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# In a network of lines that intersect: The socio-economic development impact of marine resource management and conservation in Southeast Asia

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ABSTRACT

Marine protected areas (MPAs) are rapidly spreading to meet global conservation targets, but new governance arrangements can have unintended impacts on socio-economic development that can undermine and counteract their intended outcomes. We use an exploratory mixed-method research design to understand these development impacts and their underlying mechanisms, guided by an innovative activity space framework that situates marine resource management and conservation in a network of relationships between communities, human services, and nature.

Qualitative research – based on 22 interviews in Koh Sdach Archipelago, Cambodia – demonstrates how the local community experienced improving relationships with the state and a slowing deterioration of marine resources, but also social division, heightened livelihood anxiety, and potentially a false sense of economic security. We hypothesise on this basis that marine conservation could impede socio-economic development, for which we find support in our quantitative analysis across Cambodia, the Philippines, and Timor-Leste: MPAs materialised in better-off communities but were associated with slower and partly regressive socio-economic development, in particular decreasing wealth and increasing child mortality.

These findings suggest that the rapid global expansion of MPA coverage in its current, environmental-conservation-focused form is problematic as it disregards local social realities. Livelihood adaptation support should complement the implementation of marine resource governance mechanisms to mitigate unintended negative consequences.



## 1. Introduction

The world is facing a marine conservation emergency. The global share of overexploited fish stocks in terms of biologically unsustainable extraction increased from 10% to 34% between 1974 and 2017 (FAO, 2020). The *Global Assessment Report on Biodiversity and Ecosystem Services* of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services further predicts that worldwide marine seafood production will be increasing by 17% between 2013 and 2025 (Díaz et al., 2019). The intensifying anthropogenic activity does not only increase unsustainable pressure on fish stocks, but it will also accentuate climate-change-induced risks to marine biomass and diversity (Lotze et al., 2019).

The scale of this problem has made marine protection a global priority, and policy responses have been dominated by the rapid expansion of numerical targets for marine protected area (MPA) coverage. For example, the Millennium Development Goals formulated a target of 8.4% of coastal marine area protection globally by 2014, the Sustainable Development Goals expanded the target to 10% by 2020, and policy aspirations now reach into 30–50% global marine area protection by 2030 (Humphreys & Clark, 2020a; United Nations, 2020). Yet, the evidence of the success of marine

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protection is patchy (Humphreys & Clark, 2020a; Savage et al., 2020). Scholarship surrounding MPAs has focused predominantly on pragmatic questions of effectiveness and key success factors (Di Franco et al., 2016), whereas our understanding of the "human dimension" of marine conservation (and marine resource management more broadly) and its unintended socio-economic consequences remains nascent and inconclusive (Ban et al., 2019; Gill et al., 2019). Such consequences can include for instance political instrumentalisation or a redistribution of social and financial capital in affected communities, and, if neglected, potentially undermine and counteract the primary outcomes of marine conservation.

In response to this persistent research gap, our research question asked, "*What are the socio-economic consequences of marine resource management and conservation?*" To contribute to the understanding of potential pathways through which marine management interventions affect human livelihoods, we built on political science and sociological research that problematises the unintended consequences of new policies and governance arrangements, and which is commonly employed in international development research (Ferguson, 1994; Lipsky, 2010; Mosse, 2004). We considered marine resource management and conservation broadly (encompassing formal MPAs as well as community resource management systems, see "Research Design" Section 3.1 for details) and situated it conceptually in a network of relationships between communities, human services, and nature. Our geographical focus was on Southeast Asia as a high-priority region for marine protection and especially on Cambodia, whose coastal waters were at "high risk" of overfishing (Burke et al., 2002; Hamilton, 2012; Savage et al., 2020). Our study thereby (a) broadens the methodological toolkit of interdisciplinary conservation research in the context of sustainable development, (b) it enables a comprehensive conceptual framing of MPAs as a relational phenomenon, (c) we contribute to the empirical understanding of the mixed and at times problematic socio-economic development implications of marine protection, and (d) we feed into ongoing work of Cambodian governmental and non-governmental organisations to both strengthen sustainable fisheries management and build multi-use MPAs that represent community interests and socio-economic needs.

## 2. Background and analytical framework

The empirical literature of marine resource management and conservation is understandably concerned with the impact on biodiversity, economic consequences of changing natural resource use, good governance and compliance, and the factors contributing to successful implementation, placing geographical emphasis especially on high-income settings such as Europe and North America (Arias et al., 2015; Bennett & Dearden, 2014a, 2014b; Bresnihan, 2019; Di Franco et al., 2016; Gall & Rodwell, 2016; Humphreys & Clark, 2020b; Ngoc, 2018; Pantzar, 2020; Yang & Pomeroy, 2017). A detailed synthesis of this work is not necessary in light of recent reviews and collected volumes (see e.g. Humphreys & Clark, 2020a). In overarching terms, this literature tends to be (a) broadly in agreement about the need for marine protection (considering its perceived benefits for environmental conservation) but also (b) sceptical about the effectiveness of a rapid nominal expansion of MPAs globally, (c) debating the potential livelihood outcomes for affected communities, and (d) divided between anthropo- and eco-centric concerns (Balata & Williams, 2020; Ban & Frid, 2018; Humphreys & Clark, 2020b).

In addition to the intended consequences of marine protection, well-being and livelihood outcomes as secondary objectives or unintended consequences have been foregrounded in a growing body of work as well (Blount & Pitchon, 2007; Bresnihan, 2019; Charles & Wilson, 2008; Christie, 2004; Fiske, 1992; Foale & Manele, 2004; Jentoft et al., 2007; Johnson et al., 2019; Lau et al., 2020; Linh et al., 2021; Raycraft, 2020; Walley, 2004; West et al., 2006). Recent reviews of this literature have highlighted modestly positive socio-economic outcomes, but they also stress that impacts on human livelihoods are mixed and likely heterogeneous, and that our understanding of these impacts remains limited because of a lack of (a) mixed-method research, (b) studies that consider the multidimensionality of socio-economic development outcomes, and (c) conceptual discussion of the mechanisms leading to the emergence of these outcomes (Ban et al., 2019; Gill et al., 2019; McKinnon et al., 2015).

However, critical and interdisciplinary perspectives in this field have in common that they consider MPAs and other forms of community resource management as relational concepts embedded in broader governance arrangements that regulate the relationships among and across local populations, administrations, and nature (Jentoft et al., 2007; West et al., 2006). In our conceptual framing of the socio-economic consequences of marine resource management and conservation, we built on this relational notion and complemented it with sociological and political science work on policy implementation dynamics to formulate our analytical framework – depicted in Fig. 1.

In this framework, relational elements within the "local population" are visible in phenomena such as MPA-induced conflict, tension, collaboration, but also evolving gender relations within communities (Christie, 2004; Frangoudes & Gerrard, 2019). Cross-domain interactions between populations and administrations ("human services") materialise when marine protection is instrumentalised to criminalise social groups or to secure "elite control" over lands and waters (Christie, 2004; Fiske, 1992; West et al., 2006). Ethnographic research by Raycraft (2020:7) in a coastal Tanzanian marine park documented for example how "village residents have come to perceive the [marine] park and the introduction of regulations as assertions of state power over their everyday lives." Marine resource management – by definition – also influences and regulates the relationship between populations and the natural space (Blount & Pitchon, 2007). Common examples are the control of extractive practices, the displacement of communities, or new ways of navigating space through imagined as well as physical boundaries (Bresnihan, 2019; Mascia & Claus, 2009; West et al., 2006). Alternative governance arrangements of space do not only influence how space is "valued" and commodified but also how people derive meaning from their environment (Charles & Wilson, 2008; Fiske, 1992; Johnson et al., 2019; West et al., 2006).

Marine resource management and conservation is not a unique case in these terms. Human interactions and their environmental behaviour have always been shaped by social institutions, technologies, and physical objects (Miller, 2010). New governance arrangements such as MPAs or community fisheries are thus always introduced into a network of solutions and policies with which they interact and interfere (depicted at the centre of Fig. 1 and also referred to as "activity space," see Haenssgen et al., 2018a, 2018b). Balata and Williams (2020) relate to this point by outlining that the rule set of MPAs can conflict with prevailing economic policies, which can create contradictory guidelines and expectations for communities and local-level administrators. The wider emphasis on traditional and indigenous knowledge in marine resource management also underscores that unwritten and widespread sets of rules and norms often already govern people's interactions with marine spaces (Ban & Frid, 2018; Gammanpila et al., 2019), with which formal management and conservation arrangements become "entangled" (Lau et al., 2020:3). If neglected or ignored, such entanglement can entail unforeseen behaviours

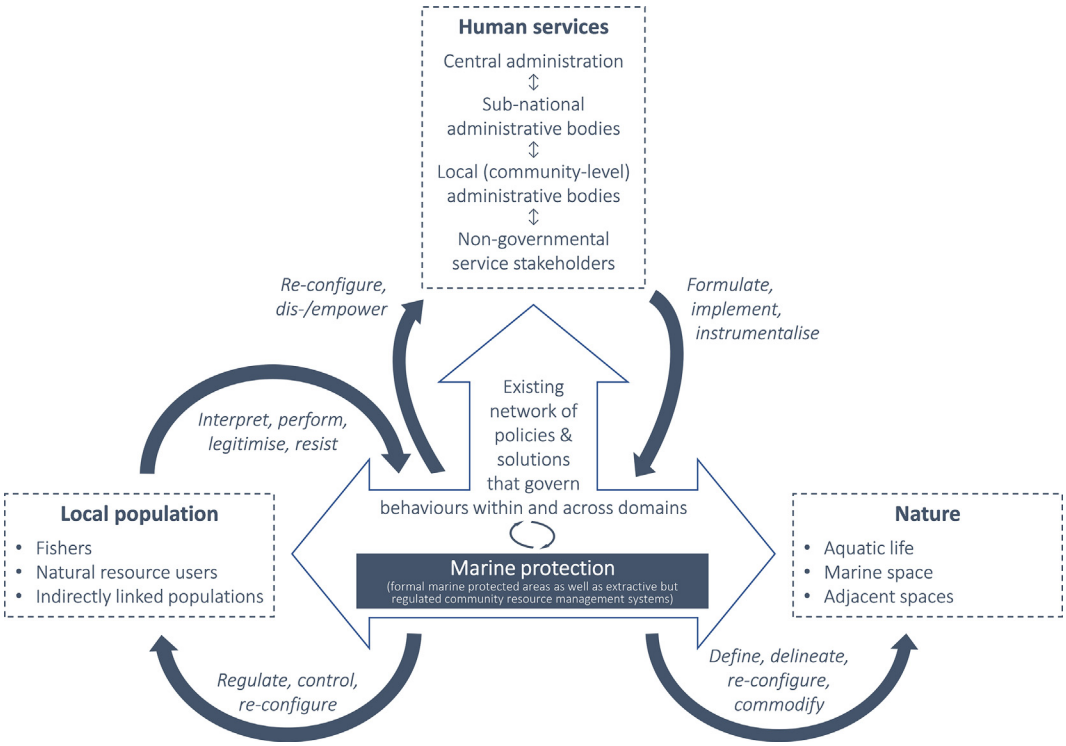


**Fig. 1.** Conceptual framework of marine protected areas as a relational problem. Source: Authors, adapted from Haenssgen *et al.* (2018a). *Notes.* Domain examples are not exhaustive and for illustration only. Marine protected areas conceptualised as additional and interacting element in a given network of policies and solutions.

