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RESEARCH ARTICLE

Mapping the social impacts of small dams: The case of Thailand's Ing River basin

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Abstract The social impacts of large dams have been studied extensively. However, small dams' social impacts have been largely neglected by the academic community. Our paper addresses this gap. We examine the social impacts of multiple small dams in one upstream and one downstream village in Thailand's Ing River basin. Our research is based on semi-structured interviews with beneficiaries, government and NGOs. We argue that small dams' social impacts are multi-faceted and unequal. The dams were perceived to reduce fish abundance and provide flood mitigation benefits. Furthermore, the dams enabled increased access to irrigation water for upstream farmers, who re-appropriated water via the dams at the expense of those downstream. The small dams thus engendered water allocation conflicts. Many scholars, practitioners and environmentalists argue that small dams are a benign alternative to large dams. However, the results of our research mandate caution regarding this claim.

Keywords Infrastructure · Ing River basin · Small dams · Social impacts · Thailand

INTRODUCTION

Following industrialization, large dams were built at an unprecedented rate (WCD 2000), culminating in over 50 000 large dams today (ICOLD 2016).[1] Recognition of their social and environmental consequences (WCD 2000), coupled with rising demand for irrigation water, flood control and low-carbon energy is driving a search for alternatives to large dams. Small dams are often proposed as a benign alternative. Yet there is limited research on the impacts of small dams, hindering our understanding of their positive and negative impacts.

Claims of the inherent environmental and social sustainability of small dams are widespread. For instance, Bakis and Demirbas (2004, p. 1106) argue that small dams promote economic development, as small hydro is a "clean and environmentally sound means of rural electrification" which can alleviate poverty and enhance economic development and living standards. Paish (2002, p. 537) suggests that small dams are a "cost-effective and environmentally benign" technology for energy production.

However, there is limited understanding and acknowledgement of the social and environmental impacts of small dams (Kelly-Richards et al. 2017), with very few studies examining small dams' impacts empirically (Kirchherr et al. 2016b). The research that has done so reveals that small dams can have significant impacts from a river basin perspective, summarised in Table 1.

Regarding Table 1—aside from Jumani et al. (2017) and Acheampong et al. (2014)—no studies undertake empirical data collection to investigate the impacts of multiple small dams across a river basin considering multiple indicators. Acheampong et al. (2014) focus on dams' economic impacts and the institutional and management characteristics that determine small dams' performance. Jumani et al. (2017) focus on perceived socio-economic impacts and access to resources, as well as human-elephant conflict.

[1] Large dams are defined as over 15 m in height, or between 5 and 15 m and impounding more than 3 million m^3 (ICOLD 2016). While there is no agreed-upon definition of small dams, ICOLD defines small dams as under 15 m in height, a definition which we have adopted for this paper.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s13280-018-1062-7) contains supplementary material, which is available to authorized users.

Table 1 Summary of key literature on the impacts of small dams

Study	Findings
Gleick (1992)	In California, the environmental impacts of multiple small dams could exceed those of one large dam, as large amounts of land are inundated relative to the small amounts of electricity generated
Kibler and Tullos (2013)	The cumulative environmental impacts of small dams on Yunnan's Nu River exceed those of large hydropower dams, including for habitat diversity, sub-basin river connectivity, water quality and disruptions to natural flow regime
Hennig et al. (2013)	Multiple small dams in Yunnan have caused severe dewatering of rivers, with harsh environmental consequences across the watershed
Ersado (2005)	In Ethiopia, the benefits of greater agricultural yields and farm incomes due to improved irrigation were offset by increased waterborne disease incidence
Sharma and Thakur (2017)	In Jammu and Kashmir, small hydropower dams generated negative impacts including damage to fisheries and aquatic ecosystems, inundation of agricultural and forest land and displacement, and increased water-borne disease

Furthermore, as far as we are aware, no studies focus on the differentiated impacts of dams on upstream and downstream communities. This presents a literature gap that we aim to address by answering: what are the social impacts of multiple small dams on an upstream and downstream community in the Ing River basin? We present the first case study that analyses the perceived cumulative social impacts of small dams from an upstream-downstream perspective, focusing on access to and distribution of irrigation water, and how this affects livelihoods, social cohesion and water conflict. This occurs in the broader context of a transition from traditional water management, Muang Fai,[2] to modern small dams. The current lack of empirical data on small dams' social impacts undermines well-informed decision-making regarding small dams. For this, we selected a comparative case study in the Ing River basin, using upstream and downstream villages impacted by development, and the replacement of collectively managed Muang Fai with modern small dams. We undertook 34 semi-structured interviews as our main method of inquiry. The flexibility of this method allowed research participants to shape the discussion within broad research themes, which is useful in an area with limited scholarly research.

Our research finds that the social impacts of multiple small dams are multi-faceted and unequal. The dams are largely perceived as negative for fish abundance and diversity, and positive for flood mitigation. Benefits of increased access to irrigation water are inequitably distributed, with upstream farmers re-appropriating water at the expense of those downstream. The transition from Muang Fai to small dams has eroded traditional collective management. Without institutions to manage water, water allocation is increasingly a zero sum game between upstream and downstream communities, engendering water allocation conflict.

THEORETICAL FRAMEWORK

To systematically analyse small dams' social impacts, we have adopted the matrix framework (Kirchherr and Charles 2016) for two reasons. First, the framework was specifically designed to analyse the social impacts of dams, and is thus highly relevant to our research. Second, the framework captures the range of possible impacts of dam projects as identified in the literature. The matrix framework analyses the social impacts of dams from a 'component' (infrastructure, livelihood and community) and 'dimension' (space, time and value) perspective. The framework has been successfully employed for large dams in empirical work (inter alia) by Owusu et al. (2017) and to analyse literature around small dams (Kirchherr et al. 2016b). We developed an adapted version of the matrix framework to understand the range of impacts of the small dams in our case study (Fig. 1).

