped in canal	Reported as ornamental species by author	Notes
		Sphaerichthys	*osphromenoides*	Sapat bagong	Forest/ River	36.9	x	x		Ng et al. (1994), Sule *et al.*, 2016	
		Trichopodus	*pectoralis*	Sapat siam	River	67.0		x			
	Pristolepidae	*Pristolepis*	*grootii*	Patung	River	45.9		x			
Siluriformes	**Bagridae**	*Leiocassis*	*micropogon*	Puntin	River	101.6		x		Sule *et al.*, 2016	
Siluriformes	**Bagridae**	*Leiocassis*	sp.	Puntin hutan	Forest	27.0	x				
		Mystus	*nigriceps*	Sanggi	Canal				x		Trapped by canal, close to Sabangau River
		Mystus	*olyroides*	Pantik	River/ Forest	97.8	x	x			
		Mystus	sp.	Baung	Canal				x		Trapped by canal, close to Sabangau River
	Chacidae	*Chaca*	*bankanensis*	Tabenkung	River	136.7		x			
	Clariidae	*Clarias*	*meladerma*	Lele	River/ Forest	137.8	x	x			Can be difficult to distinguish from *C. teijsmanni*, surveys only categorised as *Clarias* spp.
		Clarias	*nieuhofii*	Lele	Forest	155.1	x				
		Clarias	*teijsmanni*	Lele	River/ Forest	137.8	x	x			Can be difficult to distinguish from *C. meladerma*, surveys only categorised as *Clarias* spp.
		Encheloclarias	*tapeinopterus*	Lele hutan	Forest	80.4	x				
	Schilbeidae	*Pseudeutropius*	*moolenburghae*	Riyu	River	60.8		x			

Order	Family	Genus	Species	BNF name	Habitat	Mean SL (mm)	Trapped in forest	Trapped in river	Trapped in canal	Reported as ornamental species by author	Notes
	Siluridae	*Kryptopterus*	sp.	Lais kecil	River/ Forest	70.6	x	x		Sule *et al.*, 2016	
		Ompok	*leiacanthus*	Tapah	River/ Forest	65.7	x	x			
		Silurichthys	*ligneolus*	Dadasai	River						Present according to Ng and Tan (2011)
		Silurichthys	*phaiosoma*	Dadasai	River/ Forest	80.0	x	x			
		Wallago	*leeri*	Tapah besar	River	389.33		x			
Synbranchiformes	**Mastacembelidae**	*Macrognathus*	*aculeatus*	Jinjili 2	River/ Forest	108.5	x	x			
		Macrognathus	*maculatus*	Jinjili 2	River/ Forest	117.8	x	x			
	Synbranchidae	*Monopterus*	*albus*	Lindung	Forest	405	x				

APPENDIX II

Nutrient analysis specifics

P analysis following the ascorbic acid method of Eisenreich (1975) after Murphy & Riley (1962)	
River water sample volume	25 ml
$H_2S_2O_8$	4 ml of 4% (w/v)
Autoclave time	30 minutes
Combined reagent volume used	4 ml
Combined reagent mix	5N H_2SO_4 (50ml) Potassium antimony tartrate (P.A.T.) solution (5ml) Ammonium molybdate solution (15ml) Ascorbic acid solution (30ml)
Spectrophotometer wavelength used	882 nm

NO_2 analysis following the Griess test using pink azo dye	
River water sample volume	20 ml
Standards used of NO_2	0.05, 0.1, 0.2, 1, 0.025 and 0 (distilled water) ppm
Combined reagent mix	Sulfanilamide (0.025g) Naphthylamine (0.025g) Tartaric acid (2.225g)
Combined reagent mass used (added to each water sample and standard)	0.1 g
Combined reagent mix	5N H_2SO_4 (50ml) Potassium antimony tartrate (P.A.T.) solution (5ml) Ammonium molybdate solution (15ml) Ascorbic acid solution (30ml)
Spectrophotometer wavelength used	520 nm