(e.g. resistance) or potentially ineffective marine protection efforts (Foale & Manele, 2004; Lau et al., 2020), but customary institutions can also be the basis for designing locally appropriate forms of marine protection (as is e.g. currently being practised in the development of a Marine Fisheries Management Area in Cambodia).

More broadly, the emergence and implementation of a formal policy (e.g. the declaration of an MPA) has long been understood to be subject to policy makers' attention, stakeholder interactions, power struggles among stakeholders, and windows of opportunity (Baumgartner & Jones, 1991; Cairney & Jones, 2016; Etzioni, 1999; Walley, 2004). However, a policy successfully formulated on paper still needs to be translated and re-negotiated on several levels along the implementation chain (Lipsky, 2010; Mosse, 2004). Observations such as "resistance" to or "non-compliance" with marine protection can therefore not easily be reduced to issues of "public perception" or "a lack of understanding" of what marine protection is about, but rather represent the outcome of policy implementation dynamics and a sometimes subtle response to reconfiguration, interferences, and incompatibility between new and existing solutions connecting local populations, human services, and nature (Coupaye, 2009; Johnson et al., 2019; Latour, 2005; Raycraft, 2020). In short, marine resource management interventions introduce changes to a system which re-configure relationships among and across populations, human services, and nature. This reconfiguration need not necessarily fail or be a bad thing, but it can entail unintended consequences that impact the socio-economic development of local communities (Walley, 2004).

Thus far, most studies of the "human dimension" of marine resource management and conservation have mobilised in-depth ethnographic and cross-sectional qualitative designs (Bresnihan, 2019; Lau et al., 2020; Raycraft, 2020; Walley, 2004), single and comparative case study research (Andrade & Rhodes, 2012; Charles & Wilson, 2008; Christie, 2004; Di Franco et al., 2016; Fiske, 1992; Frangoudes & Gerrard, 2019; Gjertsen, 2005; Pantzar, 2020), and/or survey questionnaires in combination with expert interviews to ascertain attitudes and practices of affected communities (Arias et al., 2015; Bennett & Dearden, 2014b; Gall & Rodwell, 2016; Hamilton, 2012). All these research designs are important to understand the "human dimension" of marine protection and its un-/intended socio-economic impacts, but they are also limited by scale and international comparability and dominated by a limited range of economic and governance indicators (Ban et al., 2019; Gill et al., 2019). We build on our conceptual framework and use a qualitative case study of marine protection in Cambodia in combination with secondary household survey data from across Southeast Asia to inform this research gap. The qualitative work helps to explore and map out the interactions between the elements of our conceptual framework and to formulate expectations of socio-economic impact on this basis, while the quantitative component enables us study these outcomes at a regional scale and over a time horizon that qualitative research does not normally permit.

## 3. Methods

### 3.1. Research design

Our work responds to methodological gaps in the literature relating to the limited scale and international comparability of the multi-dimensional development outcomes of MPAs (Ban et al., 2019; Gill et al., 2019). We employed an exploratory and sequential mixed-method research design with a first qualitative and second quantitative stage, which were partially integrated in the analysis and interpretation stages of the study (Creswell et al., 2008; Leech & Onwuegbuzie, 2009; Teddlie & Tashakkori, 2009). The first stage applied our conceptual framework and interrogated pathways through which socio-economic outcomes of marine resource management materialise, using a qualitative case study of the Koh Sdach Archipelago in Cambodia – a country systematically under-researched in the human impact of marine resource management (Ban et al., 2019; Gill et al., 2019).

Stage two involved a policy exposure assessment to quantify multidimensional socio-economic impacts at a regional scale and over time (Haenssgen, 2017), thereby helping to understand how the counteracting forces within individual MPAs resolve and responding directly to methodological gaps highlighted in the recent reviews by Ban et al. (2019) and Gill et al. (2019). We focused geographically on Southeast Asia as a priority region for marine resource conservation that, however, has struggled with balancing marine protection against a challenging political climate and often competing objectives of economic development (Savage et al., 2020). The region also has high significance in international tourism as it accounted for 9% of global air passengers and 110 million international tourist arrivals in 2016 (World Bank, 2021). Our assessment utilised all available geo-coded and multi-year Demographic and Health Survey data from Southeast Asian countries; that is, from Cambodia, the Philippines, and Timor-Leste.

The empirical link between qualitative and quantitative components of this study is indirect: although the Koh Sdach site had not yet been included in the database used for the quantitative assessment, it is a setting that is currently developing a coastal MPA (i.e., Marine Fisheries Management Area) and therefore enables an insight into the early development context of MPAs and the setting in which they are implemented (as opposed to studying e.g. a mature MPA as existing research has done extensively). Our combination of a micro-level qualitative study and a macro-level quantitative assessment thereby enables us to combine the strengths and overcome the challenges of either approach: Cross-sectional qualitative analysis can enrich our understanding of the social realities of marine conservation and *how* socio-economic consequences could materialise from the early stages of an MPA onwards, but alone it would be unsuitable to conclude how different and potentially counteracting forces resolve into un-/intended development impacts over time and at scale (e.g. the implications for changing household wealth for child mortality) (Ban et al., 2019). In contrast, the quantitative analysis enables insights at scale but it would be based on inappropriately simplistic and ungrounded interpretations without the preceding qualitative exploratory phase (Teddlie & Tashakkori, 2009).

Our definition of marine resource management pertains to community fishery organisations (CFis) in Cambodia as a tenure instrument to enable local community participation in sustainable management of fisheries resources, whereas we refer to marine resource conservation arrangements as formally recognised MPAs as recorded in the World Database on Protected Areas (WDPA; Day et al., 2019; Thomas et al., 2014; UNEP-WCMC, 2019). As a community fishery organisation that was in the process of being converted into a nationally recognised MPA (Kurien, 2017), the case study of Koh Sdach therefore lent itself well to a consistent examination of the site-specific conditions and pathways through which marine resource management and conservation interventions may entail socio-economic outcomes.

### 3.2. Qualitative case study

#### 3.2.1. Case context

We studied the case of the Koh Sdach Archipelago in Cambodia (see map in Fig. 2) to assess current community fisheries management approaches and impacts, thereby also helping to inform the local MPA design and management.[1] Within Southeast Asia, Cambodia had historically attributed relatively low priority to marine protection although its reefs had been at "high risk" of overfishing (Burke et al., 2002; Hamilton, 2012; Savage et al., 2020). Koh Sdach introduced community-based fishery management in 2013 (see Section 4.1.1 for details) and is currently in the process of developing a Marine Fisheries Management Area.

The Kingdom of Cambodia is a lower middle-income and post-conflict country situated at the Gulf of Thailand. Table 2 compares the Cambodian context against two regional peers whom we analyse as part of the quantitative component of this study: the Philippines and Timor-Leste. Cambodia represented with 0.2% of its territorial waters the smallest share of marine protection according to WDPA and World Bank data (Ream national park [est. 1995], Koh Kapik and associated islets [est. 1999]; ProtectedPlanet, 2020; World Bank, 2021). However, the rapid expansion of fishing activities in the Gulf of Thailand alongside the disappearance of coastal habitats prompted a growing regional interest in marine conservation in the years preceding the case (Nasuchon & Charles, 2010). Cambodia had for instance increased its marine fish production volume by 331% since 2000, although its marine fish production in 2018 remained a fraction of its regional peers and corresponded for instance only to 0.9% of Indonesia's production volume (the largest marine fish producer in Southeast Asia) (FAO, 2021).

Table 2 further summarises Cambodia's development indicators, which presents a somewhat encouraging statistical picture relative to the Philippines and Timor-Leste (having e.g. slightly lower poverty and child mortality rates, albeit socio-economic indicators in the Philippines tend to be slightly better overall). However, as a post-conflict country, the context of Cambodia continues to reflect the recent political history of the region. Cambodia's period of the Democratic Kampuchea 1975–1979 (also known as Khmer Rouge or *samay Pol Pot*) and its history of violence until the late 1990s entailed significant loss of human life and livelihood, caused lasting disruption of education and health services provision, and fundamentally shaped people's relationship with the government (de Walque, 2004, 2006; Kiernan, 2002; Ovesen & Trankell, 2010). A period of political stability coupled with initiatives to attract foreign capital for infrastructure investments had put Cambodia on a more encouraging development trajectory, but the latter have also exposed the country to new pressures from land grabbing, forced displacement, and ethnic tensions (Neef & Siphat, 2016; Neef, 2019). The persistently challenging development context of Cambodia has underscored the importance of considering socio-economic outcomes of marine resource management and conservation.

At the time of this case study, Cambodia had 502 freshwater community fisheries (CFis) and 59 coastal community fisheries. One of the coastal CFis was our study site (the Koh Sdach Archipelago), established in 2013 with external support over the years from researchers and international non-governmental organisations (iNGOs, in particular Shallow Waters). The first coastal MPA, known as Marine Fisheries Management Area, was declared in the Koh Rong Archipelago in 2016 (based upon existing CFis); a second having been in development in the neighbouring Koh Sdach Archipelago (Savage et al., 2013, 2014). A coral reef assessment of Koh Sdach found it to be in "comparatively better condition than the nearby Koh Rong Archipelago" but nonetheless recommended the initiation of conservation efforts (Savage et al., 2014:53).

