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Inequalities And Environmental Changes In The Mekong Region: A Systematic Mapping

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Inequalities And Environmental Changes In The Mekong Region: A Systematic Mapping

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Abstract
How do accelerating environmental changes impact inequalities and how do rising inequalities affect in reverse environmental dynamics? This paper is built on a systematic mapping (2019 – 2021) studying the relationship between those two crucial aspects in five Mekong Countries: Cambodia, Laos, Myanmar, Thailand and Vietnam.

14570 scientific and grey literatures were collected and screened by title and abstract, and fulltext. 2355 items (1978-2020) are included for the systematic mapping. Overall, articles that directly discuss inequalities in relation with environmental changes are rare and recent. Three domains are dominant: resource access and right issues (967 items); climate change and disaster impacts (533 items); and a growing interest on pollution (299 items). Gaps in knowledge are identified in various realms. A repository is built with an open access to all abstract-selected references to support further research and projects on sub-topics of the inequality-environmental change nexus, and support science-based policy decisions.

Keywords
Environment inequalities, Systematic mapping, Mekong, Rights, Climate, Pollution.

Classification JEL
A13, D62, E01, E22, I30, I31, O11, Q01, Q51

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Résumé
Comment l'accélération des changements environnementaux influe-t-elle sur les inégalités, et, inversement, comment l'augmentation des inégalités affecte-t-elle la dynamique environnementale ? Ce papier de recherche s'appuie sur une cartographie systématique, menée entre 2019 et 2021, qui étudie la relation entre ces deux aspects cruciaux dans cinq pays du bassin du Mékong: Cambodge, Laos, Myanmar, Thaïlande et Vietnam. 14570 publications scientifiques et littérature grise ont été collectées et passées au crible par titre, résumé et texte intégral. 2355 articles sont inclus pour la cartographie systématique sur la période 1978-2020. De façon générale, les articles qui traitent directement des inégalités en relation avec les changements environnementaux sont rares et récents. Trois thématiques apparaissent particulièrement représentées : l'accès aux ressources et les questions relatives aux droits (967 articles) ; le changement climatique et les impacts des catastrophes (533 articles) ; les aspects - croissants - liés à la pollution (299 articles). Des limites de connaissances sont identifiées pour différentes questions. Un dépôt d'archives d'accès ouvert est créé vers les références sélectionnées et leur résumé afin de soutenir les futurs recherches et décisions politiques fondées sur la science autour du lien inégalité et changement environnemental.

Mots-clés
Inégalités environnementales, cartographie systématique, Mékong, droits, climat, pollution.

Introduction

Rising inequalities and accelerating environmental changes are two of the most significant challenges of the twenty-first century. But how do they relate to each other? Do they have common dynamic factors? We will try to address this question at the regional scale of the Mekong countries, which benefit from both an ecological and socio-economic coherence.

In a review at global scale, Hamann *et al.* (2018) show that far from being independent, inequality and the biosphere interact in many different ways through different types of interactions – or "pathways" –, including those of unequal societies leading to more degradation of the environments (emphasized in Cushing *et al.* 2015). The economic and social investigations around the increase in inequalities all over the world (Piketty, 2014) would then expand to be an ecological topic as well. More often than not, the impacts of environmental changes vary between groups of people and are also strongly informed by existing social inequalities. Environmental changes put disadvantaged population groups at significantly higher risks, as confirmed by Chancel and Piketty (2015) in the case of climate change. Confirming the issue, Mohai *et al.* (2009) conclude that exposures to pollution and other environmental risks are unequally distributed by race and class. There have been various reviews globally on the relations between inequalities and the biosphere (Hamann et al., op. cit.), between environment quality and health (Cushing et al., op. cit.), and regionally applied for environmental justice works in the US (Mohai et al., 2009). Putting an emphasis on the nexus between inequality and the environment helps identify the people at risk and/or the disadvantaged group; which then steps towards understanding the winners and losers of environmental policies supporting sustainable development (Boyce, 2007).

Different typologies of inequalities have been investigated by academic and political institutions. Let us quote the economic, political, environmental, social, cultural, spatial, and knowledge-based inequalities defined by the 2016 World Social Science Report (ISSC 2016), or the tripartite typology of equity (distributional, recognitional and procedural equity) used in Schreckenberg et al. (2016) and Leach et al. (2018), developed from Fraser (1996). There is also the distributional, recognitional, and contextual equities (McDermott et al. 2013). The notion of "Environmental justice" first emerged as early as the 1820s but was only mentioned in the United State in the mid-1980s (Mohai et al., 2009). It was transferred to Europe in the 1990s. The Organization for Economic Co-operation and Development (OECD) finally defines inequalities with four dimensions: exposure and access inequalities, policy effect inequalities, impact inequalities, policy-making inequalities (Laurent, 2011). Inequalities increasingly become an essential element towards 'a fair and equitable process of moving towards a post-carbon society' (McCauley & Heffron, 2018). The notion of just transition is indeed embedded within a political trade-off. Any ecological pathway has to be made compatible with the pursuit of 'climate justice' to current and future generations exposed to social and ecological disruptions (Newell & Mulvaney, 2013).

The Mekong river basin plays a crucial role for the livelihoods of millions of people of Cambodia, China, Lao PDR, Myanmar, Thailand, and Vietnam. At the same time those countries have faced some of the most rapid

socio-economic and sometimes political changes in the last few decades. While Thailand has explicitly articulated both with globalization and antiglobalization discourses, in the case of Laos, Vietnam and Cambodia, it is difficult to separate the advent of post-Cold War globalization discourse from the more general opening of these economies. This opening has been associated with the move from command economies, semi-autarkic in the case of Laos and Democratic Kampuchea in the latter 1970s, towards more open market economies following Laos' and Vietnam's reforms of the mid-1980s, and Cambodia's transition and end to international isolation after 1991 (Hirsch, 2001). The determinants of inequalities are thus embedded in rapidly changing institutions which have both national and regional histories. These idiosyncratic evolutions of inequalities also become more and more embedded in common ecological constraints.

The current environmental changes in the region include (but are not limited to) the construction of dams, over-extraction of underground water, pollution from fast developing cities, deforestation, sand extraction, and other activities (Stibig et al. 2014, Simpson 2007, Hirsch 2016). They have caused great environmental disturbances, threatened the life and livelihoods of millions people, among which the most vulnerable experienced a heavy toll.

Climate change adds to these ongoing environmental problems by increasing the region's fragility. Prediction states one meter of sea-level rise would cause the displacement of 7 million inhabitants and flood the homes of more than 14.2 million people in the Mekong Delta, Vietnam (ADB, 2013). Furthermore, climate change is only one of the many drivers for vulnerability. Other social and environmental stressors, including social marginalization, lack of access and rights to natural resources and poverty are drivers of environmental changes as well. In a growing economy, each inhabitant is facing these issues, including the climate change risk, differently (O'Brien 2012, O'Brien and Sygna 2013). In fact, the decisions on economic growth in the last decades have put more people, assets, and resources in the path of encroaching climate change (McElwee, 2017).

At this stage, numerous studies have tackled one specific aspect of the relation between environmental changes and inequalities in the region, but no holistic assessment has been conducted so far. As long as no mapping of this scattered knowledge exists, highlighting the diverse quality of the studies, their data sources, their representativeness, the needs for further studies or on the contrary the well-established results, a holistic view is not possible. Furthermore it is difficult for the local or national decision makers, let alone any regional institution, to take science-based action. We propose a specific regional study on how these multidimensional variables of inequality and environmental changes relate and interact with each other. It aims at building a scientific base for policy action as well as identifying under-investigated research questions. In part 2, we develop the underlying aspects of inequality and environmental change in the specific context of the Mekong River Basin countries. In part 3, we explain the methods of systematic mapping based on Armstrong et al. (2011) and (Petticrew & Roberts, 2008) and describe how it is applied in this research. The process of data collection and screening are then described in part 4. Part 5 will present the key results of the systematic mapping in terms of time, geography, disciplines, and methodologies. The resulting linkage between inequalities and environmental changes will shed light on some gaps of knowledge and potential axis for further analysis which will be exposed in part 6.