Our adapted framework applies the original framework's three main 'components' to our research, first discussing flooding (infrastructure), fisheries, irrigation water and income (livelihoods), and social cohesion and conflict (community). Infrastructure and livelihood impacts of dams are interrelated, which in turn affects social cohesion, as indicated by Kirchherr and Charles (2016). The literature suggests that large dams can provide increased irrigation water to villages downstream from a dam, improving agricultural productivity. However, villages within the vicinity of the dam experience negligible benefits in water availability, suggesting that large dam impacts are inequitably distributed spatially (Duflo and Pande 2007; Strobl and Strobl 2011). Such information on the spatial distribution of benefits is unavailable for small dams, prompting our upstream-downstream analysis of impacts.

[2] *Muang Fai* is the traditional weir and dam irrigation system of Northern Thailand (see Sect. 3.2).

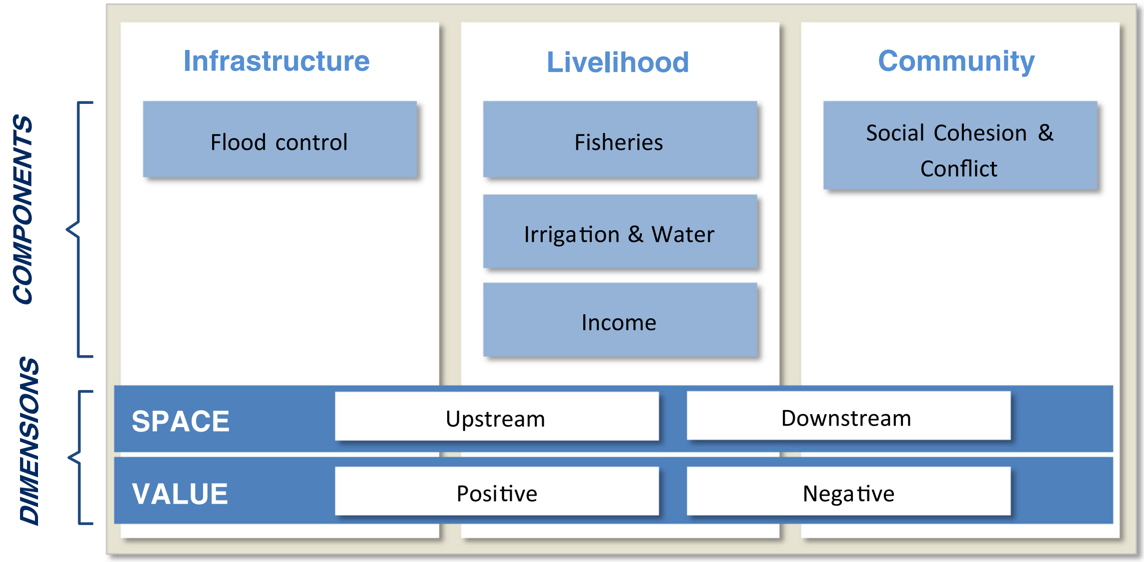

Fig. 1 Adapted matrix framework. *Source* Reproduced with permission from Kirchherr and Charles (2016, p. 7)

CASE STUDY AND METHODS

Dam construction in Thailand and the case of the Ing River basin

It is estimated that there are several thousand small reservoirs in Thailand (Venot and Krishnan 2011). A policy priority for Thailand is to enhance agricultural productivity by constructing small reservoirs and irrigation systems (KoT and FAO 2012, pp. 26–27). Thailand will also pursue small hydropower as part of its energy policy, particularly due to large dam opposition (Chamamahattana et al. 2005; Kirchherr 2017). Thailand aims to expand hydropower capacity from 86 MW to 1608 MW between 2012 and 2021 through “small hydropower systems of downstream irrigation dams” (DAEDE 2012).

The Ing River basin provides a unique case study of the impacts of cascading small barrage dams from an upstream-downstream perspective, in the context of a transition from traditional, collective water management to modern dams. The Ing River is approximately 260 km long and flows through Phayao and Chiang Rai provinces before joining the Mekong. From 2002 to 2006, 14 small dams were constructed in the middle Ing River by the Royal Irrigation Department (RID) (see Fig. 2), replacing Muang Fai. According to the RID, the dams were constructed to increase water storage and to mitigate floods (G1m, interview code explained in Appendix S1). The dams are between 8 and 10.5 m in height. The dam construction consists of a reservoir, with gates to a number of irrigation channels (Fig. 3). We have adopted the term “dam” for simplicity, as water is stored in the “reservoir”. The total area irrigated by the dams is approximately 35 000 rai (5600 ha) (Interview G1m). The 5-m high Phayao Dam regulates inflow into the Ing River from Phayao Lake (N4m).

Muang Fai

Muang Fai has operated in Northern Thailand for approximately 700-years. As the traditional water management system of the area, Muang Fai has been central to the livelihoods and culture of agricultural communities for centuries (Tan-Kim-Yong 1995). The modernisation of irrigation infrastructure and subsequent breakdown of collective management institutions has generated conflict in Northern Thailand (Badenoch 2009). The replacement of Muang Fai with small dams has rendered conflict and social cohesion important areas for analysis when considering ‘community’ impacts.