The case study site was situated in Koh Kong province, which represented the median wealth among all Cambodian provinces in 2014 (DHS data). The administrative region of Koh Sdach (i.e. "Koh Sdach Commune") was located 1 km off the coast of the Botom Sakor national park and had a total population of 4050 people in 2018 (Kingdom of Cambodia, 2019), the main occupation

[1] The research was reviewed and approved by the University of Warwick Humanities and Social Sciences Research Ethics Committee (Ref. HSS 71/18–19). Access to participants was facilitated through local stakeholders and by personal introduction to the community leader of Koh Sdach. Participation in the research was entirely voluntary, for which we obtained and documented informed consent. The participants were not financially incentivized.

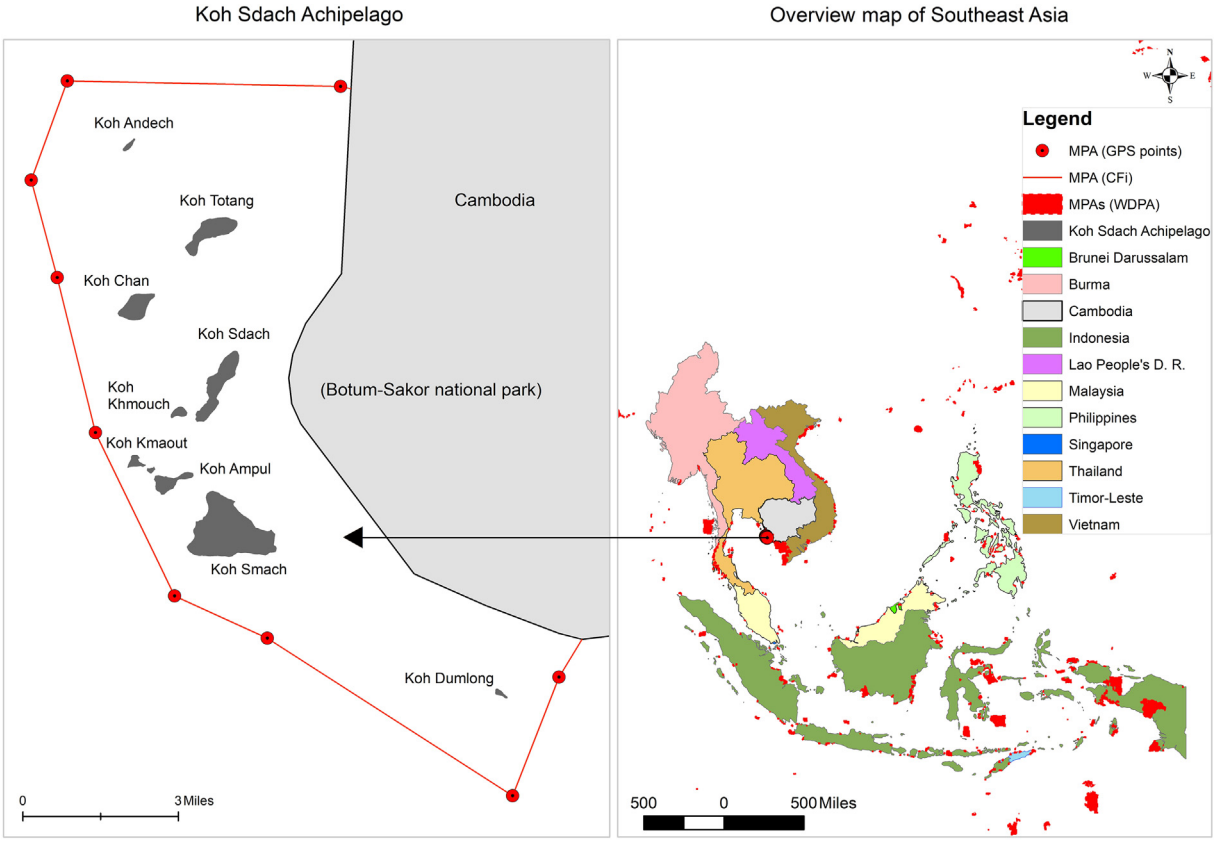


**Fig. 2.** Overview map of Koh Sdach Archipelago within Southeast Asia, including boundaries of community fishery (red, left panel) and other Southeast Asian marine protected areas (red, right panel). Sources: Authors, based on Savage (2017, Koh Sdach community fishery organisation boundaries), World Database on Protected Areas (https://www.protectedplanet.net/c/world-database-on-protected-areas, regional MPAs), https://www.openstreetmap.org/ (Koh Sdach achipelago), and http://thematicmapping.org/ (country boundaries). *Notes.* Areas depicted for simplicity as "marine protected areas" (MPAs) as per WDPA database classification.

being fishing. Its main island Koh Sdach had a population of 2400 people (incl. 29 people of Vietnamese descent and 100 "migrant" Thai speakers according to government statistics)[2] and was divided along occupational boundaries that visibly segment the island.[3] The main island was the seat of the District, Commune, and CFi administration; and it hosted a local primary and secondary school as well as a health centre. The island was also on the main shipping route between Thailand, Cambodia, and Vietnam, allowing extensive import and export opportunities. As a result, the Koh Sdach community was better situated economically and institutionally than most small coastal villages in the region (Drbohlav & Hejkrlik, 2018).

Like much of Cambodia, Koh Sdach and Koh Kong province had been subjected to pressures from international investment. Parts of the neighbouring Botom Sakor national park on the mainland had been sold in 2008 to create a US$ 4bn commercial development and tourism space (Siphat, 2015). While this may boost nominal economic output and infrastructure development, it also entailed the relocation of more than 1000 households across 12 coastal fishing villages further inland – accompanied by protest, official complaints, and disruption of local livelihoods (Drbohlav & Hejkrlik, 2018; Siphat, 2015). With Koh Sdach having been a local administrative and human services hub, the displaced populations also suffered more difficult access to education and health services (Neef, 2019). In short, the socio-economic context of Koh Sdach Archipelago was relatively developed compared to other coastal fishing settings in Cambodia, whereas its neighbouring communities were adversely affected by disruptions from land disputes and displacement.

### 3.2.2. Data collection and analysis

Qualitative research took place in April 2019, using semi-structured interviews with community members and key stakeholders (Haenssgen, 2020). The main themes of the stakeholder interview guides included (a) the introduction of new programmes in an existing policy context, (b) policy implementation dynamics, (c) un/intended policy consequences, and (d) the everyday practices and strategies of the policy implementers. Community mem-

[2] Unfortunately, Cambodian national and local statistics (as well as latest DHS data) provide only relatively limited ethnic diversity information. For further indication, a previous small-scale survey on the island included 3 out of 20 Thai-speaking participants (Savage et al., 2017), whereas our qualitative data included 5 Thai-speaking respondents in a maximum variation sample of 15 community respondents.

[3] The main island is divided into four main segments, three of which are inhabited: Firstly, *Kbal pia* or *pia Royal* (Head pier or Royal pier) is located in the northern part of the Koh Sdach and dominated by speed boat ferries and pot fishing as main occupations, plus street vendors. Secondly, *Phum Kandal* (Center of village) is the most populated area and located at the centre of the island. This area contains the public school, offices, the Commune office, a traditional market, the health centre, a dry dock, and other infrastructural facilities. Thirdly, *Chung Phum* (End of village) reaches from the centre to the southern end of Koh Sdach. This area comprises two piers owned by relatively influential villagers, and other people living in this area mostly engage in squid and crab fishing. This area also comprises the main share of Thai and Vietnamese minority groups. Lastly, *Krouy Koh* (Behind island) is an uninhabited area located in the western part of the island, comprising a guesthouse area and recreational space for many villagers. Note further that the village on Koh Sdach was cleared during the Khmer Rouge regime, and later recolonised.

ber interviews focused on the lived experiences and consequences of marine protection. Our sampling procedure was purposive to ensure variation of the respondents in terms of marine protection experience and their general livelihood (Haenssgen, 2020). We conducted 22 face-to-face semi-structured interviews (15 local community members, 5 local stakeholders, 2 sub-/national stakeholders), which were documented through field notes and audio recording where permitted by the participants (17:32hrs total duration). Whereas with 6 out of 7 the majority of the stakeholders were male (average age: 49), the community interviews had a more balanced sex ratio of 8 men and 7 women (average age: 44). The research team comprised local and international researchers (including a Koh Sdach resident) and the interview language was Khmer, Thai, or English, depending on the language ability of the participant. The English-language version of the semi-structured interview guides can be found in the Supplemental Material.

We used thematic qualitative analysis to identify responses that corresponded to the framework categories and to derive unforeseen new categories from the interview records (Lapadat, 2010) – especially in view of the probable unintended consequences of introducing a new governance arrangement. The analysis was conducted by the lead social researcher of the project team; all research team members reviewed and validated the analysis. The qualitative data analysis took place using NVivo 11 (QSR International, 2017).

### 3.3. Quantitative assessment

#### 3.3.1. Data

We accessed all available geo-coded Demographic and Health Surveys (DHSs; https://dhsprogram.com/) across Southeast Asia, which comprised ten data sets, namely Cambodia (2000, 2005, 2010, 2014), Myanmar (2015), Philippines (2003, 2008, 2017), and Timor-Leste (2009, 2016). DHSs are standardised and nationally representative surveys to compare countries' development progress in health and education, which supports researchers' calls for standard socio-economic indicators in conservation research (Ban et al., 2019). The surveys use a two-stage cluster random sampling design, sampling between 5000 and 30,000 households and women in reproductive age (15–49 years). Our four-country sample from Southeast Asia comprised 159,436 individual-level and 145,987 household-level observations, which we analysed on the rural cluster (i.e. primary sampling unit) and provincial level. To preserve anonymity, geo-coded data sets include a random displacement of cluster coordinates of between 0 and 5 km.