1. Defining inequalities and the environment

Equality or equity have currently been at the center of the development agenda for their relevance and interdependence with growth dynamics and poverty alleviation. In the Mekong region, extensive interventions on land, water, and other resources in the last decades have fueled economic gains, while leaving significant negative impacts on the environment and communities, especially the most vulnerable ones, in particular ethnic groups, the poor, fishers, women, children, migrants, smallholders and so on. The social groups mentioned above are also likely to become even more vulnerable in the near future (Resurreccion et al. 2011). Adding to the problem, vulnerability to climate change is also socially differentiated and those consistently identified as most vulnerable to climate risk are those already socially vulnerable. The reverse relation also exists. Indeed inequalities often lead to an overuse of natural resources through different channels. Different human activities and behaviors may also hinder the attempts towards environmental protection. As noted by various authors (Cushing *et al*., op.cit , Boyce, op.cit), inequality has often been discussed in its economic (income) dimension (Piketty, 2013, op. cit.) without focusing on the diverse and holistic dimensions of inequalities in their relation to different environmental dynamics.

This systematic mapping builds on the relations between environmental changes and inequalities. For this matter, it is necessary to select in a coherent way the associated keywords. For that matter, we follow different theoretical approach to the literature. We follow the definition from Leach et al. (2019) that emphasizes: "ensuring that everyone has what they need for wellbeing in a given context, implying 'more for those who need it'" rather than "treating everyone in the same way, or evenly distributing a given 'pie'". Inequalities or inequities can be economic, political, social, cultural, environmental, spatial and knowledge-based (McDermott et al., 2013, ISSC and IDS 2016, Leach et al. 2019), which is put under the tripatite typology of distributional, recognitional and procedural equity (Schreckenberg 2016, Leach et al. 2019, developed from Fraser 1996), or distributional, recognitional, and contextual equity (McDermott et al., 2013). Distributional equity refers to how resources, costs and benefits are allocated or shared amongst people and groups; recognitional equity refers to the acknowledgement of and respect for identity, values and associated rights; and procedural or contextual equity highlights how decisions are made, and the extent to which different groups are able to influence these or have their voices represented or incorporated. Among others, history, culture and norms also affect the level and reproduction of inequalities. They often maintain and even reinforce social exclusion based on gender, race, class, caste, ethnicity, disability and other axes of difference (ISSC 2016).

In listing out the relevant themes and scopes for the search and screening, we also follow the elaboration of environmental inequality definition from Chancel et al. (2015) and Laurent (2011). Indeed, environmental inequalities relate strongly to policy challenges, encompassing unequal access to environmental resources, various degrees of exposure and sensitivity to hazards and whether environmental (adaptation) policies have diverse effects on different segments of society (Chancel et al. 2015). According to Laurent (2011), environmental inequalities could be considered in four categories: (1) exposure and access inequalities,

which encompass unequal access to environmental goods, as well as different degrees of exposure and vulnerability to environmental risks, represented for example by natural hazards or droughts; (2) policy effect inequalities, which refer to the unequal effects of environmental policies such as carbon taxes, energy subsidies, protected area policy or REDD+; (3) impact inequalities, which relate to the unequal environmental impacts of individuals and groups, such as the unequal amounts of pollution produced by different segments of the population; and (4) policy-making inequalities, which refer to the unequal access of individuals and groups to environmental policy-making.

Figure 1. Practical scheme for systematic mapping to summarize the two-way relation between environmental changes and Inequalities in the Mekong region
Source: Authors' construction.

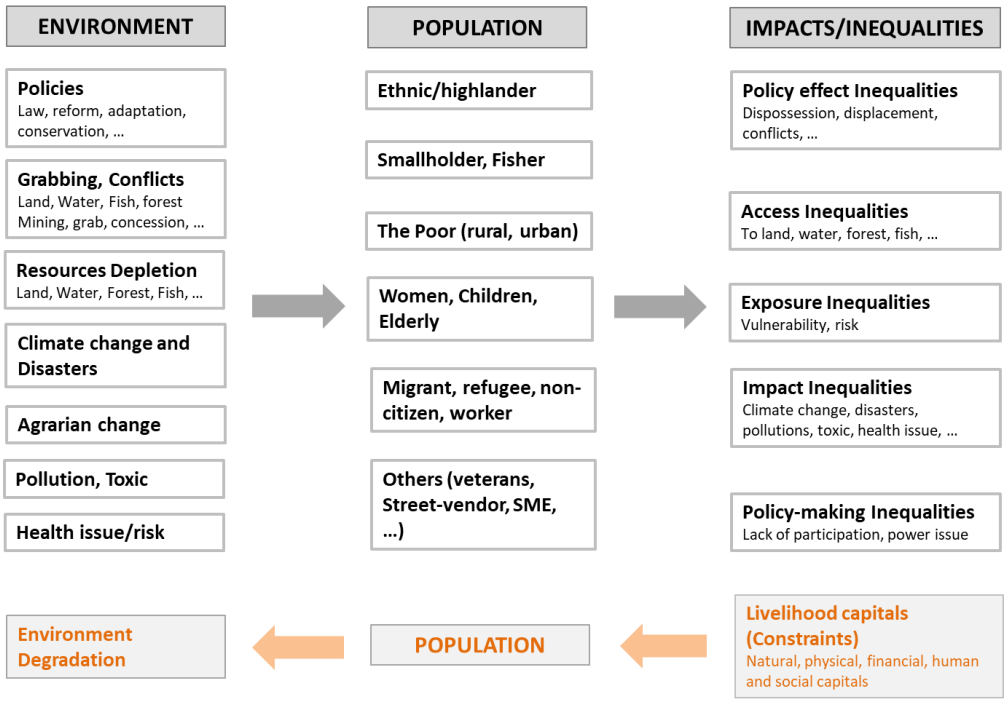


Figure 1 shows the practical scheme that guides the systematic mapping in order to capture the existing literature and narratives on the linkage between environmental changes and inequalities in the Lower Mekong region and Myanmar. From left to right, the changes in the environment, such as resource governance policies, reform or concession, grabbing of resources, natural disasters including the effects of climate change, pollution issues and health risk, affect several or particular groups of vulnerable or disadvantage people. The impacts of those issues on certain groups, with or without a comparison with others, illustrate various manifestations of inequality. As elaborated above, inequalities could happen in different ways, namely exposure, access, impact inequalities and policy making process inequalities.

The reverse relation is also explored. Constraints in livelihood capitals affect the capacity and decision of certain groups towards environmental conservation. We distinguish between five types of livelihood capitals: natural, physical, financial, human and social capitals as part of the sustainable livelihood framework (Scoones, 1998, Serrat, 2017). They are elaborated as follows:

- **Human capital**, e.g., health, nutrition, education, knowledge and skills, capacity to work, capacity to adapt.

- **Social capital**, e.g., networks and connections (patronage, neighborhoods, kinship), relations of trust and mutual understanding and support, formal and informal groups, shared values and behaviors, common rules and sanctions, collective representation, mechanisms for participation in decision-making, leadership.

- **Natural capital**, e.g., land and produce, water and aquatic resources, trees and forest products, wildlife, wild foods and fibers, biodiversity, environmental services.

- **Physical capital**, e.g., infrastructure (transport, roads, vehicles, secure shelter and buildings, water supply and sanitation, energy, communications), tools and technology (tools and equipment for production, seed, fertilizer, pesticides, traditional technology).