Muang Fai is a collectively managed irrigation system comprised weirs or diversion dams (fai) and irrigation canals (muang), constructed using local materials (e.g. bamboo, wood, rock). Tan-Kim-Yong (1995) defines Muang Fai as an “ecological unit with boundaries encompassing all the paddy land … irrigated by one weir system” and the farmers tending this land. Muang Fai was managed through community-devised rules governing water allocation and use (Tan-Kim-Yong 1995), including weir building and maintenance in return for water rights and scheduled rice planting during the rainy season only (Surarerks 1986). Farmers were organised into ‘water user associations’ based on canal networks to operate Muang Fai and distribute water equitably (Shivakoti 2000). In Northern Thailand, the traditional rice-farming season is the rainy season, from mid-May to mid-October. Seasonal

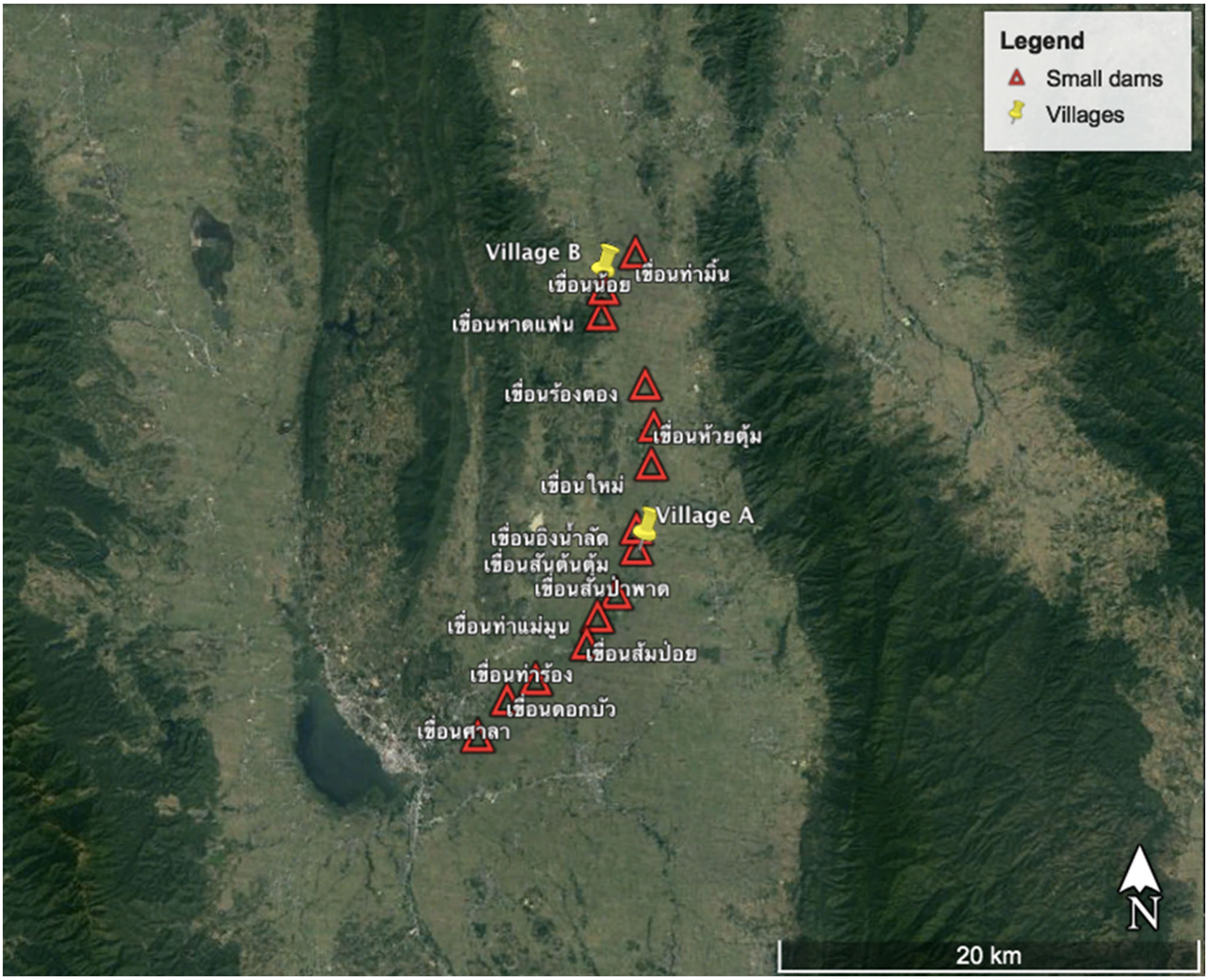

Fig. 2 The Ing River dams and two fieldwork villages. *Source* Reproduced with permission from Google Earth (2016)

water availability has dictated farming practices and social norms for centuries, with cropping patterns developed to mitigate seasonality and dry season water scarcity (Surarerks 1986).

Methods

This research provides a comparative case study of an upstream and downstream village using small dams in the floodplain of a river basin. Comparative case studies are important for building a theory in an area with limited scholarly research (Lijphart 1971). We utilised semi-structured interviews as our main method of inquiry since their flexibility allows the research participant to shape the discussion whilst adhering to broad research themes, i.e. the matrix framework (Bryman 2012, p. 472).

Sites were selected on two criteria: (1) proximity to the small dams and location within the middle Ing floodplain, with these communities most likely impacted by the dams, (2) communities reliant on the dams for agricultural production, with the dams likely to affect their incomes and livelihoods. Based on these criteria, one upstream and one downstream village were identified. Upstream 'Village A' uses Dam 7 and 8 for irrigation, and downstream 'Village B' uses Dams 13 and 14 (Fig. 1). These categorisations of 'upstream' and 'downstream' were used only in the analysis; the same methods and questions were used in each village. According to the Village A head the population of Village A is around 400 people. The Mekong Community Institute (MCI) estimated the population of Village B to be 600 people. Village B was selected as it is located beside Dam 13 and is one of the furthest villages downstream (see Fig. 2). There is only one village further downstream of Village B in the middle Ing floodplain that uses the small dams.

Fig. 3 Dam construction viewed from upstream, looking downstream, showing the low water level in the reservoir. *Source* Author's photo

As a comparative case study, Village A is significantly further upstream than Village B. Respondents from Village A perceived benefits from the dams that are associated with being upstream, including increased access to irrigation water. Village A was chosen as the 'upstream' village as it is part of the Mae Ing sub-district, which is located in the upper section of the middle Ing River. According to the MCI, each sub-district has a sub-committee for water management. The Village A headman represents the upstream villages in the Mae Ing sub-committee, and has an important role in making decisions on their behalf.