We merged the DHS data with the World Database on Protected Areas (WDPA, https://www.protectedplanet.net/c/world-database-on-protected-areas). The WDPA is a global catalogue containing spatial information about marine and terrestrial protected areas that has been maintained since 1981 (UNEP-WCMC, 2017). Out of 248,561 entries globally as of 5 April 2020, 17,274 or 6.9% were referenced as MPAs. Following the merging of the data sets, Myanmar was dropped as it did not contain clusters within a 5 km radius of an MPA. The final data set contained 3874 clusters, of which 1.8% were located directly within an MPA and 18.5% within at least a 20 km radius of an MPA. A summary of the combined data set used for the analysis is provided in Table 1.

The combination of these data sets enabled us to identify DHS clusters that were – or were going to be – situated inside or within a 5, 10, and 20 km radius of an MPA (either completely or partially, i.e. coastal communities). Based on contextual information about the establishment of the MPA and the timing of each household survey, we were able to calculate a cluster's temporal and spatial exposure to marine resource conservation. Alongside temporal exposure (in years; which can take negative values in anticipation of the future establishment of an MPA), we also calculated the contemporaneous proximity of a cluster to a nearby protected area.[4]

As outcome indicators of socio-economic development, we used the dimensions of household wealth, education, and health, for which data are collected systematically across the DHSs. To represent household wealth, we developed a simple agglomerative index of household assets comprising 17 categories such as television, mobile phones, or motorboats. Educational indicators included the average literacy (ability to read a sentence) and the highest attained year of schooling of surveyed household members. Health outcomes focused on average body mass index figures and the number of children who had died in the household. The outcome indicators were aggregated on the household and cluster levels.

#### 3.3.2. Empirical strategy

To study the socio-economic development impact of marine resource conservation (i.e. MPA declarations), we engaged in descriptive statistical, multi-level regression, and panel data analysis. Descriptive analysis was used to depict the evolving association between MPA exposure and development outcomes. We analysed the role of MPA exposure (different categories of MPA proximity over time) for all outcome indicators individually. The analysis took place on the cluster level and was stratified by country, considering that each country represented different social, economic, environmental, and institutional contexts.

We subsequently estimated multi-level regression models on the cluster level (repeated cross-sections) and on the provincial level (panel data) to assess whether a systematic statistical relationship existed between MPA exposure and socio-economic development (Rabe-Hesketh & Skrondal, 2012). We analysed each of the five socio-economic outcomes separately; the key independent variables of interest were in/direct exposure and proximity to an MPA as linear and squared term (to identify potential U-shaped relationships). On the cluster level, we estimated two variants of a 2-level linear random intercept model for cluster $i$ in country $j$, namely:

$$Y_{ij} = (\beta_0 + \zeta_j) + \beta_e \mathrm{EXP}_{ij} + \beta_t \mathrm{Year}_{ij} + u_{ij} \quad (1)$$

where $EXP_{ij}$ was the respective exposure variable (i.e. MPA exposure, proximity) and $\zeta_j$ was the country-level random intercept. We estimated exposure in years and as categorical variable to study both the intensity and the extent, respectively, to which regions may be affected by MPAs. The non-linear specification was formulated as follows:

$$Y_{ij} = (\beta_0 + \zeta_j) + \beta_e \mathrm{PROX}_{ij} + \beta_{e2} PROX_{ij}^2 + \beta_t \mathrm{Year}_{ij} + u_{ij} \quad (2)$$

Results were estimated with robust standard errors (Huber, 1967; White, 1980, 1982) and sensitivity checks involved the single-level specification of the model with country-fixed effects.

In addition to the cluster-level analysis, we generated a provincial-level panel data set combining all clusters within a province with the same degree of proximity to an MPA (including those outside the 20 km buffer area) – both pre and post exposure. The aggregation enabled us to follow similar groups of clusters over time, tracing the evolution of average socio-economic outcomes in relation to MPA establishment (and avoiding an accidental conflation of the role of MPAs with systemic differences between coastal and inland areas). We focused the panel analysis on fixed effects and random effects regressions. In the fixed effects model, demeaning of all variables enabled us to control for time-

[4] The proximity assessment helps mitigate the analytical impact of the random displacement of geo-coordinates and prevents the analysis from accidentally capturing the more systemic differences between coastal and inland socio-economic development.

**Table 1**
Variable description and summary statistics.

| Level | Variable | | Description | *n* | Unique values | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|---|---|---|
| Cluster level | Outcome variables | hh_assets | Average household (HH) ownership of 17 assets[a] | 3,874 | 1,650 | 5.70 | 2.28 | 0.15 | 11.79 |
| | | educ_yr | Average HH education (highest attained year of any HH member) | 3,864 | 2,135 | 4.99 | 2.92 | 0.75 | 14.50 |
| | | educ_lit | Average HH literacy (partial or full) | 3,068 | 952 | 0.72 | 0.23 | 0.00 | 1.00 |
| | | health_bmi | Average body mass index in HH | 2,305 | 2,287 | 2129.71 | 192.39 | 1703.00 | 3997.64 |
| | | health_childdeath | Average number of child deaths in HH | 3,874 | 333 | 0.30 | 0.28 | 0.00 | 2.59 |
| | Marine protected areas (MPAs) | MPA_proximity | Proximity of cluster to MPA[b] | 715 | 4 | 3.11 | 1.04 | 1 | 4 |
| | | any_MPA | Province has at least one MPA at any point in time ([1]: "yes") | 3,874 | 2 | 0.31 | 0.46 | 0 | 1 |
| | | exp_MPA_inPA | Direct exposure (years) to MPA | 69 | 18 | 13.78 | 11.93 | −8 | 50 |
| | | exp_MPA_in5 | Indirect exposure (years) to MPA within 5 km radius | 146 | 36 | 13.34 | 12.82 | −13 | 85 |
| | | exp_MPA_in10 | Indirect exposure (years) to MPA within 5–10 km radius | 139 | 35 | 13.69 | 14.80 | −4 | 81 |
| | | exp_MPA_in20 | Indirect exposure (years) to MPA within 10–20 km radius | 344 | 52 | 18.03 | 18.94 | −5 | 98 |
| | | exp_MPA_inPA_cat | Categorical[c] direct exposure to MPA | 3,874 | 3 | −0.96 | 0.26 | −1 | 1 |
| | | exp_MPA_in5_cat | Categorical[c] indirect exposure to MPA within 5 km radius | 3,802 | 3 | −0.93 | 0.38 | −1 | 1 |
| | | exp_MPA_in10_cat | Categorical[c] indirect exposure to MPA within 5–10 km radius | 3,651 | 3 | −0.93 | 0.37 | −1 | 1 |
| | | exp_MPA_in20_cat | Categorical[c] indirect exposure to MPA within 10–20 km radius | 3,487 | 3 | −0.81 | 0.59 | −1 | 1 |
| Provincial level (cluster group) | Outcome variables | hh_assets | Average HH ownership of 17 assets[a] | 326 | 323 | 5.52 | 1.96 | 0.63 | 10.32 |
| | | educ_yr | Average HH education (highest attained year of any HH member) | 326 | 326 | 4.93 | 2.67 | 2.40 | 12.52 |
| | | educ_lit | Average HH literacy (partial or full) | 267 | 242 | 0.76 | 0.19 | 0.09 | 1.00 |
| | | health_bmi | Average body mass index in HH | 163 | 163 | 2124.61 | 111.60 | 1815.60 | 2603.55 |
| | | health_childdeath | Average number of child deaths in HH | 326 | 308 | 0.28 | 0.20 | 0.00 | 1.46 |
| | MPAs | MPA_prox_panel | Proximity of cluster group to MPA[d] | 326 | 5 | 3.85 | 1.31 | 1 | 5 |
| | | exposure_MPA | Exposure (years) to MPA proximate MPA (0 if non-proximate) | 322 | 112 | 7.47 | 11.31 | −8 | 62.07 |

*Notes.* Unweighted statistics. HH = household, MPA = marine protected area.
[a]. Asset index comprising: toilet facilities, electricity, radio, television, refrigerator, bicycle, motorcycle/scooter, car/truck, finished floor/wall/roof materials, mobile telephone, motor boat, computer, arable land, livestock, and bank account.
[b]. [1]: "Within MPA," [2]: "Within 5 km radius," [3]: "Within 10 km radius," [4]: "Within 20 km radius."
[c]. [-1]: "No MPA," [0]: "Not yet exposed," [1]: "Exposed to MPA."
[d]. [1]: "Within MPA," [2]: "Within 5 km radius," [3]: "Within 10 km radius," [4]: "Within 20 km radius," [5]: "Outside of 20 km radius."

**Table 2**
Comparison of key marine and socio-economic development indicators between Cambodia and regional peers.

| Indicator | Cambodia | Regional comparisons | | (Data year) |
|---|---|---|---|---|
| | | Philippines | Timor-Leste | |
| General | | | | |
| Population (million) | 16.5 | 108.1 | 1.3 | (2019) |
| Land area (thousand km$^2$) | 176.5 | 298.2 | 14.9 | (2018) |
| Marine indicators | | | | |
| Marine protected areas (% of territorial waters) | 0.2% | 1.2% | 1.3% | (2018) |
| Number of threatened fish species | 48 | 91 | 13 | (2018) |
| Total fisheries production (metric kilotons)[a] | 943.2 | 4356.9 | 4.8 | (2018) |
| Marine fish production (metric kilotons)[a] | 169.0 | 3871.3 | 4.7 | (2018) |
| Socio-economic indicators | | | | |
| Gross domestic product per capita, PPP (current US$) | $4,583 | $9,302 | $3,710 | (2019) |
| Agriculture, forestry, and fishing (value added as % of GDP) | 20.7% | 8.8% | 14.2% | (2019) |
| Population living below national poverty line (% of population) | 17.7% | 25.2% | 41.8%[b] | (2012) |
| Rural access to electricity (% of rural population) | 89.0% | 92.5% | 79.2% | (2018) |
| Rural population with at least basic drinking water (% of rural pop.) | 72.9% | 90.0% | 69.7% | (2017) |
| Adult literacy rate (% of people aged 15 and above) | 80.5% | 98.2% | 68.1% | (2015) |
| Life expectancy at birth (years) | 69.6 | 71.1 | 69.3 | (2018) |
| Prevalence of undernourishment (% of population) | 14.5% | 14.5% | 30.9% | (2018) |
| Maternal mortality ratio (per 100,000 live births) | 160 | 121 | 142 | (2017) |
| Under-5 mortality rate (per 1,000 live births) | 26.6 | 27.3 | 44.2 | (2019) |