- **Financial capital**, e.g., savings, credit and debt (formal, informal), remittances, pensions, wages.

Due to constraints in one or several of the other capitals, groups of people continue exploiting natural resources in a way that degrades the resources themselves. Also because of some financial, educational or broader social constraint, some people are not willing to adopt conservation practices that could both improve their livelihood and environment at the same time. We will now explain how these different channels are investigated in the existing literature, thanks to the systematic mapping methodology.

2. Building a systematic mapping of the relation between inequalities and environmental changes

We adopt the systematic mapping methods (Armstrong et al. 2011, Petticrew and Roberts 2008) to study how the multidimensional variables of inequality and environmental changes relate and interact with each other. We can define the process as follows:

> "Systematic reviews use a transparent and systematic process to define a research question, search for studies, assess their quality and synthesize findings qualitatively or quantitatively. A crucial step in the systematic review process is to thoroughly define the scope of the research question. This requires an understanding of existing literature, including gaps and uncertainties, clarification of definitions related to the research question and an understanding of the way in which these are conceptualized within existing literature." (Armstrong et al. 2011)

Scoping and systematic reviews are different from a classical bibliographic review by the very specific search methodology they follow. The scoping review, also called systematic mapping, is an independent step in itself and is the backbone method of this research.

Our research question can be stated as: What is known from the existing literature about the inequality - environmental changes nexus in the Mekong region?

We first established a test-list to ensure the comprehensiveness of the search equation. The list consists in papers identified together with an external expert group. With keywords identified with the contribution of the experts, search equations are built and tested with the list. At screening stage, inclusion and exclusion criteria are justified ex ante with only minor adjustments ex post if needed. In the following section, we develop in more details the different steps applied in this mapping.

2.1. Mapping process

The review took place from October 2019 until February 2021 (detailed calendar is presented in the annex) following the steps detailed in Box 1.

Box 1. Steps for the systematic mapping applied in the Mekong Environmental changes and Inequalities project (2019-2021).
Source: Authors' construction.

Steps of the systematic mapping
1. Scoping question Formulation
What is known from the existing literature about inequality - environmental changes nexus?
2. Contact and formulate expert committee
3. Establishing test list with the advises from the experts
4. Identify search terms (equation - PECO)
5. Search on various platforms
6. Search for grey literature
7. Refine the results (three levels: title, abstract, fulltext), criteria is built with the experts
8. Quantity and mapping analysis

2.2. Literature search

The search equation was based on discussions with an external expert committee which provided the test-list (see Annex). The test-list consists in 16 relevant reference papers that any relevant search equation should find. The use of such a test-list is a quality criteria for the search equation. It makes sure the search equation succeeds in retrieving the most relevant sets of studies, as selected by the external expert committee. The experts also engaged in the process of building the screening criteria for the studies. The equation below was identified and applied in the search for literature on online databases.

The equation was built on the elaboration of 4 elements: P - Population, E – Exposure, C - Comparator, O – Outcome (Box 2). We consider the two-way relation between environmental changes and inequality: environmental elements can thus be either Exposure or Population (exposed), while inequality, causing environmental degradation or hindering the efforts for conservation, can be Exposures.

We run the search equations on Web of science, Science Direct, Wiley Online, Taylor & Francis Online, Proquest, Springerlink, Sagepub, JSTOR, adjusting the equation according to the guidelines and limitations of each databases. The search took place in the topic section or in the title/abstract/keyword whenever the options were possible. These databases were either available in open-access, or through a pre-existing subscription of IRD and Chiang Mai university in Thaïland.

Other search exercizes were run on various institutional websites and local libraries by 5 teams in the 5 countries. Blogpost, in-depth analyses on newspapers, websites were also collected. Those were separated at the full-text screening stage for a different analysis apart from this systematic mapping.

Language: We searched for literature written in English and in local languages. The total items collected were 18286 English texts, 1112 in Thai, 2 in Khmer, 19 in Laotian, 143 in Vietnamese, and 7 in Burmese. Only English, Thai and Vietnamese items were screened at title and abstract stages, and only English items entered full-text screening for the mapping.

The details of search and number of items achieved are recorded in the annex 1. All items were stored in Zotero for sharing between reviewers (annex).

Box 2. Steps for the systematic mapping applied in the Mekong Environmental changes and Inequalities project (2019-2021).
Source: Authors' construction.

Text underline: repeated between P and O.

Search Equation = [**P**opulation (countries)] AND (**E**xposure) AND [**O**utcome OR **P**opulation (others)]

POPULATION:

- Lower Mekong, Laos, Cambodia, Vietnam, Thailand, Burma/Myanmar **(Countries)**
- Urban, rural, the poor, the rich, beneficiaries
- Woman, children, farmers, small-holders, peasant, fishermen
- Vulnerable group, marginalized, disadvantaged group, minority, highlanders, indigenous, lowlander, ethnic group, ethnicity, communities, hill-farmers, forest people, downstream/upstream

EXPOSURE (Environmental changes and Policy/Driver): Interventions

- **Land**, land use, Land grabbing, swidden farming, green grabbing, subsidence, land degradation
- **Agriculture,** Agrarian change, Cropping pattern, Aquaculture, Fisheries
- **Air**, air pollution, air quality, haze
- **Water**, water pollution, waste, pesticide, contamination, erosion, salinization, flood, storm, typhoon, extreme event, drought, water supply, hydropower, water regime change, irrigation, groundwater
- **Climate**, climate change, sea level rise, heat, temperature; hazard
- **Ecosystem, biodiversity**, fishes, fauna; biological services, National park
- **Forest**, mangrove, deforestation, conservation, protected zone, community-based; environment changes, biosphere, resources, nature, coast, anthropogenic degradation, agro-forestry
- mining, gas exploitation, sand, sediment transport

COMPARATOR:

Before and after the climate events, the changes, between locations/communities/countries

OUTCOME (Inequality): *Environmental changes leading to inequality and vice versa; Inequality of what*

- Equality, Inequality, Equity, Social injustice, Climate justice, environmental justice, vulnerable group, marginalized, disadvantaged group
- **Economic**, income, poverty, livelihood, well-being, debts, education, health, Access,
- **Social**, resettlement, risk, migration, Class, occupation, employment, job
- **Cultural**, perspective, belief
- **Political,** participation, governance, distribution of wealth
- **Spatial**
- **Environment**, resilience, adaptation, mitigation
- **Knowledge**, information
- **Identity**, right, citizenship, gender, generation,
- **Geography**, ethnicity, ethnic conflict, highland, lowland, urban, rural

DRIVERS/INTERVENTIONS/CONTEXT (to be used in secondary equation)
Equation(2)= [**P**opulation (countries)] AND (**E**xposure) AND [**O**utcome OR **P**opulation (others)] AND (**D**rivers)

- National policy: green growth, smart city, Industry 4.0, urban development, industrialization, special economic zone, policy, contract farming, privatized public land, tourism, new rural area
- Macro-economic, FDI, Free trade, commercialize, climate-smart,
- Science and technological innovation solar, innovation
- Intensification, pesticide, chemical

The search includes a wide range of topics which by and large will help us build the largest possible fishing net for the existing literature.

2.3. Screening process

The screening process included title and abstract screening, and full text screening. The title and abstract screening was performed by three reviewers. Full-text screening was performed by the main reviewer and 4 assistants from Vietnam and Thailand. Kappa tests were applied at title and abstract screening stages to ensure the consistency between reviewers. Cohen's kappa coefficient (k) is a statistic that is used to measure interrater reliability for qualitative items (McHugh, 2012). It is a quantitative measure of reliability for reviewers. In this review, Kappa tests were done with 46 articles for title and 45 articles for abstract to make sure the agreement between reviewers. Disagreements were discussed before entering the title and abstract screening. Details of Kappa tests could be viewed in the link:

https://drive.google.com/file/d/174zorddEEDGdrVo3KiR8FJGBu-OaQ5aE/view?usp=sharing

In full text screening, we made decision to include or exclude one document by the criteria built between the reviewers and the scientific committee, following Petticrew and Roberts (2008). The list of criteria were also used as a coding information for fulltexts (see Table 1).