NO_3 analysis using nitration between nitronium and salicylate following methods as described by Yang et al. (1998)	
River water sample volume	1 ml
Standards used of NO_3	0 (distilled water), 1, 2, 3, 4, 6 and 10 ppm
Volumes of standards added to water sample	1 ml
Volume of TRI solution used	0.5 ml
TRI solution mix	Sodium salicylate (1g) NaCl (0.2g) Ammonium sulfamate (0.1g) - Above dissolved in 0.01M NaOH (100ml)
Oven temperature and time	24 hours at 105°C
Solution after oven treatment	H_2SO_4 (1 ml) H_2O (5 ml) 40% NaOH (5 ml)
Spectrophotometer wavelength used	410 nm

APPENDIX III

Basic Information Sheet

Tanggal wawancara *(Interview date)*:

Lokasi wawancara *(Interview location)*:

1. Gender *(Gender)*	
2. Berapa umur Anda? *(What is your age?)*	
3. Darimana asli suku Anda? *(What is your ethnicity?)*	
4. Memiliki Anda selalu tinggal di sini *(How long have you been living here?)*	
5. Apa agama Anda? *(What religion do you follow?)*	
6. Apa pendidikan terahir? *(What is the highest level of education you have reached?)*	
7. Apa mata pencaharian utama Anda /pekerjaan? *(What is your main source of income/job?)*	
8. Anda sebagai pemancing/nelayan (kalau 'ya', berapa lama anda sebagai pemancing/nelayan?) *(Are you a fisher – if 'yes', how long have you been fishing?)*	

APPENDIX IV

Interview guide

Start by asking participant to fill in [with Kris writing and asking] the basic information sheet dealing with age, occupation, education level etc. of participant].

This is used as a guide only, and depending on the interviewee and their answers some questions may be changed, added or skipped, or the order adapted.

Ask question in blue only to participants who fish.

<u>Fishing Questions</u>

1. What percentage of people in Kereng/Taruna are full time fishermen?
2. What is the split between women and men who are full time fishermen?
3. How did you learn to fish?
    a. [If relevant] What do you remember from your childhood fishing? Are things different now and if so how?
4. How do you choose your fishing locations?
    a. Are there rules about where you can or cannot fish, and the methods you may use to fish?
5. Does traditional adat play any role in your fishing activities? If so, what?
6. Show them photos of fish: what can you tell me about these species?
    a. Local market prices?
7. Do you sell fish?
    a. When you catch a fish, what happens to it? What are the processes to get it sold?
    b. How important is selling fish for you or your family's income?
8. Have you seen any increase or decrease in the numbers of fish you are catching throughout your time fishing here? If so, how much, over what period of time and why do you think these changes have occurred?
9. Are the fish population trends a problem? Why?
    a. What are the possible solutions?
10. Would you like to use bejes? Why or why not?
    a. How would you design the beje and use it?
        i. How often would you harvest?

ii. Would you harvest all of the fish?
iii. Where would you build the beje and why?

11. What do you think the future of fishing looks like in this area? *[If not fisherman, adapt to more general question]*
    a. What are the main challenges that fishing in the area faces?

Fire Questions

12. I have heard that fire is used to clear land is used because of tradition and to improve access for fishing, are there any other reasons to use fire?
    a. what proportion of fishermen would you say use this method in this area?
13. Are there any impacts of fire on fish or fishing? *OR* Are there any impacts of fire on your livelihood?
14. What do you think of burning land?
    a. If negative, ask what they believe possible solutions are

Dam Questions

15. Why do you think dams are built? What are they for?
16. What do you think of dam building?
    a. [If they are causing fish deaths] what do you think the solution for this is?
17. Do you know if fish populations or captures have changed from the presence of dams?

Palm Oil and Gold Mining Questions (For Taruna Jaya)

18. In previous interviews I was told that they are planning to plant palm oil in Sabangau (Kalampangan) area. What do you think about this?
19. Who is planting the palm oil?
20. Will there be any impact on fishing [or your livelihood] with the palm oil being grown? If so, what will this impact be?