Sources: FAO (2021); World Bank (2021).
*Note.* Data year indicates latest available data from respective sources to enable comparison. GDP = gross domestic product, PPP = purchasing power parity.
[a]. FAO data including capture and aquaculture (disaggregated data not available) of aquatic species for all commercial, industrial, recreational and subsistence purposes. The harvest from mariculture, aquaculture and other kinds of fish farming is also included.
[b]. 2014 data for Timor-Leste.

invariant unobservable characteristics of the cluster groups (Cameron & Trivedi, 2010). We also interacted exposure with proximity to consider the latter's importance in determining socioeconomic outcome changes (MPA proximity would otherwise drop from the analysis as a time-invariant cluster characteristic). For each cluster group $c$ at survey round $t$, we therefore estimated the following fixed effects model:

$$\ddot{Y}_{ct} = \beta_e \ddot{EXP}_{ct} + \beta_{int} EXP \times \ddot{PROX}_{ct} + \beta_t \mathrm{Year}_{ij} + \ddot{u_{ct}} \quad (3)$$

where $\ddot{Y}_{ct} = Y_{ct} - \overline{Y}_c$ etc. were time-demeaned variables, $EXP_{ct}$ was MPA exposure in years, and $PROX_c$ was the cluster group's proximity to the nearest MPA (interacted with $EXP_{ij}$, noting that $PROX_c$ as time invariant variable dropped from the equation). A survey round variable ($Year_{ij}$) was included to discern general trends from variations in exposure. Based on Breusch and Pagan (1979) heteroscedasticity tests, we estimated the model with country-cluster-robust standard errors. Considering the limited ability to estimate time-invariant attributes in fixed-effects models (Wooldridge, 2010), we also estimated a random effects specification of the aforementioned model, which enabled the direct estimation of $PROX_c$ but assumed that unobserved variables $a_c$ were uncorrelated with the independent variables in each survey round (Cameron & Trivedi, 2010; Hausman, 1978, tests indicated that this might not be the case). The corresponding random effects model (estimated with heteroscedasticity-robust standard errors and country dummy variables) was:

$$Y_{ct} = \beta_0 + \beta_e \mathrm{EXP}_{ct} + \beta_p \mathrm{PROX}_c + \beta_{int} \mathrm{EXPPROX}_{ct} + \beta_t \mathrm{Year}_{ct} + \beta_c \mathrm{Country}_c + \mathrm{a}_c + u_{ct} \quad (4)$$

We considered results to be statistically significant at the 5-percent level and indicated significance levels below 0.1, 0.05, and 0.01 with *, **, and ***, respectively. Goodness-of-fit was assessed using the Akaike Information Criterion (Akaike, 1974). The data sets were prepared using Stata/MP 15.1 (StataCorp, 2017) and ArcGIS Desktop 10.5.1 (Esri, 2019); the analysis was carried out using Stata/MP 15.1. We also related the interpretation of the findings back to the qualitative data as part of the mixed-method research design.

## 4. Results

### 4.1. Qualitative results

#### 4.1.1. Policy implementation dynamics

In 2013, fishers as part of the local Koh Sdach island community identified the opportunity to establish a community fisheries organisation (known locally as a CFi), a model which evolved out of existing bottom-up governance mechanisms used in Cambodian freshwater fisheries. The establishment took several years, and the later phases were supported by a diving tourism and conservation organisation (Shallow Waters). Community members operating within waters of less than 20 m depth formed a 10-member governing committee with responsibility for the coastal waters surrounding the archipelago (a new committee was elected in 2018).[5] The members of the committee as well as local fishery stakeholders were conscious of a deterioration of marine resources at the time, highlighting the existential importance of upholding marine productivity in statements such as, "*I volunteered* [to join the committee] *because we are the seaside dwellers without plantation or rice fields to work on. This place is like our rice pots*" (committee member). Yet the acute awareness of marine space deterioration appeared to have been driven by "*foreign organisations*" (i.e. iNGOs) as a former committee member described. Owing to the interest in coastal marine space protection, the fisheries organisation was thus set up by the Koh Sdach community to govern extractive activities around the Koh Sdach Archipelago, superseding informal yet ineffective policing of illegal fishing by provincial authorities and community members. Yet, most fishers on Koh Sdach island were operating in deep seas (i.e. areas outside the CFi boundary with depths of more than 20 m), meaning that the fisheries organisation's rules did not apply to them directly (please refer back to Fig 2. in Section 3.2.1 for the boundaries of the Koh Sdach CFi highlighted in red).

Considering limited human resources in the government administration but also the historically strained relationship between people and the state, both government and local stakeholders expressed appreciation for support from the "foreign organisations," which over the years spanned training, data generation, consultancy, organisational and management tools, and in-kind support such as patrol boats. However, reports from the CFi committee members suggest that iNGOs were actively and significantly involved in shaping the local understanding of marine resource management during the implementation process.

The two main themes surrounding CFis operationalisation within the Koh Sdach community (i.e. outside the fishery management committee) were thus trash and illegal fishing, and the interpretation of these two themes varied widely among the villagers. For instance, a founding member of the CFi explained that several previously unregulated practices had gradually become defined as illegal through the CFi ("*people around here weren't caring about the destruction of the marine environment and therefore did not pursue what is now illegal fishing*"). The ensuing interpretations of illegal fishing variously yet not consistently pertained to different types of destructive fishing (e.g. cyanide, dynamite, electrofishing, trawling), intrusion and industrial-scale exploitation of the local fishery by international fishers (Malaysia, Thailand, and Vietnam), but for some (esp. committee members) also the islanders' own small-scale violations of CFi rules within its boundaries. In general, community members themselves rarely considered the islanders' own fishing activities to fall into the realm of "illegal fishing" but rather associated it with the presence of international fishers. Similarly, some respondents interpreted trash management advice to burn trash, others to throw it into the sea, and yet others to leave trash management to the commune administration. This suggests that marine resource management was operationalised in idiosyncratic interplay between iNGO/expert advocacy and local populations' existing practices, subordinating other aspects of marine-related livelihood and environmental concerns.

Limited community involvement impeded implementation further. Material incentives and convincing over several years were needed for the community to adopt notions of marine conservation, during which time the CFi had lost momentum – noticeable still six years after inception. At the same time, the CFi struggled to engage community members due to its voluntary and regulatory nature. As a local government stakeholder commented, "*Some people owe money from the bank. So they don't join us* [for committee meetings] *because they have to do their business*" (local stakeholder).

Aside from these competing priorities, the implementation process proceeded as if the fishing "community" was a homogenous and cohesive unit, which was at odds with the highly fragmented realities on the ground. Interviewees reported that there is generally little interaction across village segments and across Khmer and Thai speaking members of the community. However, the CFi was initially developed by a team of founders from the central *Phum Kandal* section of the village, and the elected committee member

[5] Cambodian fishing law covers two specific zones, firstly the region between the coast up to a depth of 20 m, and secondly greater than 20 m out to the exclusive economic zone. Rules governing fishing activities, such as use of specific methods or gear, apply up to the 20 m depth contour. This includes the management activities of the CFi.

were all from the same area – whose views and realities the CFi reflected. Community members accordingly reported how invitations to regular meetings dissipated across segments ("*they didn't invite us because this area is so quiet*") and social groups ("*people who join the community mostly invited each other or know each other*"). It was therefore not surprising that, still years after its introduction, knowledge about the CFi was relatively limited in adjacent segments. Non-central villagers and especially the ethnic minority groups even displayed a degree of animosity and anger that other villagers assumed authority to invoke rules over common resources (Savage, 2017). We explain further in the next section how the implementation process potentially reinforced these divides.

#### 4.1.2. Socio-economic consequences

Before considering socio-economic consequences, it is worth highlighting perceptions about the intended outcomes of the CFi among community members and stakeholders. Focusing on enforcement and the conservation of fish stocks as two major themes in the interviews, the stance from within the current 10-member committee was overall enthusiastic. Committee members would cite examples of improved enforcement of regulated fishing activities, a reduction of trawling and illegal fishing, and more voluntary participation in marine resource management, deeming the arrangement overall as "*70% successful*" with room for improvement in tourism, income-generation and sharing, and resource conservation.

Despite perceiving improvements in pursuing illegal fishing activities, villagers were sceptical about the CFi's effectiveness and enforcement abilities, which was accentuated by fears of personal harm and conflicting interests. For example, the committee reported a case in which a member was "*threatened*" for planning to report illegal fishing activities and ended his committee membership in fear of getting "*shot*." More vocal forms of community opposition arose in response to monetary loss: Patrols suddenly restricted local fishing activities during the initial operation of the CFi, one small-scale fisher reported receiving a US$ 250 fine (equivalent to two fishing nets and likely exceeding a monthly household income),[6] and several others lamented the loss of costly equipment – whilst struggling to operate GPS equipment to avoid the CFi boundaries. Other rules with financial implications (e.g. seahorse fishing) were defied outright, for instance by deploying the tactic of "feigning ignorance:"

> *"Currently, people know more than before about how to protect the natural resource and some regulations. Some people know, but they fake to be misunderstood. For example, some areas ban people to enter, but they still come to those areas.*"
>
> [(local stakeholder)]

More broadly, divisions arose among respondents in terms of the marine resource governance impacts on fish stocks and their consequences for incomes on the island. A local stakeholder observed that squid trawling was now possible within the CFi because stocks had replenished, and others attributed marine protection to increased tourism and hospitality business, for instance linking trash reduction to "*tourists* [who] *are very interested in the corals. They keep coming back when they leave*" (community member). But other residents were less enthusiastic. A female member of family fishing business simply observed that now, despite several years of CFi operation, "*The fish is gone,*" and a local food vendor reported earning less income as her customers – fishers – had less income to spend. Alongside declining catch, fish prices had reportedly risen, but not enough to offset the reduced volume. The CFi therefore appeared at best limitedly effective in preserving economic livelihoods of coastal fishers.