Both Village A and Village B were asked the same open-ended interview questions. Thus, participants were unaware of the 'upstream' or 'downstream' perspective. As the interviews were semi-structured, discussions were shaped by the individual's perceived impacts of the dams, e.g. several villagers in Village B complained of upstream water theft, whereas Village A residents often discussed that now they were able to undertake a second rice planting during the dry season due to increased irrigation water.

Based on advice from the MCI, consent was sought from each village head before conducting interviews. Sampling involved three stages: (1) the village head initially nominated three participants; (2) we purposively sampled villagers within the two villages based on four criteria: (i) use of water from the dams for livelihoods, (ii) location of their home or farm near the dams, (iii) roughly equal numbers of males and females, and (iv) residency in their village for at least a decade to have observed changes. 15 of our 34 interviewees were born in their villages, with the remaining 19 residing in their village for 15–70 years. For sampling stage (3), we utilised snowball sampling (Rubin and Rubin 2005). This involved asking interviewees to direct us to houses or farms where participants may meet the aforementioned criteria. All fieldwork was undertaken in the summer of 2016 with the MCI, which has extensive local networks including with village heads, government and NGOs. Our fieldwork coincided with a drought in the Ing River basin and across the region, attributed in part to El Niño (Wangkiat 2016). Interviews requiring translation from the Northern Thai dialect Kam Muang (30 of 34)

Table 2 Interview categories

Stakeholder	No. of interviews	Gender	Age range
Village A, including head	14	F: 6 M: 8	36–77
Village B, including head	10	F: 6 M: 4	36–73
Academia	2	F: 2 M: 0	Not applicable
NGOs	6	F: 1 M: 5	
Government	2	F: 0 M: 2	
Total	34		

F female, *M* male

were conducted with an experienced translator from Chiang Mai University. All interviewees were assured anonymity, as is the standard for similar qualitative, social science research (Hensengerth 2015).

The number of interviews conducted in each village was based on thematic saturation, with interviewing terminated when multiple interviews produced no novel information on key research themes (Fusch and Ness 2015). Research suggests that it is possible to reach thematic saturation after 12–16 interviews (Guest et al. 2006; Creswell 2012).

Key informants (Table 2) were selected based on their expertise on small dams' impacts on aquatic ecosystems and communities, particularly in the Ing River basin. Key informant interviews were undertaken to complement interviews with beneficiaries, which comprises the core data of our research. In the results section, stakeholder groups are presented as separate only when perspectives differ. The research received a favourable ethical opinion from departmental review process at Oxford University prior to implementation.

RESULTS

We start this section with a summary of our core results. The perceived social impacts of the Ing River dams are complex and unequal. Overall, respondents from all stakeholder groups perceived the dams as negative for fisheries and positive for flood mitigation. For irrigation water, perceptions were spatially determined, with the dams perceived as mostly positive for upstream Village A, and overwhelmingly negative for downstream Village B. Water allocation was perceived to be inequitable between upstream and downstream villages, generating conflict (Table 3).

Infrastructure

Small dams mitigate flooding

Most respondents across both villages believed that the small dams in the Ing River basin mitigate flooding. 19 of 23 village respondents suggested the dams have reduced the frequency and severity of flooding: "the dams absolutely alleviate floods, as the gates can be opened to release water" (A4f). This was reported as beneficial for

Table 3 Summary of dam impacts

Overall summary of impacts		
Infrastructure	**Livelihoods**	**Community**
Decreased flooding both upstream and downstream	Decreased fish stocks both upstream and downstream	Upstream-downstream water allocation is inequitable, generating conflict
Increased capacity for water storage in dam reservoirs	Increased seasonal water availability for irrigation upstream.	Lack of rules and institutions to govern water allocation with demise of Muang Fai
Upstream		
Increased access to irrigation water	Increased seasonal water availability, enabling dry season rice farming by 11 of 14 respondents	Increase in water conflict, attributed to downstream impatience, water theft, and failure to follow water-sharing agreements
	10 of 13 respondents are 'better off' overall with the dams	
	9 of 13 respondents reported increased incomes since the dams were built	
Downstream		
Inadequate access to irrigation water.	Inadequate seasonal water availability, with only 4 of 10 respondents undertake dry season rice farming	Increase in water conflict, attributed to over-abstraction of water and water theft upstream
	4 of 10 respondents are 'better off' overall with the dams	
	3 of these 4 reported increased incomes since the dams were built	

livelihoods, as floods less frequently destroy crops and rice fields. Flood mitigation was also highlighted as a key positive impact by both government departments (G1m, G2m). NGO respondents recognised the benefits of dams for flood mitigation, but also noted negative impacts from altering natural streamflow: "wetlands and ecosystems are accustomed to natural flood patterns. Now the wetlands are there but they no longer flood", causing damage to agriculture and aquaculture (N6m). NGOs' perception of negative impacts do not necessarily outweigh flood mitigation benefits. Villagers also highlighted that large dams on the Lancang (Mekong) River alter natural streamflow, negatively impacting their communities, which are adapted to seasonal flooding for agriculture, as also discussed by Molle et al. (2009, p. 405).

Small dams increased irrigation water for upstream beneficiaries

The small dams enhanced the availability of irrigation water for upstream farmers, as dam gates can be closed to block and store water. This enables upstream farmers to undertake rice farming during the dry season. However, downstream farmers reported an insufficient amount of water for irrigation, causing upstream-downstream conflict. This is further explored in Sect. 4.2.2.