21. Can you tell me about gold mining in the area?
    a. Has this impacted fish? How?

Cultural Questions

22. Are there any types of fish that are pali [taboo] for you or your family to eat? [elicit more info]
23. Do you ever give offerings for the river?
    a. If so, what do you use as offerings and what are the offerings for?
24. Do you know of any spirits which live in the river?

    a. If you do, would you be willing to tell us about them?

<u>Access Questions</u>

25. How is the access from your town to markets and schools?
    a. Does this influence fishing or your ability to sell fish?
26. What education possibilities do you have here?
    a. Do you have to pay for school?
27. Do you feel like you have good work opportunities here?

<u>Wellbeing Questions</u>

28. What do you find most important for your wellbeing?
29. What negatively impacts your wellbeing?

<u>Ending Questions</u>

30. What do you want to see change in the Sabangau and why?
31. Is there anything else you think we should know?

APPENDIX V

Questionnaire (English version)

Introduction to respondents

The following introduction must be given to each person interviewed:

INTERVIEWER: "Sorry sir /ma'am, I hope that you may let me ask you some questions about the use of fish and how the economical fish is important to you. This will take only your short time. Please understand that these questions are asked purely for research purposes, And that your identity will not be stored or disclosed at any time to anyone for any reason.

You can end the interview at any point should you not want to continue. Do I have your permission to ask these questions?"

Respondent: "Yes"

INTERVIEWER: "Thank you, please answer the following questions as honestly as possible."

There are 5 sections to this interview. To choose which section is relevant to use, see below:

- **A:** Basic information: <u>everyone</u>
- **B:** Use of fish: only people that eat fish
- **C:** Fishers: only people that fish, either recreationally or as a job
- **D:** Selling fish: only people that sell fish
- **E:** Other information <u>everyone</u>

Basic Information (A)

Record (do not ask) the following:

Date of interview:

Interviewer:

Location of interview:

RT / RW / block:

Gender interviewed:

9. How old are you? ……………….years old
   If preferred, the following categories can be used instead.
   a. ≤ 20
   b. 21-30
   c. 31-40
   d. 41-50
   e. ≥ 51
   f. Rather not say

10. Are you married?
    a. Yes
    b. No
    c. Widow/widower
    d. Rather not say

11. How many children do you have?
    a. None
    b. 1
    c. 2
    d. 3
    e. 4
    f. 5
    g. 6
    h. ≥ 7
    i. Rather not say

12. What is your ethnicity?
    a. Dayak KALTENG
    b. Dayak KALTIM
    c. Dayak KALBAR
    d. Dayak KALSEL
    e. Javanese (moved during transmigration)
    f. Javanese (Moved to Palangka Raya after the transmigration program)
    g. Sumatran
    h. Other (namely)…………………….
    i. Rather not say

13. What religion do you follow?
    a. Christianity
    b. Islam
    c. Hindu Kaharingan
    d. Buddhism
    e. Other (namely) ……………………………
    f. Rather not say

14. What is your main livelihood/job? (e.g. Fisher, farmer, shopkeeper, business etc.)
    ....
    ....
    ....

15. What sources of income do you have (check all that apply)?
    a. None
    b. Fishing
    c. Builder
    d. Farmer
    e. Shopkeeper
    f. Bird hunter
    g. Hunting forest animals (Specify animals)..
    h. Gather other forest products (namely)…………………………………………….........................
    i. Other (namely)…………………………………………………………
    j. Rather not say

Use of fish (B)

16. What is your main protein?
    a. Fish
    b. Beef
    c. Chicken
    d. Pork
    e. Eggs
    f. Soy (such as tofu or tempe)
    g. Other (namely)…………………………………………………………….