In light of the implementation dynamics and economic developments, the direct and indirect well-being consequences of marine resource management remained limited.[7] Illegal forms of marine resource extraction continued, both at night and around the CFi borders. A committee member commented that "*Trawlers still sneak in at night ceaselessly. We patrol at daytime. They enter at night. We cannot stop it*" and there was a widespread community opinion that expanding pursuit into night-time would pose danger to human life ("*It's very dangerous at night*"). Sources of anxiety from pursuing and reporting continued illegal fishing activities added to increasingly difficult fishing conditions and indebtedness. According to a fishing household member, the fishing community had therefore not been able to generate peace of mind from marine protection, contrary to expectations. Outside of fishing, some of the additional income from tourism was being put into housing construction, but village residents also commonly commented that it would be used for gambling and alcohol purchases, meaning that the health and well-being implications were ambiguous.

From a relational perspective, the CFi reconfigured the historically weak relationship between communities and the government, offering some degree of cohesion and linkage: "*the community also patrols and fishery officials and government authorities also help. It means they are in partnership with the community*" (committee member). The extent of integration was limited but the CFi appeared to have functioned as a vehicle to at least improve relationships. On the flipside, the increased policing of local waters also hardened the relationships between the local population and intrusive external fishers. In addition, the reconfiguration of relationships specifically within the community was potentially detrimental. On the one hand, the initiation of the CFi provided policing powers to some fishers, creating a power (and responsibility) gradient that had not existed before. While the social consequences of such a reconfiguration were likely to affect only a small number of people whose political role in the community had changed, it might potentially render the ability of the community to police its waters more brittle – for example when the CFi would enter periods of dysfunction, leaving the rest of the island in an authority vacuum.

More problematic, however, was the tendency of the CFi to become an instrument of exclusion and social division. As the implementation process and the CFi operations proceeded as if the community was a homogenous and cohesive group, it did not account for and accommodate language barriers (e.g. the Thai-speaking minority), the presence of community segmentation that impeded communication (e.g. strong connections within sub-village communities but not across them), or the competing priorities that community members with particularly precarious

[6] Net costs as indicated by a Koh Sdach community member. Household income data from Koh Sdach is unavailable, but mean rural household incomes are estimated (with caution) by the latest *Socio-Economic Survey 2019/20* to be in the magnitude of KHR 1,328m per month (approx. US$ 330) (National Institute of Statistics, 2020). However, figures from research across Cambodia indicate a skewed income distribution with high variability across rural households and seasons, with many households (including fishing households and households located in communes) earning well below US$ 250 per month (Lonn et al., 2018; Seary et al., 2021). Note further that, although the CFi sets these fines, the high amount in this report indicated a range of unofficial variability and community members affected by them are not necessarily fully aware of their existence or reach. For instance, the very same respondent was unaware "*about the rules or the boundary*" and the frictions in including community members as outlined below further impeded the transparent communication of the CFi regulations.

[7] Note that the CFi was designed with the explicit intention of improving livelihoods and village infrastructure. This was one of the ways through which the committee and founders encouraged buy-in from the local community in early stages of the development, and community members would consequently express their expectations that healthcare and education would improve directly as a result of the economic impact of the CFi (Savage, 2017).

livelihoods experienced (e.g. poorer and indebted segments of the island's fishing population). As a result, while members of the CFi praised the social cohesion of being part of the group and alluded to non-members as ignorant or arrogant, non-members themselves felt "*discriminated*," excluded, or ignored ("*nobody invites us to join the meeting* [, ...] *we don't know anything clearly*," local community stakeholder).

#### 4.1.3. Synthesis

Guided by our conceptual framework, this section presents the main themes of our thematic analysis which we also summarise in Fig. 3. During the early stages of MPA formation in Cambodia, we documented how the human dimension of fishery governance created counter-acting forces that at the same time legitimise and undermine the effectiveness of the Koh Sdach community fishery organisation. The recognition of resource deterioration together with the catalysing influence from external non-governmental organisations created impetus to conserve fisheries for the relatively well-off setting of Koh Sdach. However, the varied fishing practices and social divisions within the community meant that some groups remained involuntarily excluded, others evaded participation in the CFi and adherence with its rules, and yet others struggled with the consequences of rule enforcement – while varied interpretations challenged the consistent application of the narrow resource management agenda.

What could this entanglement of the CFi with the community structures and practices mean for its longer-term socio-economic development consequences? The qualitative research suggested that the limited reach of the CFi attenuated tangible outcomes, with the fishing community on the island at best benefiting from a slowing deterioration of marine resources and from a more conducive environment to diversify their livelihood towards tourism. However, this effect may also create a false sense of security that locks beneficiaries into dependence on marine resources that are continually infringed upon by increasingly aggressive outside fishers. The tentative economic respite also does not appear to improve well-being in the community more broadly since livelihood anxiety, indebtedness, but also social divisions and fears of personal harm persisted and deepened. Despite the noteworthy positive unintended consequence of improving community-state relationships (which is rather unlike the common focus on "conflict" in the qualitative marine conservation literature), this creates scepticism that further intensification of marine resource governance through an MPA would reflect the "more positive than negative well-being outcomes" as reported by Ban et al. (2019:526).

### 4.2. Quantitative results

The early development stages of the Koh Sdach CFi prior to its gradual graduation into an MPA (i.e. a Marine Fisheries Management Area in the local context) provided useful insights into the community setting into which new forms of marine resource governance are being introduced, and the network of solutions and policies with which they interact. How the ensuing counteracting forces resolve on a larger scale is subject to this second, quantitative component of our study.

Clearly every MPA and CFi has unique features which mean that the relationships between communities, administration, and nature play out differently. The case of Koh Sdach suggests that (a) marine resource management is introduced in a setting that is rel-

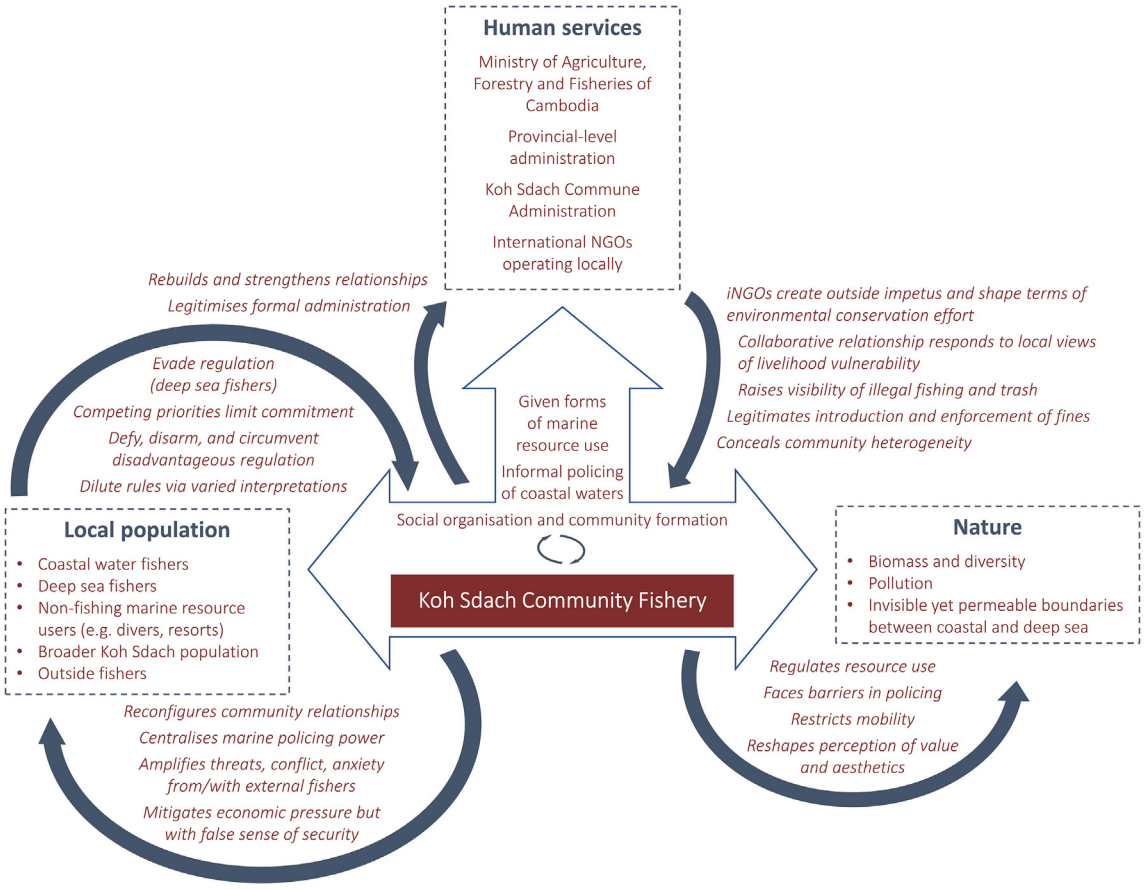


**Fig. 3.** Summary of thematic analysis. Source: Authors. *Note.* Specifications of the original abstract framework based on the qualitative research are indicated in red.

atively well off compared to its immediate neighbourhood and that (b) the management of resources is limitedly effective. However, the new governance arrangements could lock communities into persistent resource dependence and growing stress that could, in the longer term, impede their socio-economic development compared to neighbouring areas.

While we are interested broadly in how the socio-economic development consequences of marine resource management and conservation emerge empirically, our qualitative case study suggests that, at least in the setting of Cambodia, areas setting up marine conservation mechanisms could experience impeded socio-economic development and even potentially fall behind if they started from a more privileged position than their regional peers. We will explore this hypothesis here through an analysis of all available geo-coded multi-year DHS data across Southeast Asia, which comprised 3874 clusters across Cambodia, the Philippines, and Timor-Leste. We first describe general relationships between MPA exposure and socio-economic development over time, followed by multivariate analysis on the cluster and provincial level.