Livelihoods

Small dams negatively impact fisheries

Damage to fisheries was highlighted as a key negative impact of the dams across all stakeholder groups. Villagers overwhelmingly believed that the dams have reduced fish quantity and species diversity, corresponding with literature on small dams' negative impacts on fisheries (Ziv et al. 2012; Jumani et al. 2017). Villagers reported five native fish species as 'disappeared' from the Ing River. A local academic (AC1f) reported that one of these species has disappeared, whereas the others are decreasing (Table 4)[3]:

The dam gates were seen as barriers to fish migration: "I observed some fish trying to jump across the dam gates but they could not" (N1m). The Fishery Department (G2m) reported that the key negative impact of the dams was the difficulty for fish to migrate past the dam gates (G2m). There are no fish ladders to assist with fish migration (N1m) and no information could be obtained from the government on why none were installed. One NGO respondent believed fish ladders were not constructed because the government was "not concerned about this, they did not think there would be impacts, and they do not have the budget" (N1m). Respondents highlighted other factors contributing to fishery damage, including invasive species from government breeding experiments (N1m); pesticide overuse and subsequent reduction in water quality (A3m, A10m); and increasing use of advanced fishing equipment (A4f). Overall, stakeholders perceived the dams to negatively impact fish abundance and diversity, although other factors may have also played a role.

Damage to fisheries has impacted villagers' livelihoods. Many villagers changed from mostly catching to mostly purchasing fish for consumption: "Before the dams, I never used to purchase fish. The amount of fish I had, I could raise 10 kids! I prefer to catch and eat fish, but there are never enough fish anymore so now I must purchase them" (A7m). Some villagers reported that they had stopped fishing altogether, while others started fishing elsewhere: "there are less fish and less water to catch them. Because of this, I fish outside my village" (A1f). One respondent highlighted that damage to fisheries reduces protein intake and results in a higher proportion of incomes being spent on food (N1m).

Irrigation benefits were unequally distributed

Irrigation benefits were unequally distributed between upstream and downstream villages. Upstream respondents were generally satisfied with the dams' impacts on irrigation water availability. The dam reservoirs are deeper than run-of-the-river Muang Fai, allowing more water to be stored. 11 of 14 respondents now undertake dry season agriculture for the first time. Most upstream villagers believed that this had improved their livelihoods, with 10 of 13 respondents reporting they were 'better off' with the dams, and 9 of 13 reporting increased incomes. Government respondents agreed, as "now people can do a second harvest—they have more income and … less debt" (G1m). Although 10 of 13 upstream respondents now generally have enough water for irrigation, 7 of these 10 did not have enough water for irrigation in the last two years due to drought.

In contrast, only 4 of 10 downstream respondents engaged in dry season agriculture, and none of the respondents felt they had enough water for irrigation. Only 4 respondents believed they were 'better off' with the dams, with one of these respondents highlighting this was negated when considering fishery damage (B7f). Of these 4, just 3 reported increased incomes due to undertaking a second planting. Another 2 respondents had increased incomes in the rare years they undertook a second planting:

[3] Data on the dams' impacts on fish species and quantities were unavailable, thus gathering this required multiple steps. First, villagers identified disappeared or decreasing fish. Their perceptions were compared with interviews with NGO workers (N1m, N3m) and an academic (A2f). The majority of these species are migratory, and are thus more likely impacted by small dams.

Table 4 Declining and disappeared fish in the Ing River

No.	Scientific Name	Common Name	Status	
			Academic	Villager
1	*Acantopsis* spp.	Long-nosed	Disappeared	Disappeared
2	*Oxyeleotris marmoratus*	Marble gaby	Decreasing	
3	*Trichogaster microlepis*	Moonlight gourami		
4	*Macrognathus siamensis*			
5	*Macrognathus semiocellatus*	Spiny-eel		
6	*Glyptothorax lampris*	Siam giant carp		Decreasing
7	*Trichopsis vittatus*	Snakeskin gourami		

"Water is everything. When we have water, we have food, rice, vegetables and fish. The dams have improved incomes for those who can do a second harvest, but that is not many people" (B7f).

Community

Small dams generated water allocation conflict

Almost all respondents (31 of 33) across all stakeholder groups reported water allocation conflict as a significant negative issue resulting from the small dams. Water conflict coincided with the erosion of Muang Fai collective management. Nascent institutional arrangements are being established to manage new patterns of water use, however to date they have not prevented conflict.

Both villages reflected positively about Muang Fai. 11 of 13 upstream respondents said they had enough water with Muang Fai. However, 7 of these 11 highlighted Muang Fai enabled only one planting annually. All 10 downstream respondents reported that there was enough irrigation water with Muang Fai. Water allocation with Muang Fai was perceived as more equitable by downstream respondents, as there were no gates to block and over-abstract water (HA1, B8f). A common perception downstream is that the dams enabled upstream farmers to over-abstract water: "Upstream villagers block the water for themselves. When it reaches us, there is nothing. The dams have helped upstream to take more water" (B4f). Some villagers (A2f, HA1, B8f, HB1) believed there was less water conflict with Muang Fai, as there were no dam gates to block water upstream, and rules existed for water allocation. The dams have increased the excludability of irrigation water, enabling upstream farmers to re-appropriate water during the dry season.

Water conflict was worse during the dry season. Most respondents agreed that there was limited or no conflict during the rainy season. All 18 villagers who discussed the seasonality of conflict, and both village heads agreed that it was worst during the dry season prior to the second planting, as did key informants (ACf, G1m, G2m). During drought, farmers were unable to undertake a second planting and there was no conflict. With drought, no water is released from Phayao Lake, including in 2015–2016 (G1m), thus "last and this year there were no fights because there is no water" (A5m). Many respondents, including 4 NGO respondents, believed that the small dams have altered traditional agricultural practices (a second annual planting), which benefits upstream farmers. This in turn generates conflict: "Before this, conflict did not exist because there was not enough water for a second crop" (G1m).