17. In a week, how much fish do you or your family (please circle the appropriate answer) eat in kilograms?

    …………………………………………… Kg **for:** me/ my family

18. In a week, how much meat do you or your family (please circle the appropriate answer) eat in kilograms?

    ………………………………………….. Kg **for:** me/ my family

19. In a week, how much soy product do you or your family (please circle the appropriate answer) eat in kilograms?

    ………………………………………….. Kg **for:** me/ my family

20. What type of fish do you or your family eat most often:

    ………………………………………………………………………………………………

    for: me/ my family

21. Why do you eat this fish the most often? (Choose all that apply)
    a. Price
    b. Good taste
    c. Good nutrition
    d. Easy to obtain
    e. Other (namely?)…………………………………………

22. How do you obtain the fish you eat? (Choose all that apply)
    a. Buy
    b. Fish myself

c. Get from family members who fish
d. Other (namely?)…………………………………………

Choice A: Go straight to question 15

Choice B: Go straight to question 17 (C)

Choice A and B: Answer all following questions, starting with 15

Choice C and/or D: Go straight to question 45 (E)

Buying fish:

23. Where do you buy your fish?

…………………………………………………………………………………………
………………………………………………………………………………………

24. What is the average amount you pay for fish in one week?

Rp. ....

If participant only buys fish, proceed to question 45 (E)

If participant is a fisher, continue with question 17 (C)

Fishing (C)

25. On which river do you most often go fishing?

……………………………………………………………………………………………
…………………………………………………………………………………………

26. How long have you been a fisher?
    a. Less than a year (≤1 year)
    b. 1-2 years
    c. 3-5 years
    d. 6-10 years
    e. 11-15 years
    f. 16-20 years
    g. ≥ 21 years
    h. Can't remember

27. During this time, have the fish catches changed?
    i. Yes, catches have decreased drastically
    j. Yes, catches have decreased
    k. No, catches have remained stable
    l. Yes, catches have increased
    m. Yes, catches have increased drastically
    n. Don't remember

28. Why do you think this is the case?
……………………………………………………………………………………………
……………………………………..……………………………………………….
……………………………………………………………………………………………
……………………………………..……………………………………………….

21. During this time, has the size of fish that you are catching changed?
    a. Yes, the size has decreased drastically
    b. Yes, the size has decreased
    c. No, the size of the fish has remained stable
    d. Yes, the size of the fish has increased
    e. Yes, the size of the fish has increased drastically
    f. I don't know/can't remember

29. Why do you think this is the case?

....
....

23. If a decrease in catches has been reported by the participant, ask the following:

You say there is a decrease in the number of fish in the river. Do you think the fish need to be conserved in any way?

a. Yes
b. No
c. Don't know

If yes, how do you think they should be conserved?

....
....

24. Are forests important for healthy fish populations?

a. Yes
b. No
c. Don't know

Why/why not?

....
....

25. Where have you caught fish that are breeding or spawning?

....
....

26. What method do you use to catch fish, circle all that are appropriate (if other, specify)?

a. Pancing
b. Kalang
c. Lunta
d. Hancau
e. Rengge
f. Tampirai
g. Lukah
h. Hantai
i. Rawai
j. Salambau
k. Lalangit
l. Pangilar
m. Sungkur
n. Taut
o. Banjur
p. Other (specify)…………………………

26. Rank the method used according to how much you use each method (frequency), write the numbers next to the method: 1) most important, 2) important, 3) medium importance, and so on.

a. Pancing	
b. Kalang	
c. Lunta	
d. Hancau	
e. Rengge	
f. Tampirai	
g. Lukah	
h. Hantai	
i. Rawai	
j. Salambau	
k. Lalangit	
l. Pangilar	
m. Sungkur	
n. Taut	
o. Banjur	
p. Lainya, sebutkan __________	

27. In what month do you go fishing (can tick more than one)?
   a. All year
   b. January
   c. February
   d. March
   e. April
   f. May
   g. June
   h. July
   i. August

j. September
k. October
l. November
m. December
n. varies, but generally start of rainy season
o. varies, but generally end of rainy season
p. varies, but generally start of dry season
q. varies, but generally end of rainy season
r. Varies, does not depend on a season
s. Don’t know

28. During which month do you catch the most fish (can tick more than one)?
    a. January
    b. February
    c. March
    d. April
    e May
    f. June
    g. July
    h. August
    i. September
    j. October
    k. November
    l. December
    m. varies, but generally start of rainy season
    n. varies, but generally end of rainy season
    o. varies, but generally start of dry season
    p. varies, but generally end of dry season
    r. Varies, does not depend on a season
    s. Don’t know

29. What limits your fishing season?
    a. I only fish on certain days (side job)
    b. The amount of fish caught (too low)
    c. Revenue earned (too low)
    d. Other (namely)
    e. Don’t know

30. During the rainy season: On average, usually how many fish do you catch in a week?

    ....fish

31. During the dry season: On average, usually how many fish do you catch in a week?

    ....fish

32. What is the maximum number of fish that have you have caught in a week this season?

....fish

33. What is the average size (kg) of fish you capture in a week?

....kg

34. Do you manage your fishing location in any way to improve the fishing outcome?

....