Fig. 4 illustrates the evolution of household assets (Panel a), completed years of education (Panel b), literacy rates (Panel c), body mass index (Panel d), and child mortality in the household (Panel e) depending on a cluster's proximity to the nearest MPA. Clusters within MPAs are depicted in red, different degrees of proximity are indicated in shades of grey, and the average of clusters not in proximity to MPAs is shown in green. The figure shows that MPA clusters evolved mostly similarly to clusters with varying degrees of proximity, but instances of diverging trajectories were also present: Cambodian MPA clusters and their immediate neighbours showed alternating over- and under-performing asset and literacy developments compared to non-MPA clusters, and MPA clusters in the Philippines slightly outperformed all other groups in asset accumulation, albeit starting from the lowest level. The most notable differences emerged in child mortality. Whereas Cambodian MPA clusters stagnated at a high level ranging from 0.32 to 0.42 child deaths per household, child mortality in Timor-Leste reduced substantially faster in MPA (from 0.51 to 0.07) than in non-MPA clusters (e.g. from 0.47 to 0.23 in non-proximate clusters) between 2009 and 2016. The descriptive analysis thereby provided first indicative evidence that MPA exposure had subtle links to socio-economic development.

Table 3 summarises the multi-level regression results (the full results are provided in the Supplemental Material), showing that literacy rates were independent of MPA exposure or proximity, whereas other outcome indicators exhibited an ambiguous association with MPAs: with the exception of child mortality, the extent of exposure was linked to indicators that were statistically significantly better when compared to non-MPA clusters; the virtuous association tended to wane or invert (body mass index) with growing distance from the MPA. However (and controlling for a gradual trend), a growing number of years spent under this governance arrangement was associated with worse socio-economic development outcomes; only clusters located at least 10 km away from MPAs showed consistent improvements. Increases in the proximity category (i.e. growing distance to MPAs) were statistically significantly and negatively linked to educational attainment (squared specification) and to body mass index (linear specification), suggesting that the periphery of MPAs exhibited relatively worse educational and nutritional outcomes. The results were robust to single-level regression specifications, which reproduced the findings albeit with slightly varying significance levels (see Supplemental Material).

To illustrate these relationships, the models predicted for instance that MPA membership was associated with a 0.52 higher asset score (e.g. in Cambodia: 6.94 vs. 6.41 for clusters not exposed to MPAs), but that every ten years of additional exposure to an MPA were linked to 0.79-unit lower household assets (see Supplemental Material for a summary of the asset index predictions). In contrast, clusters in a 10–20 km range of an MPA saw their asset wealth increase by 0.15 units for every 10 years of exposure (all these estimates controlled for a time trend).

To limit potential biases from unobserved heterogeneity and reverse causality, Table 4 summarises the main results for the fixed and random effects panel regression models (separately for each of the five outcome indicators). The fixed effects models did not show statistically significant associations between exposure/proximity variables and development outcomes (the isolated result among the five models appeared to be rather the result of random variation). The random effects models were more susceptible to unobserved heterogeneity but enabled a broader estimation of time-invariant characteristics, including country and proximity indicators. These models showed statistically significant associations between MPA exposure (in interaction with proximity) and wealth, education, and child mortality. In all three cases, the relationship suggests that MPAs underperformed socio-economically when compared to proximate regions. Concerningly, controlling for country and time trend, MPA exposure was associated with decreasing wealth and increasing child mortality, which weakened with further distance to MPAs. The random effects models predicted for instance that MPA regions had an increase from 0.22 to 0.29 child deaths per household after 20 years of exposure, whereas regions in a 10–20 km radius had a predicted reduction of child deaths from 0.26 to 0.22 under the same conditions (controlling for time trends and country). A similarly inverse relationship was predicted for household assets, with reductions from 5.9 to 5.4 in MPA regions compared to a predicted increase from 5.1 to 5.6 average household assets in the proximity category "10–20 km."

Our quantitative findings suggest that MPA clusters tended to have similar if not better socio-economic conditions at the time when marine protection was established (compared to the national average). This is consistent with the specific context of the qualitative case study. Similar to the hypothesised longer-term impact of formal marine resource governance in the case of Koh Sdach (and if a causal interpretation is applied to the statistical association), the presence of an MPA also appeared to slow down or even invert several dimensions of socio-economic development when compared to non-MPA regions.

## 5. Discussion

Our qualitative and quantitative findings provided consistent evidence that marine resource governance can have mixed and potentially detrimental socio-economic consequences. The qualitative case study of Koh Sdach outlined an early MPA development context where the CFi catchment area exhibited a relatively well-off setting compared to other coastal communities but also compared to its immediate vicinity where issues of forced displacement had cast a shadow over large-scale commercial developments. During the establishment of community-based marine resource management, extensive iNGO mediation, implicit assumptions, and policy implementation dynamics entailed an operational focus on illegal fishing and trash. The upside of this process was a catalytic effect enabling some degree of reconciliation between communities and the state and supporting livelihood diversification towards hospitality and tourism business. However, the indirect consequences of the CFi did not appear to discernibly improve fishing-dependent livelihoods, while leaving communities divided, agitated, and locked into marine resource dependence. The probable well-being consequences were therefore mixed and heterogeneous within the community (Gill et al., 2019), but the

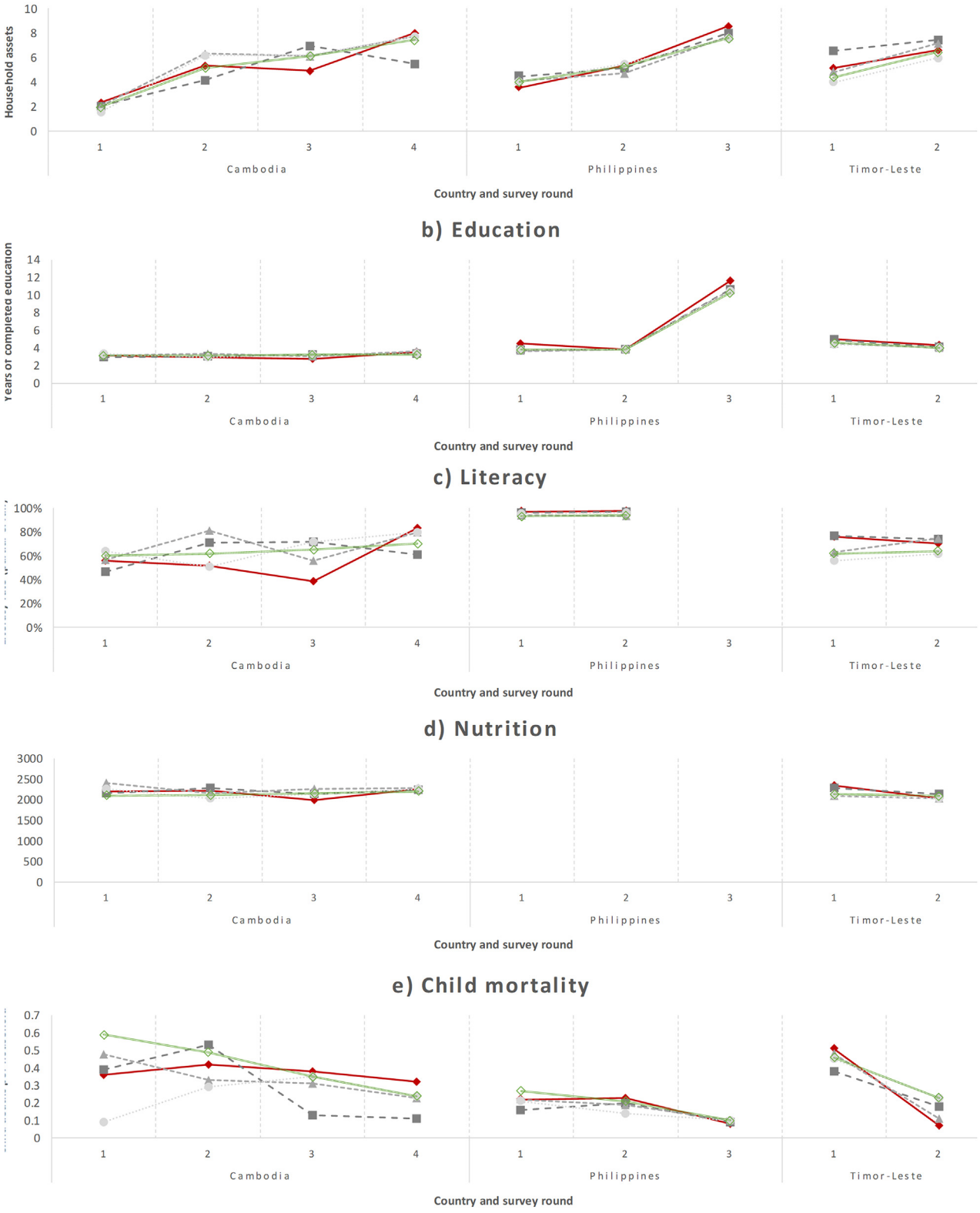


**Fig. 4.** Descriptive statistical analysis of socio-economic outcomes across countries and DHS survey rounds. Source: Authors. *Notes.* Contemporaneous proximity to marine protected areas; mutually exclusive and collectively exhaustive proximity categories. Average body mass index values per country range from 2071.7 to 2201.7 g/m$^2$ and fall squarely into the category of "normal/healthy" weight (WHO Regional Office for Europe, 2020), meaning that variations need not necessarily indicate increased health problems. Increases in body mass index can thus be interpreted as an indicator of socio-economic development, though not of health per se.