The reviewers followed the rule below to decide the inclusion or exclusion of one item. When the information provided by the title or abstract was not sufficient to exclude or include the article with certainty, it was kept and examined at the next screening stage.

Title:

Inclusion criteria:	Presence of the element of environment and population OR Country/region not mentioned OR Title mentioning the impact of environmental change without directly pointing to social impact
Exclusion criteria:	Absence of the above-mentioned elements OR Presence of the name of countries that are not within the 5 countries OR Indication that the article is a review, a meta-analysis, a policy brief

Abstract:

Inclusion criteria:	Presence of keywords of both environmental changes and population OR environmental changes and impacts, OR Population and environmental conservation elements OR Regional studies with no specific country mentioned OR Items with no abstract
Exclusion criteria:	Similar to criteria for title screening

Full text:

Inclusion criteria:	Presence of all PEO elements: the linkage Population – Exposure – Outcome in either one or reverse relation between environmental changes and population at risk. Notes about the positive impacts: As we aim at inequality, so if the relation leads to a negative impact, the comparator element is not required. But if the study points to a positive impact (eg. conservation or adaptation of certain group), there MUST be a comparator or statement about factors that restrict the people to adopt conservation or able to adapt. Some special cases In the case of land use change (agrarian change) that affect the people, small-farmers got disadvantaged due to the expansion of other crops but were unable to adopt them OR Small farmer lost income and land due to the expansion of new landlord (rubber, maize, etc.). Fishery workers working in air-polluted environment.
Exclusion criteria:	Similar to those applied for title or abstract screening. Special cases: farmers that join contract farming/maize, rubber farming without clear discussion on the difficulties to adapt or to sustain in the commercial agriculture; Marine fisheries human trafficking in general with no specific environmental element such as: pollution or induced migration. Overlapped papers: publications with similar data set of previously included paper are excluded and stored separately from the exclusion list, Collective books that have its chapters screened separately.

2.4. Data coding strategy

Informations from 2355 final documents were extracted. The list of information is presented in the Table 1. below whereas detailed elaboration of each component are presented in the annex.

Table 1. Data coding for the systematic mapping.
Source: Authors' construction.

The title and author	a. Title: in full b. First author
Bibliographic information	a. Publication type b. Year c. Geography
Information for inclusion/exclusion	
Population	a. Population I: Human population (affected by environment changes) b. Population II: Environment affected by human activities (Reverse relation) c. Population III: Location of exposure/affected d. Population IV: Activities/condition of human population (at exposure)
Exposure or Intervention	e. Exposure I: group of environmental changes f. Exposure II: Human activities hindering environmental protection (Reverse relation)
Outcome	h. Outcome I: Types of human impact i. Outcome II: Types of environmental impact (Reverse relation)
Study type and design	a. Study type (only empirical) b. Study design and method c. Timescale (the investigating period and the study duration) d. Disciplinary
Comparator and other criteria	a. Comparators

2.5. Data mapping method

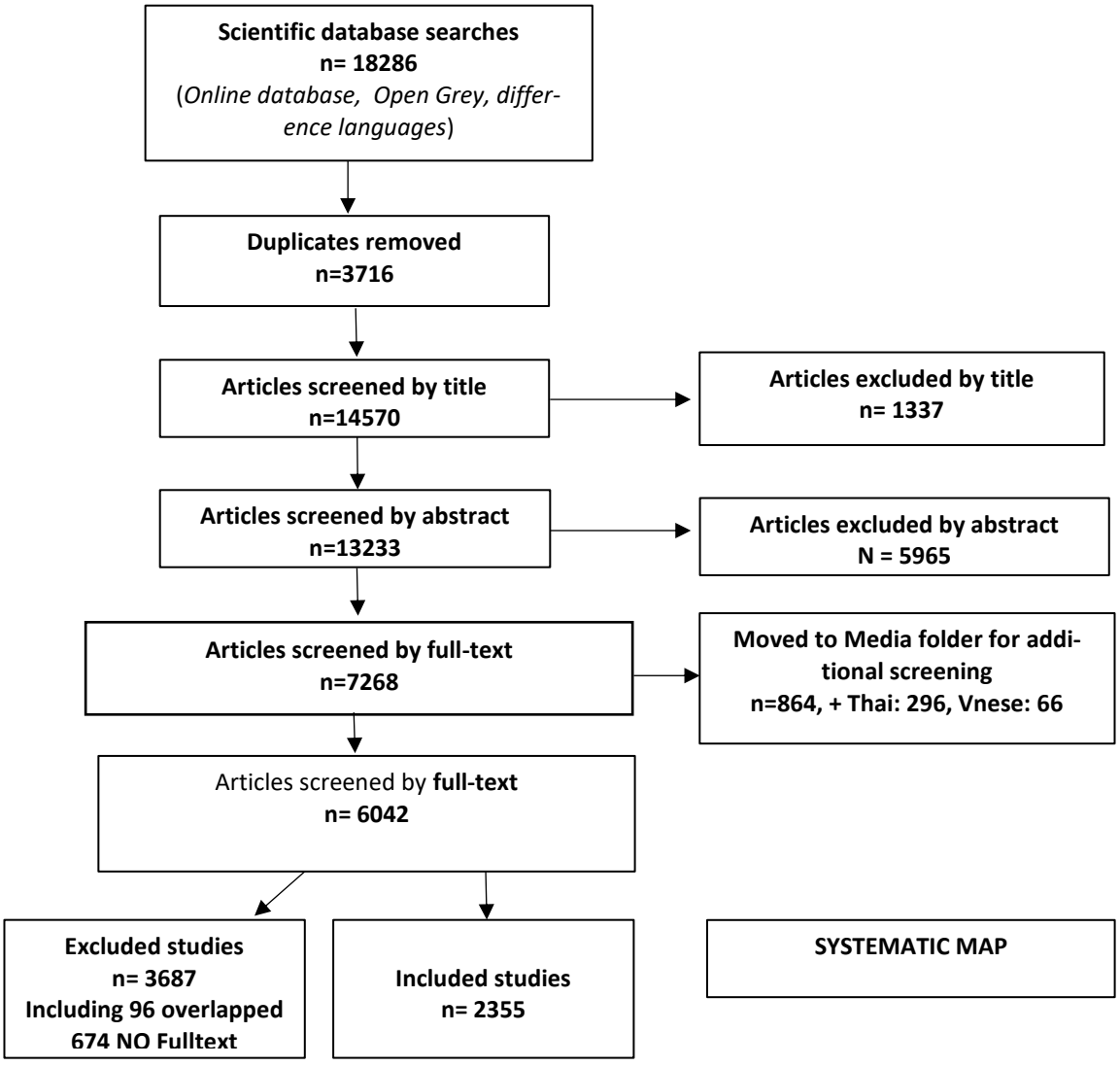
We map quantitative information on the corpus: geographical distribution of the studies, number of works published in year, types of publication and types of study, co-authorship occurrence, proportion of studies on different groups of population at risk. Two heat maps of Exposure – Population "Environmental changes - population at risk" and Exposure – Outcome "Environmental changes and Outcome" from the 2355 studies are presented. They constitute the basic material to identify knowledge gaps

3. Findings

In total, 18.286 items were collected. 14.570 items entered screening after duplications removal.