Perceptions of why water conflict occurs differed between stakeholders. In upstream Village A, 7 of 14 respondents attributed conflict to impatience and water theft downstream: "We catch them when they [downstream villagers] are sneaking to open the gates, and there are arguments" (A3m). Another reason given was failure to follow the government's recently devised Water Sharing Agreements (WSAs) (A1f, A5m, A6m, HA1), a sentiment also shared by government (G1m, G2m). For downstream Village B, 6 of 10 respondents attributed the conflict to over-abstraction and/or cheating upstream, with many outlining conflict (B1m, B9f, HB1) and inequality (B2m, B4f, B5f) as the key negative impacts of the dams. Without institutions to monitor water use basin-wide, downstream villagers substitute for this by monitoring water use themselves: "We camp overnight at each dam to ensure water flows downstream. Otherwise people close the gates and grab the water … sometimes we stay one week" (B1m). Local NGOs agreed that upstream farmers were violating the WSAs and over abstracting water (N1m, N2m).

The government has attempted to address annual dry season conflict with WSAs; however, these are often ignored upstream: "the RID sets an amount officially, but getting enough water for our farms is most important and then we release water downstream" (A5m). With villagers unable to participate in water governance through the WSAs, the village heads have created a group chat using the Line application (comparable to WhatsApp) on their smart phones to discuss water sharing, including where and when to open the dam gates and water levels. Aside from the heads, no villagers are present in the Line chat group (N4m). To date, neither the WSAs nor the Line chat groups have facilitated equitable upstream-downstream water sharing, as one downstream resident noted: “only in 1 or 2 years has water reached our village. The rest of the years there has been none” (HB1). This may be attributed to limited participation by beneficiaries in devising ‘fair’ water allocation rules that suit their specific context (Ostrom 1990). Similarly, Jumani et al. (2017) conclude that the key reason for small hydropower dams not promoting sustainable development is a lack of participation.

DISCUSSION AND CONCLUSION

The impacts of large dams have been scrutinised (WCD 2000; Scudder 2005; Richter et al. 2010). However the cumulative, and sometimes distributed, effects of small dams are often overlooked (Kibler and Tullos 2013, p. 3114). Our paper addresses this gap by examining the multi-dimensional social impacts of multiple small dams on one upstream and one downstream village in Thailand’s Ing River basin. Our research, along with the emergent literature on small dams, suggests that their impacts are not necessarily benign. With policy decisions to be made as to whether small dams are a viable alternative to large, it is essential that their impacts be considered prior to construction.

Our research suggests that multiple small dams can impose both positive and negative social impacts, and that these impacts are unequally distributed spatially. We found social impacts similar to those identified by scholars examining large dams:

- First, our interviews revealed that small dams are perceived to improve flood mitigation. This is also the case for large dams (Lindström et al. 2012). The negative impacts of large and small dams altering natural flood regimes have also been highlighted (Timpe and Kaplan 2017).
- Second, fish abundance and diversity were perceived to have reduced due to the small dams. This is consistent with literature on small and large dams (Dugan et al. 2010; Ziv et al. 2012). For instance, the construction of Pak Mun Dam saw the extinction of 50 fish species and a decrease in fish catches by 60–80% (Richter et al. 2010; Kirchherr et al. 2016a).
- Third, small dams’ impacts on irrigation and water are unequal and spatially determined. This has also been demonstrated with large dams (Duflo and Pande 2007; Strobl and Strobl 2011). More specifically, the dams provided increased irrigation water and subsequently increased agricultural output and incomes for upstream farmers. Yet these benefits are location dependent, and are partially offset by negative impacts on fisheries. In the Ing River, downstream farmers rarely received enough water for irrigation.

Overall, upstream villagers perceived more positive impacts from the dams, with downstream villagers generally dissatisfied with the dams’ impacts on irrigation, and the demise of Muang Fai. Analysing the differing perceptions of upstream and downstream residents demonstrates that, as with large dams, the impacts of small dams are unequally distributed spatially.

Based on our findings, we make the following three recommendations. First, as the most comprehensive framework to analyse the range of social impacts from dam projects, we recommend that the matrix framework (Kirchherr and Charles 2016) be amended to consider ‘conflict’ under the ‘Community’ component, as in our amended framework (Fig. 1).

Despite increasing evidence of small dams’ impacts such as social conflict (Kelly-Richards et al. 2017), their construction remains largely unregulated (Sharma and Thakur 2017, 688). In Thailand, reservoirs under 100 million m^3 or with a surface area of under 15 km^2 do not require an Environmental and Social Impact Assessment (ESIA). Irrigation projects with an irrigated area of under 80 000 rai (12 800 ha) also do not require an ESIA (ONREPP 2012, p. 82). Our second recommendation is stronger regulation of small dam impacts prior to construction (Kirchherr et al. 2017). As suggested by key informants (N1m, N4m, N6m), this could be achieved through mandating ESIA for small dam projects. ESIA enables specific impacts on socio-ecological systems to be identified (Couto and Olden 2018, p. 98). For instance, negative impacts on fisheries may have been (at least partly) mitigated via fish ladders—a measure that could have been suggested under an ESIA. Our recommendation echoes Sharma and Thakur (2017), and Tortajada (2014, p. 405) who argues that infrastructures’ negative impacts can be largely avoided through best practice ESIA. ESIA could be included as part of basin plan, as conducting separate ESIAs is time consuming and expensive. Furthermore, ESIA should go beyond evaluating individual small dam projects to consider the cumulative impacts of all current and planned projects across a river basin, as part of strategic planning. This would enable specific socio-ecological impacts to be identified and improved impact mitigation prior to construction (Couto and Olden 2018, p. 98).

Finally, clear rules around water sharing should be established to regulate water extraction at each dam. This would prevent upstream communities from over-appropriating water at the expense of those downstream. Clear rules that are context-specific and adaptable are essential for the sustainable management of resources over time (Ostrom 1990). As highlighted by various interviewees (N1m; N2m; N4m; N6m), community participation is essential in devising water allocation rules that are perceived to be 'fair'. Although top-down attempts have been made to formulate new rules in the Ing River basin including WSAs, they have not adequately included community participation in the process. The demise of Muang Fai and subsequent absence of institutions has enabled upstream farmers to over-appropriate water at the expense of those downstream, engendering conflict. Strengthening community institutions (such as the Line Chat group) to support monitoring and enforcement of water sharing rules (for example, WSAs) is essential for more equitable upstream-downstream water sharing (Ostrom 1990).