35. Ideally, would you want to manage a fishing location to improve your catch?
    a. Yes
    b. No
    c. Don't know

If yes, how would you do this?

....
....

36. What type of fish do you prefer to catch?
....

37. Why?

....

38. Is there a fish you will throw away if you catch them (certain species, or e.g. fish with eggs)?
....

Why?
....

39. What do you do with the fish you catch (can tick more than one)?

a. Eat it myself/give to family members
b. Sell (If selected, go to question 40)
c. Other (namely)...

If participant does not sell fish, go to Question 45.

Selling fish (D)

40. Who do you sell fish to?

    ....

41. Approximately, In the rainy season how much do you earn from fishing per week?

    Rp. ....

42. Approximately, In the dry season how much do you earn from fishing per week?

    Rp. ....

43. How much do you earn per year from fishing?

    Rp. ……………………………………………………………………

44. What proportion of your income does this contribute to in a year?
    a. ≤ 20%
    b. 21-40%
    c. 41-60%
    d. 61-80%
    e. 81-100%
    f. Don't know

Other information (E)

45. Do you have any other information that can be useful? (Continue on a separate sheet if necessary):

APPENDIX VI

Statistical results for environmental variables in the Sabangau River

Statistical analysis (Spearman rho, r_s) of the Sabangau River environmental variables, catch-per-unit-effort (CPUE) and Fractional Trophic Levels (FTL).
n=13, (* = p < 0.05, **=p < 0.01, ***=p < 0.001)

	CPUE	FTL	Max. Temp	Av. DO (mg/L)	Av. pH	Av. depth river	Av. secchi disk depth	Av. Temp	Av. rainfall	Av. P	Av. NO3
Max. Temp	0.215	0.187									
Av. DO mg	-0.148	-0.297	-0.495								
Av. pH	-0.121	-0.335	0.107	-0.154							
Av. depth river	-0.571*	0.044	-0.534	0.714**	0.132						
Av. secchi disk depth	-0.5	0.19	0.347	-0.19	0.238	0.119					
Av. Temp	0.049	0.044	0.674*	-0.324	0.253	-0.159	0.357				
Av. rainfall	-0.429	-0.206	-0.51	0.718**	0.297	0.784**	0.108	-0.393			
Av. P	-0.126	0.06	-0.3	0.044	0.121	0.214	-0.238	-0.269	0.523		
Av. NO3	0.184	-0.319	-0.361	0.757**	0.033	0.561*	-0.431	-0.432	0.656*	0.146	
Av. NO2	0.3	0.136	0.085	0.147	-0.107	0.158	-0.024	0.362	-0.204	-0.48	0.192

APPENDIX VII

Fish pond results

Fish pond 1 had the highest number of harvested individual fish at 54, and the least successful was fish pond 4 with only 9 fish harvested. Fish pond 1 also had the highest species diversity, with fish pond 4 (closest to the forest edge) the lowest species diversity.

Table 8.1: Summary data from the fish pond surveys, standard deviation in brackets where appropriate.

Fish pond (distance from river, meters)	Number of fish	Species richness	Sum weight (kg)	Average weight (g)	Max weight (g)	Min weight (g)	Average SL (mm)
1 (39m)	54	11	31.8	590 (±969)	3,600	20	189 (±214)
2 (209m)	46	5	8	175 (±163)	618	0.2	213 (±81)
3 (600m)	38	4	5.7	151 (±365)	2,000	0.2	20 (±86)
4 (971m)	9	2	5.9	656 (±498)	1,500	200	318 (±77)

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