1337 items were excluded at title screening (9,2%), 5965 items were excluded from abstract screening (45,1% of 13233 items), after excluding media/blogpost texts and those in Thai and Vietnamese, 6.042 items, published between 1961 – 2020, entered full text screening for systematic mapping. In team, 2355 items (32,4%) were included for the mapping, see Figure 2. In addition, 96 items overlap with the studies presented in the previously included papers. They are not counted for the mapping. Due to time and access constraints, 674 items had no full-text found or accessed, thus were not screened.

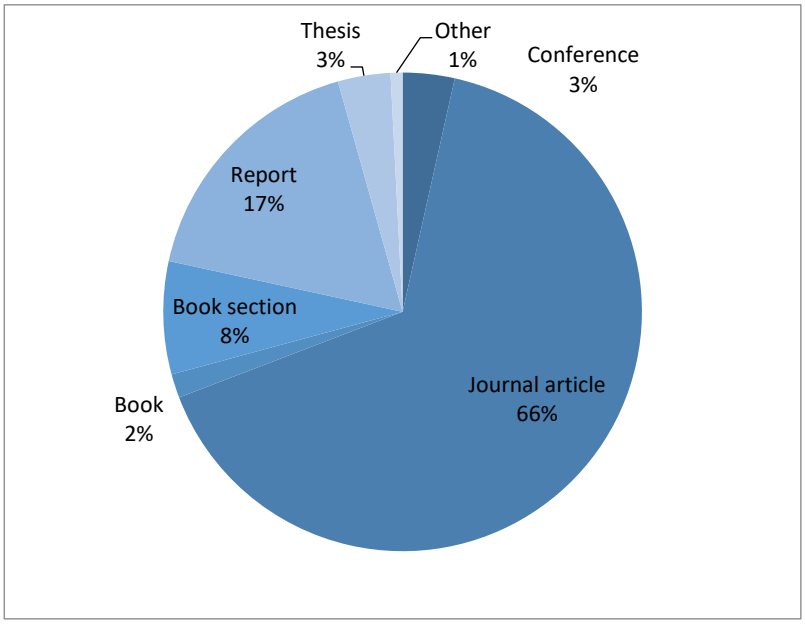
Figure 2. PRISMA Flow chart: Mekong Environment and Inequalities systematic mapping.
Source: Authors' construction.



3.1. Distribution of research from 1970s – 2020: The evolution of imbalance in research capacity

A majority of the literature included is constituted mainly by journal articles (66%), others include book section, thesis, conference papers, reports, and unpublished manuscripts[1] (Figure 3). A fair number of reports (17%) reveals the attention of institutions, especially NGOs on the inequality aspect of environmental changes (Hirsch 2001, Yasuda 2015, Partelow et al. 2020).

Figure 3. Types of publications mapped
Source: Authors' construction.



We found more researches about environmental changes and inequality relation in Thailand (38% of the studies including the regional ones – Mekong, Southeast Asia, Asia and global scale), Vietnam (24%), and less publications about cases in Cambodia (12%). Myanmar (8%) and Laos (8%) have the least works found in our collection (Figure 4).F It demonstrates the differences in the volume of scientific spread and capacity of research facilities between countries. Thailand has been the regional hub for social science research, notably the Mekong Land Research Forum managed by Chiang Mai University. 697 publications were collected from the repository of the program alone[2].

Besides, more work from and/or related to the discussion about human right, environmental protests and NGOs are found about Thailand, and more recently about Myanmar. Indeed, the higher number of studies in Myanmar compared to Laos is strongly contributed from the NGOs works, especially in the fields of conflicts on resources, rights in the country.

1. 1 Due to time and human resources constraints, the research and works in local languages are not included in this table due to time and language constraints. Media such as newspaper articles, blog post and so on are also excluded in this screening for their different in structural nature.
2. 2 http://www.mekonglandforum.org/search

Figure 4. Geographical distribution of the studies only applied for 5 studies on the issues in five country (Left) and the percentage contribution to the total number including those researching at regional and global scales (Right).
Source: Authors' construction.

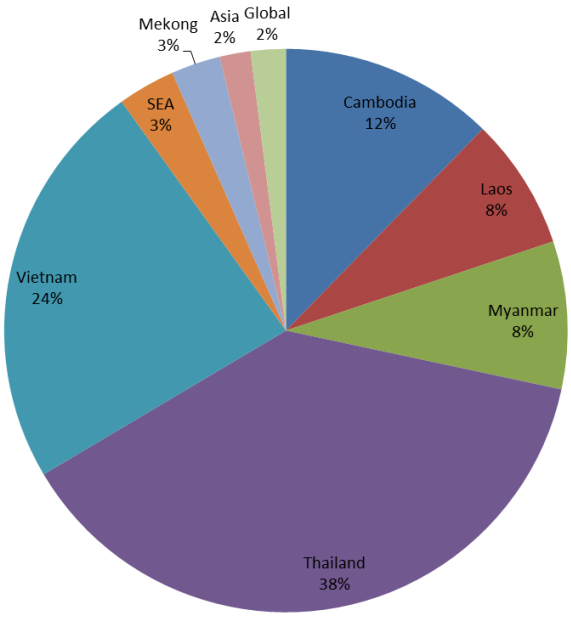
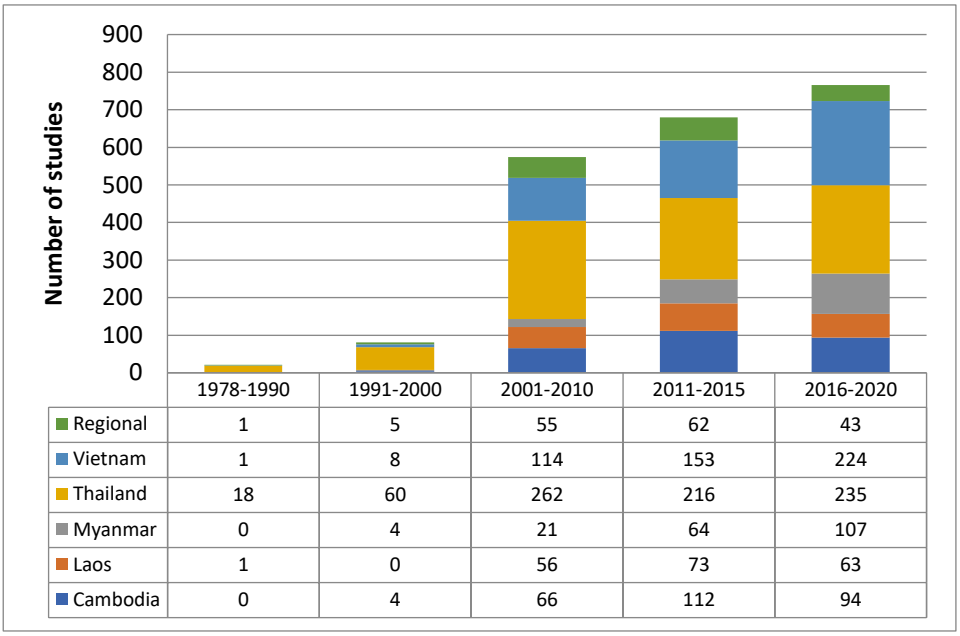


Figure 5 shows significant increase in studies in the area during the 2000s (6,7 fold compared to the previous decade), especially in Vietnam and Thailand. The following decade (2011-2020) witnessed a boom in scientific works on the vulnerable groups regarding the impacts of environmental stressors, 2,6 times higher than the number in the 2000s.

Figure 5. Evolution of research on environmental changes and inequalities from 1978 to 2020; distribution between periods and per country.
Source: Authors' construction.