As discussed, our research suggests that multiple small dams can generate negative social impacts, which are experienced more severely by a downstream community, indicating that impacts may be cumulative. Similarly, the literature suggests that multiple small dams can generate significant cumulative impacts, with Kibler and Tullos (2013) showing that the cumulative impact of 31 small dams exceeds those caused by four large dams when considering per unit of energy generated. Our case study contained 14 dams—it is likely that fewer dams would generate less severe social impacts, with upstream Village A reporting fewer negative impacts than Village B. However, Jumani et al. (2017) found that just 4 small dams generate "numerous unanticipated adverse impacts".

Defining a single 'cut-off' number for how many small dams a river basin can sustain is not feasible. Such a 'cut-off point' will be context-specific. As Couto and Olden (2018) note, diverse dam characteristics (size, inundation area, operation mode and flow modification etc.) combined with the specific social and ecological context in which dams are built, produce unique social impacts. Thus, a methodology to define impacts in such systems would be more appropriate than attempting to define a universal 'cut-off point' for the number of small dams acceptable in a river basin. This is further complicated by the lack of agreement over the definition of small dams (Abbasi and Abbasi 2011).

Our findings should be considered as preliminary since knowledge on the social impacts of small dams remains limited. Our paper entails at least two limitations that could be addressed by future research. First, our case study is context-specific. The Muang Fai system is a particularity of the region, for instance. This warrants caution regarding extrapolation of our findings based on the socio-cultural context, particularly those findings relating to irrigation. Interviewees highlighted that Muang Fai provided sufficient irrigation water that was more equitably distributed, with limited or no water conflict. The loss of Muang Fai led to the over-appropriation of water by upstream farmers at the expense of those downstream, generating conflict. In another context without Muang Fai, there may have already been water allocation conflict prior to small dams, thus the difference pre- and post-dam would be less detectable. Nevertheless, we believe that our research provides valuable new data on a topic with limited scholarly research, and contributes to an emergent body of work on small dams' social impacts. Second, we have not quantified the social impacts found. Hence, we were unable to outline (inter alia) if income benefits due to increased irrigation water for upstream communities are offsetting declines in income due fishery damage. Research in different contexts on small dams' social impacts that quantifies these impacts is an important next research step.

Our research suggests that the negative social impacts of dams are not negligible, and we hope that this study contributes to a discourse and additional research on these negative impacts to ensure that policy decisions on small dams are based on evidence rather than assumptions of their inherent sustainability.

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REFERENCES

Abbasi, T., and S.A. Abbasi. 2011. Small hydro and the environmental implications of its extensive utilization. *Renewable and Sustainable Energy Reviews* 15: 2134–2143.

Acheampong, E.N., N. Ozor, and E. Sekyi-Annan. 2014. Development of small dams and their impact on livelihoods: Cases from northern Ghana. *African Journal of Agricultural Research* 9: 1867–1877.

Badenoch, N. 2009. The politics of PVC: Technology and institutions in upland water management in Northern Thailand. *Water Alternatives* 2: 269–288.

Bakis, R., and A. Demirbas. 2004. Sustainable development of small hydropower plants (SHPs). *Energy Sources* 26: 1105–1118.

Bryman, A. 2012. *Social research methods*, 4th ed. Oxford: Oxford University Press.

Chamamahattana, P., W. Kongtahworn, and R. Pan-aram. 2005. The small hydropower project as the important renewable energy resource in Thailand. *Asian Journal on Energy and Environment* 6: 139–144.

Couto, T.B.A., and J.D. Olden. 2018. Global proliferation of small hydropower plants – science and policy. *Frontiers in Ecology and the Environment* 16: 91–100.

Creswell, J.W. 2012. *Educational research: Planning, conducting and evaluating quantitative and qualitative research*, 4th ed. Boston: Pearson.

Department of Alternative Energy Development and Efficiency (DAEDE). 2012. *The renewable and alternative energy development plan for 25 percent in 10 years*. Bangkok: DAEDE.

Duflo, E., and R. Pande. 2007. Dams. *The Quarterly Journal of Economics* 122: 601–646.

Dugan, J.D., C. Barlow, A.A. Agostinho, E. Baran, G.F. Cada, D. Chen, I.G. Cowx, J.W. Ferguson, et al. 2010. Fish migration, dams, and loss of ecosystem services in the Mekong Basin. *Ambio* 39: 344–348. https://doi.org/10.1007/s13280-010-0036-1.

Ersado, L. 2005. *Small-scale irrigation dams, agricultural production, and health: Theory and evidence from Ethiopia*. World Bank Policy Research Working Paper 3494, January 2005. Washington, D.C: World Bank.

Fusch, P.I., and L.R. Ness. 2015. Are we there yet? Data saturation in qualitative research. *The Qualitative Report* 20: 1408–1416.

Gleick, P.H. 1992. Environmental consequences of hydroelectric development: The role of facility size and type. *Energy* 17: 735–747.

Google Earth 7.1.5. 2016. Ing River Dams. 19°13'31.26"N, 99°59'30.75"E, elevation 398 m.

Guest, G., A. Bunce, and L. Johnson. 2006. How many interviews are enough? An experiment with data saturation and variability. *Field Methods* 18: 59–82.

Hennig, T., W. Wang, Y. Feng, X. Ou, and D. He. 2013. Review of Yunnan's hydropower development. Comparing small and large hydropower projects regarding their environmental implications and socio-economic consequences. *Renewable and Sustainable Energy Reviews* 27: 585–595.

Hensengerth, O. 2015. Global norms in domestic politics: Environmental norm contestation in Cambodia's hydropower sector. *The Pacific Review* 28: 505–528.