**Table 3**
Summary of multi-level regression results on cluster level.

| Out-come | Model type | a) Extent of exposure (categorical) | | | | b) Intensity of exposure (years) | | | | c) Proximity | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Household assets | Group | in MPA | <5km | 5–10 km | 10–20 km | in MPA | <5km | 5–10 km | 10–20 km | Exposed clusters | |
| | Model number | (1) | (2) | (3) | (4) | (21) | (22) | (23) | (24) | (41) | (42) |
| | Not yet exposed[a] | 0.580** | 0.304** | 1.018** | 0.025 | | | | | | |
| | Exposed[a] | 0.447** | 0.524 | 0.126 | −0.083 | | | | | | |
| | Exposure (years) | | | | | −0.079** | 0.017** | 0.019** | 0.015** | | |
| | Proximity | | | | | | | | | −0.255* | 0.078 |
| | (Proximity)$^2$ | | | | | | | | | | −0.061 |
| | $N_1$ (Clusters) | 3874 | 3802 | 3651 | 3487 | 69 | 146 | 139 | 344 | 715 | 715 |
| | $N_2$ (Countries) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Education (years) | Group | in MPA | <5km | 5–10 km | 10–20 km | in MPA | <5km | 5–10 km | 10–20 km | Exposed clusters | |
| | Model number | (5) | (6) | (7) | (8) | (25) | (26) | (27) | (28) | (43) | (44) |
| | Not yet exposed[a] | −3.255** | −2.005 | −2.084 | −1.846 | | | | | | |
| | Exposed[a] | 1.169** | 0.361** | 0.505** | 0.075 | | | | | | |
| | Exposure (years) | | | | | −0.040** | 0.032* | 0.033** | 0.006** | | |
| | Proximity | | | | | | | | | −0.293** | −1.362** |
| | (Proximity)$^2$ | | | | | | | | | | 0.195** |
| | $N_1$ (Clusters) | 3864 | 3792 | 3641 | 3477 | 69 | 146 | 139 | 344 | 715 | 715 |
| | $N_2$ (Countries) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Literacy | Group | in MPA | <5km | 5–10 km | 10–20 km | in MPA | <5km | 5–10 km | 10–20 km | Exposed clusters | |
| | Model number | (9) | (10) | (11) | (12) | (29) | (30) | (31) | (32) | (45) | (46) |
| | Not yet exposed[a] | 0.043** | 0.046** | 0.057** | 0.050** | | | | | | |
| | Exposed[a] | 0.030 | 0.052 | 0.035 | −0.010 | | | | | | |
| | Exposure (years) | | | | | −0.001 | −0.000 | −0.002 | 0.000 | | |
| | Proximity | | | | | | | | | −0.025 | 0.038 |
| | (Proximity)$^2$ | | | | | | | | | | −0.011 |
| | $N_1$ (Clusters) | 3068 | 3018 | 2919 | 2823 | 47 | 94 | 86 | 245 | 474 | 474 |
| | $N_2$ (Countries) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Body mass index[b] | Group | in MPA | <5km | 5–10 km | 10–20 km | in MPA | <5km | 5–10 km | 10–20 km | Exposed clusters | |
| | Model number | (13) | (14) | (15) | (16) | (33) | (34) | (35) | (36) | (47) | (48) |
| | Exposed[a] | 91.378** | 89.728** | −6.625 | −31.468* | | | | | | |
| | Exposure (years) | | | | | −23.843** | 5.467 | 12.228** | 13.099** | | |
| | Proximity | | | | | | | | | −40.046** | −20.862 |
| | (Proximity)$^2$ | | | | | | | | | | −3.577 |
| | $N_1$ (Clusters) | 2305 | 2269 | 2226 | 2177 | 36 | 43 | 49 | 146 | 274 | 274 |
| | $N_2$ (Countries) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Child mortality | Group | in MPA | <5km | 5–10 km | 10–20 km | in MPA | <5km | 5–10 km | 10–20 km | Exposed clusters | |
| | Model number | (17) | (18) | (19) | (20) | (37) | (38) | (39) | (40) | (49) | (50) |
| | Not yet exposed[a] | −0.193** | −0.080** | −0.154** | −0.028* | | | | | | |
| | Exposed[a] | −0.034 | −0.049** | −0.016 | −0.026** | | | | | | |
| | Exposure (years) | | | | | 0.001 | −0.001 | −0.001* | −0.001** | | |
| | Proximity | | | | | | | | | 0.005 | −0.024 |
| | (Proximity)$^2$ | | | | | | | | | | 0.005 |
| | $N_1$ (Clusters) | 3874 | 3802 | 3651 | 3487 | 69 | 146 | 139 | 344 | 715 | 715 |
| | $N_2$ (Countries) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

*Notes.* Coefficients reported. Time trend (survey round counter), constant, and robust standard errors omitted. Analysis at cluster level. MPA = Marine Protected Area.
*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
[a]. Benchmark: no MPA.
[b]. No observations for the Philippines, where all pre-exposure clusters were located.

overall picture suggested an attenuation of the community's socio-economic development. The quantitative analysis accentuated this impression. Surprisingly similar to the case of Koh Sdach, MPAs tended to emerge initially in socio-economically relatively well-off communities of Cambodia, Philippines, and Timor-Leste, but prolonged exposure was associated with a slower development pace in terms of household wealth, education, and child mortality. Over time and compared to neighbouring communities, MPA exposure was even linked to an absolute decrease in asset wealth and an increase in child mortality. While further mixed-method research is required (involving original and locally grounded quantitative assessment tools), our qualitative study therefore suggests that the human dimensions of marine resource management and conservation can affect longer-term development through pathways including livelihood anxiety and fears as well as reinforced social divides within communities.

As far as other studies of the social and economic consequences of marine resource management and conservation are concerned, we identified previously described patterns of opposition to the regulation of resource use (Johnson et al., 2019; Raycraft, 2020), but noted also a general commitment even among former CFi members to conserve marine environments and to provide environmental education locally. Contrary to Fiske (1992) and Raycraft (2020), our study also highlighted how marine resource management in Koh Sdach fostered rather than undermined community-state relationships. In addition, anthropological studies of protected areas have previously problematised tensions and divergent socio-economic impacts between neighbouring insiders and outsiders (Linh et al., 2021; West et al., 2006), and our study underscored the importance of complementary long-term quantitative research to establish such patterns more firmly.

**Table 4**
Summary of fixed and random effects panel regression results on provincial level.

| | Fixed effects model | | | | | Random effects model | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Outcome | Household assets | Education (years) | Literacy | Body mass index[d] | Child mortality | Household assets | Education (years) | Literacy | Body mass index[d] | Child mortality |
| Model number | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Exposure (years) | −0.008 | 0.194 | 0.002 | −22.521 | 0.002 | −0.024** | 0.043 | −0.001 | −10.230 | 0.004 |
| EXPxPROX[a] (prox: <5km) | −0.001 | 0.019 | −0.011 | −3.851 | 0.002 | 0.023 | 0.096** | −0.001 | 4.891 | −0.000 |
| EXPxPROX[a] (prox: 5–10 km) | −0.022** | −0.082 | −0.005 | 20.229 | 0.003 | 0.017 | 0.043 | −0.002 | 15.306 | −0.003 |
| EXPxPROX[a] (prox: 10–20 km) | 0.011 | −0.117 | −0.003 | 14.627* | −0.003 | 0.050** | 0.001 | 0.002 | 9.993 | −0.006** |
| Proximity[b] (<5km) | | | | | | −0.078 | −0.975** | 0.021 | 39.715 | −0.028 |
| Proximity[b] (5–10 km) | | | | | | −0.074 | −0.639 | 0.017 | −146.562 | 0.001 |
| Proximity[b] (10–20 km) | | | | | | −0.740* | −0.618 | −0.038 | −112.838 | 0.069 |
| Proximity[b] (no MPA) | | | | | | −0.264 | 0.189 | −0.026 | −100.132 | 0.068* |
| Country[c] (Philippines) | | | | | | 1.320** | 3.408** | 0.346** | | −0.255** |
| Country[c] (Timor-Leste) | | | | | | 2.277** | 2.570** | 0.051* | −54.129** | −0.150** |
| Survey round | 1.750** | 1.096 | 0.044* | 35.271 | −0.120** | 1.695** | 0.918 | 0.035** | 26.170 | −0.091** |
| *N* | 322 | 322 | 264 | 163 | 322 | 322 | 322 | 264 | 163 | 322 |

*Notes.* Coefficients reported. Constant, and country-cluster-robust standard errors omitted. Analysis at cluster group level.
*p < 0.1, **p < 0.05, ***p < 0.01.
[a]. Benchmark: in MPA.
[b]. Interaction with category "no MPA" dropped due to collinearity. Proximity is time invariant and therefore dropped from the fixed effects model.
[c]. Benchmark: Cambodia.
[d]. No observations for the Philippines.

Before concluding, it is important to highlight key limitations of this study. An important yet unexplored question in this paper remained the relationship of socio-economic impacts of MPAs compared to terrestrial protected areas like national parks, considering that enforcement mechanisms, economic activities, and networks of relationships are systematically different among these types of protected areas. Quantitatively, we note the temporal and spatial mismatch between our CFi case study and the Cambodian MPAs registered in the WDPA, which future research can overcome by linking longitudinal multi-site qualitative research in Marine Fisheries Management Areas with an original and theory-based survey instrument that for instance captures indicators of community-state relationships and livelihood anxiety, but also with upcoming surveys of the Cambodia DHS that will include the emerging Marine Fisheries Management Area. A global analysis would further enable more precise estimates considering the random displacement of DHS cluster coordinates and the data requirements of fixed effects regression models. A global scope would also enable a detailed analysis of MPA attributes (e.g. size, no-take zones, management systems) and link socio-economic outcomes to other determinants such as tourism, industrialisation, and location.

## 6. Conclusion

We conducted a mixed-method research study to explore the link between marine resource governance and socio-economic developments. An in-depth qualitative case study of the Koh Sdach Archipelago in Cambodia identified interactions between community fishery management and existing social and environmental arrangements in the Koh Sdach community. Although the CFi appeared to have fostered state-community relationships, reduced the pace of environmental degradation, and enabled a limited degree of livelihood diversification, the qualitative case suggested that social exclusion, more aggressive tactics of outside fishers, and perpetuated resource dependence associated with marine space governance could impede socio-economic development compared to neighbouring areas. The regional quantitative analysis demonstrated surprising similarities to the case of Koh Sdach in that MPAs were established in relatively well-off communities, but long-term exposure was associated with slower and at times regressive socio-economic development, in particular in terms of asset accumulation and child health.

These findings make an important contribution to the understanding of socio-economic impact in MPAs. Enabled by a methodologically innovative exposure analysis and the conceptual framing of marine resource governance as situated in a network of relationships that intersect communities, state, and nature, our research problematises implementation challenges, insider-outsider dynamics, and the livelihood consequences of marine protection. While recent marine management design processes with local partners in Cambodia are building on these insights to rectify rather than perpetuate socio-economic inequalities, our work emphasizes that the rapid global expansion of nominal MPA coverage can undermine community livelihoods if it proceeds with a sole focus on marine resource conservation, a disregard of local social contexts, and a lack of livelihood adaptation support for affected communities.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.worlddev.2021.105576.

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