	1978-1990	1991-2000	2001-2010	2011-2015	2016-2020
Regional	1	5	55	62	43
Vietnam	1	8	114	153	224
Thailand	18	60	262	216	235
Myanmar	0	4	21	64	107
Laos	1	0	56	73	63
Cambodia	0	4	66	112	94

Since the 1990s, Mekong governments invested in large scale infrastructure projects like roads, dam buildings, and commercial agriculture in replacement of subsistent shifting cultivation (including opium production). In the 2000s, the economic gains of large-scale development started to be questioned by the visible negative impacts, especially on local communities. Among those, some face more problems than the others. The included items illustrate how the interest on impacts of investments and policies has gained attention since the 2000s. During the decade, researchers, institutions conducted studies on (1) how hydropower and infrastructure investments affected the communities that are resettled/displaced; (2) how conservation policy as national parks and protected areas revealed its drawbacks; such discussion already took place in Thailand in early 1990s responding to the policy implementation in the country since the 1960s; (3) how commercialization of agriculture and land concession for it led to tenure and livelihood insecurity of some communities across the region. It is also in the 2000s, environmental movement were captured in researches and reports, with the "jump of scale" resistance to globalization in Thailand (already started in the 1990s) and a more poorly articulation with local processes in a surrogate manner in Laos (Hirsch, 2001). There were movements against dam building, land grabbing with the upscale of support from local communities to local NGOs, then international organization. In this theme, majority of publication is about cases in Thailand.

Then until 2010s, reports on environment movement against largescale project backed by the military are boom in Myanmar. Also, the period 2000-2010 marked the expansion of researches on the impact of climate change and natural disasters, which are followed by the discussion of adaptation, resilience in the following years. Nominal events are especially studied for their impacts, such as the 2004 tsunami in Thailand, flood in the basin, 2016 drought and salinity intrusion for the region. From 2011 to 2020, the region achieve more work on gender impacts of the environmental changes and pollutions issues, especially since 2015. Also in the last 5 year, more research have highlighted the issue of rights, then at lesser extent but increasing, injustices and inequalities. It is also due to the focus on right, political ecology appear to be the most dominant discipline applied in the reviewed studies (Figure 6, 7).

Figure 6. Distribution of the literature according to disciplines.
Source: Authors' construction.

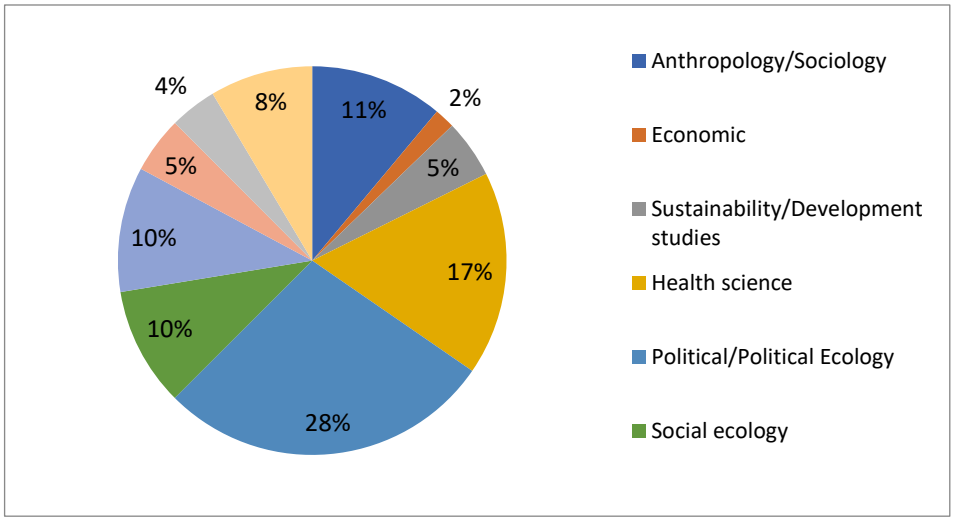
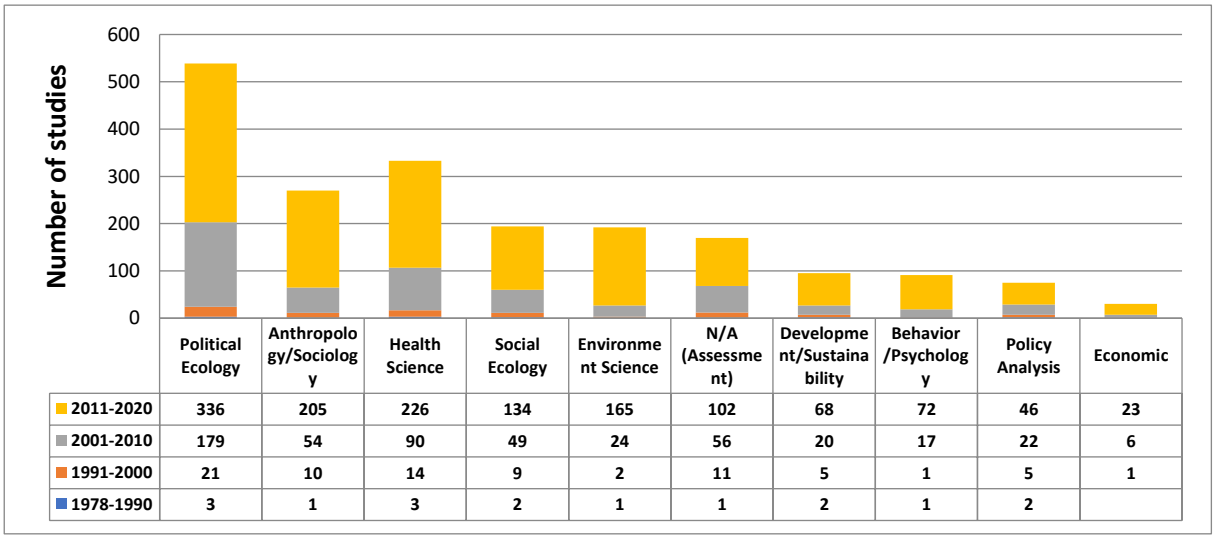


Figure 7. Distribution of literature in disciplines and in periods of year.
Source: Authors' construction.

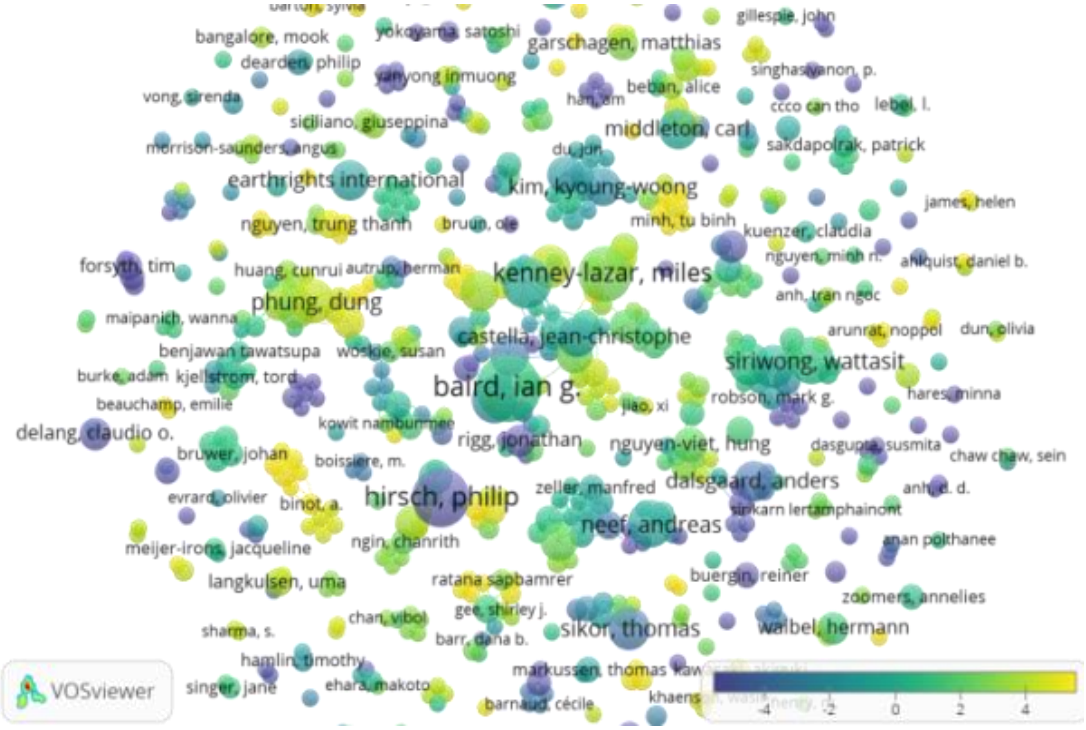


	Political Ecology	Anthropology/Sociology	Health Science	Social Ecology	Environment Science	N/A (Assessment)	Development/Sustainability	Behavior/Psychology	Policy Analysis	Economic
2011-2020	336	205	226	134	165	102	68	72	46	23
2001-2010	179	54	90	49	24	56	20	17	22	6
1991-2000	21	10	14	9	2	11	5	1	5	1
1978-1990	3	1	3	2	1	1	2	1	2	