International Commission on Large Dams (ICOLD). 2016. World Register of Dams. ICOLD. Retrieved 29 August, 2016, from www.icold-cigb.net/GB/World_register/world_register.asp.

Jumani, S., S. Rao, S. Machado, and A. Prakash. 2017. Big concerns with small projects: Evaluating the socio-ecological impacts of small hydropower projects in India. *Ambio* 46: 500–511. https://doi.org/10.1007/s13280-016-0855-9.

Kelly-Richards, S., N. Silber-Coats, A. Crootof, D. Tecklin, and C. Bauer. 2017. Governing the transition to renewable energy: A review of impacts and policy issues in the small hydropower boom. *Energy Policy* 101: 251–264.

Kibler, K.M., and D.D. Tullos. 2013. Cumulative biophysical impact of small and large hydropower development in Nu River, China. *Water Resources Research* 49: 3104–3118.

Kingdom of Thailand (KoT) and FAO. 2012. *Country program framework 2012–2016 for Thailand*. Rome: FAO.

Kirchherr, J. 2017. Strategies of successful anti-dam movements: Evidence from Myanmar and Thailand. *Society and Natural Resources*. https://doi.org/10.1080/08941920.2017.1364455.

Kirchherr, J., and K. Charles. 2016. The social impacts of dams: A new framework for scholarly analysis. *Environmental Impact Assessment Review* 60: 99–114.

Kirchherr, J., T. Pomun, and M.J. Walton. 2016a. Mapping the social impacts of 'Damocles Projects': The case of Thailand's (as yet unbuilt) Kaeng Suea Ten Dam. *Journal of International Development*. https://doi.org/10.1002/jid.3246.

Kirchherr, J., H. Pohlner, and K.J. Charles. 2016b. Cleaning up the big muddy: A meta- synthesis of the research on the social impact of dams. *Environmental Impact Assessment Review* 60: 115–125.

Kirchherr, J., N. Matthews, K.J. Charles, and M.J. Walton. 2017. "Learning it the hard way": Social safeguard norms in Chinese-led dam projects in Myanmar, Laos and Cambodia. *Energy Policy* 102: 529–539.

Lindström, A., Granit, J., and Weinberg, J. 2012. Large-scale water storage in the water, energy and food nexus: Perspectives on benefits, risks and best practices. SIWI Paper 21. Stockholm: SIWI.

Lijphart, A. 1971. Comparative politics and the comparative method. *The American Political Science Review* 65: 682–693.

Molle, F., T. Foran, and M. Käkönen. 2009. *Contested waterscapes in the Mekong Region: Hydropower, livelihoods and governance*. London: Earthscan.

Office of Natural Resources and Environmental Policy and Planning (ONREPP). 2012. *Environmental impact assessment in Thailand*. Bangkok: Ministry of Natural Resources and Environment.

Ostrom, E. 1990. *Governing the commons: The evolution of institutions for collective action*. Cambridge: Cambridge University Press.

Owusu, K., P.W.K. Yankson, A.B. Asiedu, and P.B. Obour. 2017. Resource utilization conflict in downstream non-resettled communities of the Bui Dam in Ghana. *Natural Resources Forum*. https://doi.org/10.1111/1477-8947.12139.

Paish, O. 2002. Small hydro-power: Technology and current status. *Renewable and Sustainable Energy Reviews* 6: 537–556.

Richter, B.D., S. Postel, C. Revenga, T. Scudder, B. Lehner, A. Churchill, and M. Chow. 2010. Lost in development's shadow: The downstream human consequences of dams. *Water Alternatives* 3: 14–42.

Rubin, H.J., and I.S. Rubin. 2005. *Qualitative interviewing: The art of hearing data*, 2nd ed. Thousand Oaks: SAGE Publications.

Scudder, T. 2005. *The future of large dams: Dealing with social, environmental, institutional and political costs*. London, UK: Earthscan.

Sharma, A.K., and N.S. Thakur. 2017. Assessing the impact of small hydropower projects in Jammu and Kashmir: A study from north-western Himalayan region of India. *Renewable and Sustainable Energy Reviews* 80: 679–693.

Shivakoti, G.P. 2000. Participatory interventions in farmer managed irrigation systems in Northern Thailand: Dynamism in resource mobilization. Paper presented at the 8th conference of the international association for the study of common property, Bloomington, Indiana, May 31–June 4, 2000.

Strobl, E., and R.O. Strobl. 2011. The distributional impact of large dams: Evidence from cropland productivity in Africa. *Journal of Development Economics* 96: 432–450.

Surarerks, V. 1986. *Historical development and management of irrigation systems in Northern Thailand*. Chiang Mai: Chiang Mai University.

Tan-Kim-Yong, U. 1995. *Muang-Fai communities are for people: Institutional strengths and potentials*. Bangkok: Chulalongkorn University.

Timpe, K., and D. Kaplan. 2017. The changing hydrology of a dammed Amazon. *Scientific Advances*. https://doi.org/10.1126/sciadv.1700611.

Tortajada, C. 2014. Dams: An Essential Component of Development. *Journal of Hydrologic Engineering*. https://doi.org/10.1061/(ASCE)HE.1943-5584.0000919.

Venot, J.P., and J. Krishna. 2011. Discursive framing: Debates over small reservoirs in the Rural South. *Water Alternatives* 3: 316–324.

Wangkiat, P. 2016. Farmers look for long-term solutions. *Bangkok Post*, May 1st, 2016.

World Commission on Dams (WCD). 2000. *Dams and development: A new framework for decision-making*. Earthscan: The Report of the World Commission on Dams. London.

Ziv, G., E. Baran, S. Nam, I. Rodríguez-lturbed, and S.A. Levin. 2012. Trading-off fish biodiversity, food security and hydropower in the Mekong River Basin. *Proceedings of the National Academy of Sciences of the United States of America* 109: 5609–5614.

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