Research in all fields have increased significantly since the 2000s and gained strongest growth in the period of 2011-2020 (Figure 7).

The share of knowledge production is higher from international experts since the 1990s, yet, most of them have worked extensively in the region. The publications from local researchers have grown, showing in the current increase in number of publications, especially after 2000s (Figure 8).

Figure 8. Mapping co-authorship working on environment-inequalities nexus; 2355 items, 3559 authors, the graph includes those with 2 times occurrence in the database. Left. 100% zoom.
Source: Authors' construction.

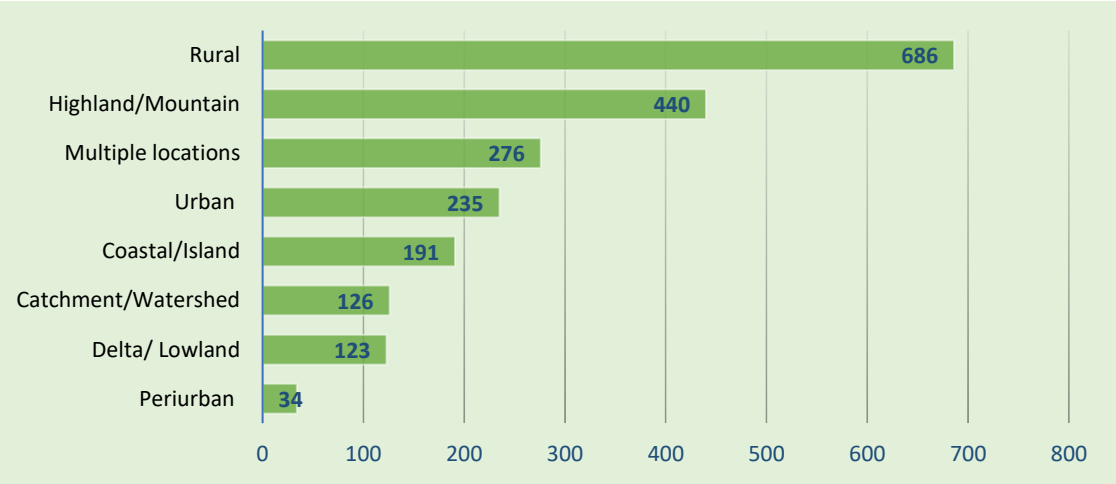


In short, literature and scientific research on environmental changes and inequalities relation have evolved, strongly since the 2000s. As stated above, it is part of the growth in research facility worldwide, and due to the growing interest in the impacts of policies, development and environmental changes. There is an imbalance in scientific work produced between countries that raise attention on upcoming capacity building focus.

4. The inequalities of environmental change impacts

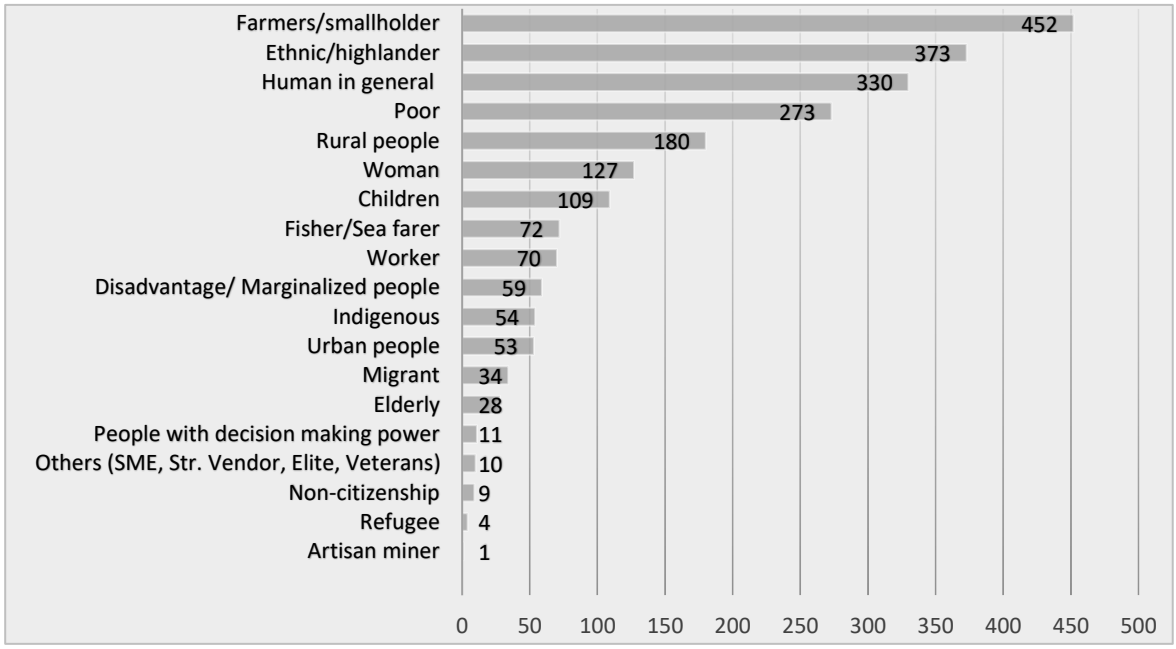
The highest occurrence is rural area (686 studies) and highland region (440 studies). Others such as urban and coastal highland have less representation. Little has been said on the peri-urban space particularly (Figure 8). It concise with the dominance of rural people, the poor, and ethnic minorities (highlanders, hill tribes, indigenous people) as population of the studies (Figure 9). Those are the landscapes where work on vulnerability, marginalization, right issue and livelihood insecurity have been targeted. Thanks to the enormous database on the issues and conflicts around rights to land, forest space, forest products, right to water and fish, we are now looking at already elaborated analyses on the matters. Attention should also be taken to space that has less works on such as peri-urban area.

Figure 9. Number of study in different environments.
Source: Authors' construction.



Regarding the investigated population, while a number of studies use local community in general as the population at risk, farmers/smallholders, highlander/ethnic, the poor are the three most dominant actors researched in terms of their vulnerability and disadvantage to environmental changes (Figure 10). Other actors are also represented at lesser extent, including children, women, worker, fisher, urban people, migrant, elderly. Indeed, the poor, rural communities, and farmers are the traditional targets of research as for their obvious disadvantages. There is a growing interest, showing in our databases, in gender-deviated impacts of environmental changes, and urban populations, especially the urban poor, or the so called slum communities in the city. We also found in some rare studies where elite, decision maker, refugee, non-citizenship, small and medium enterprises (SMEs) or street vendor are studied in their disadvantages in dealing with environmental changes.

Figure 10. Human Populations affected by environmental changes (Population I).
Source: Authors' construction.



Among others, three domain of environment – inequality relations stand out. They are: Right issues and conflicts around land (land grabbing and concession), forest and its products, water, and other resources – 967 Population – Exposure – Outcome (PEO) relations presented; Climate change and disaster impacts on vulnerable groups - 533 PEO relations recorded; and a growing interest on Pollution – 299 cases (Figure 11). Details of the themes will be elaborated in the following sessions.

Figure 11. Linkage between keywords from the 2355 included full-texts, showing three dominant themes from the database
Source: Authors' construction.

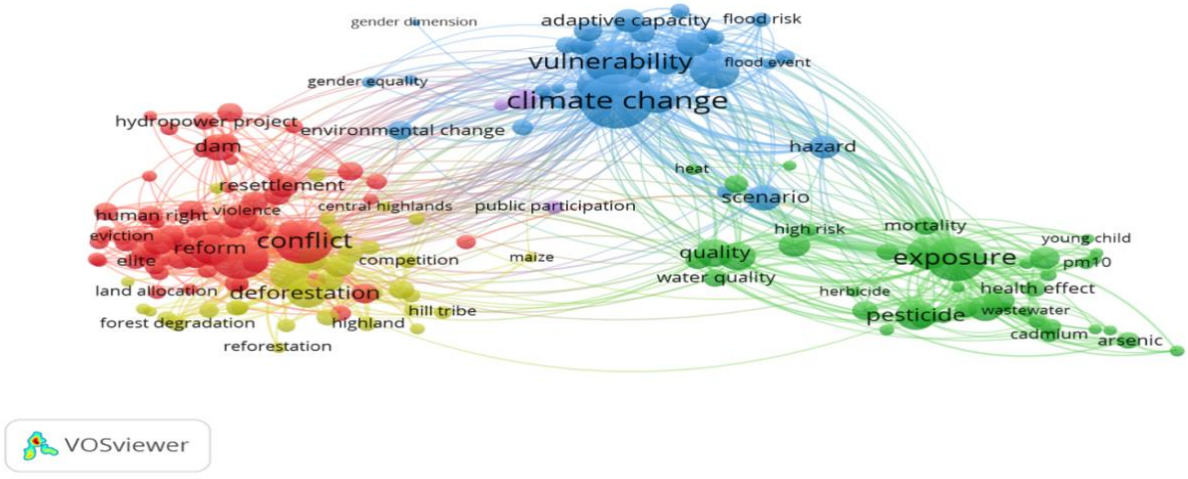
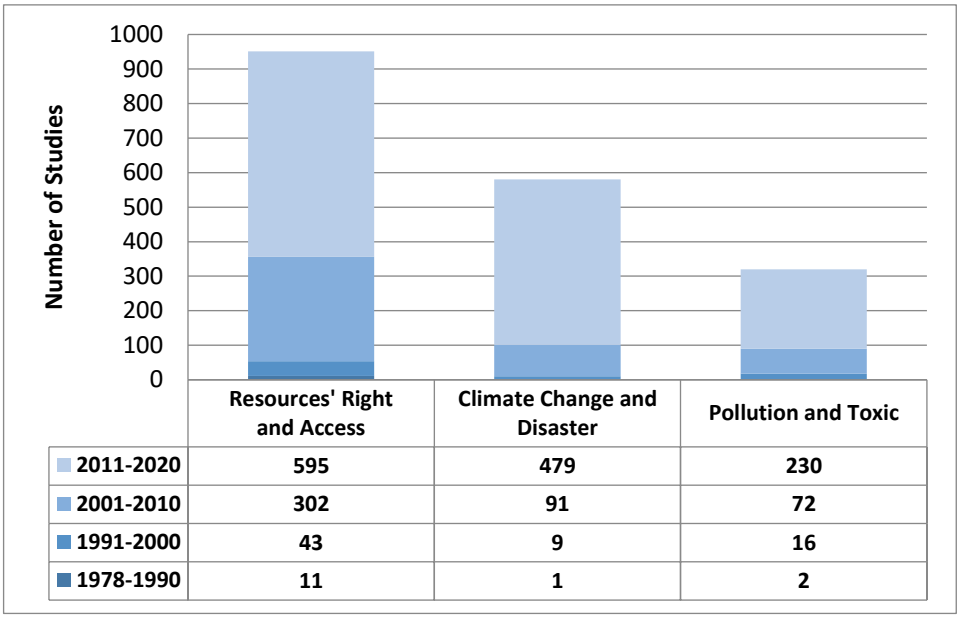


Figure 12. Distribution of studies in three dominant themes in years.
Source: Authors' construction.



	Resources' Right and Access	Climate Change and Disaster	Pollution and Toxic
2011-2020	595	479	230
2001-2010	302	91	72
1991-2000	43	9	16
1978-1990	11	1	2

Looking at the research evolution in years, studies in all three themes significantly increase since the 2000s. Indeed, the data shows no research on climate change and inequalities relation before 2000. It implies the shifting focus on the vulnerable groups, whom were probably out of the radar of economic development in the region in the 1990s. Between the periods 2000-2010 and 2011-2020, there are more than 400% and 300% growth of researches on the inequalities linking to climate change - disaster impacts and to pollution and toxic issues, respectively (Figure 12).

4.1. Domination of ethnic studies and right issues: Recognition Inequalities as the root cause

Upland and its shifting agriculture has long been the target of "development". To the government of Thailand, Laos, Cambodia, Vietnam and Myanmar until the early 1990s, highlanders and hill-tribes are the cause of forest degradation. Their practice of shifting cultivation have been blamed for various environmental problems, including lowland flooding and upland erosion. Such identification provides legitimacy for agrarian changes to cash crop or 'boom crops' such as maize, coffee, cacao, rubber and palm oil (Mertz et al. 2009, Thongmanivong et al. 2009, De Koninck 2011, Fold and Hirsch 2009). It paves the way for land concession and grabbing for large-scale plantations invested mainly by lowlanders and also foreign investors. For instance, Chinese and Vietnamese investors have invested on rubber plantations in Laos and Cambodia since the 1990s and have created significant changes to the areas (Global_Witness 2013, Kenney-Lazar 2009). The common expectation for the expansion of market-based farming was better income for the highland farmers. However, like in the case of Nan province, Thailand, where arable land is only 10%, forest encroachment for maize farming grown significantly in the 2000s, yet the poverty problem faced by local people has also exacerbated (Pampasit & Pampasit, 2018). The authors question the relation between poverty and commercialization of farming.

In facing the flow of commercial cropping into the land, local communities also find their way to adapt and take chances. On a study about the Philippine and Thailand, Dressler & Roth (2011) confirm that farmers can both welcome emerging market opportunities and feel coerced by them, transforming from engaging markets "passively," to now negotiating "active". Swidden farmers while increasing their income become more vulnerable (Cramb et al., 2009). Also, Kong et al. (2019) report in the shifting of changing forest land to maize and cassava cultivation in the Northwest Cambodia that the boom crops engage smallholders in a risky business of growing crops that are part of a wider capitalist mode of production. It alternately traps them into indebtedness and wage labor or outmigration to Thailand, broaden social differentiation with wealth accumulated among privileged farmers (ibid). Also in that process, inequalities continue playing a role in increasing social differentiation. Livelihood capitals (human, physical, natural, financial, and social capitals) then play a role in whether one could adapt and make benefit of the changes, or fall into insecurity (eg. Land right, debt, and so on). Often, poor and small farmers become losers in the market play of commercial cropping.

Besides, investments on the uplands with infrastructure projects, mining, crop cultivation have created the biggest era of land and water grabs in the region (Shepard & Mittal 2009, Neef et al. 2013, Hirsch and Scurrah 2015, Cotula 2012); 255 cases document these dynamics in the databases (see Figure 13). The issue is within the landscape of land concession, acquisition, and resettlement for projects. Ethnic minorities, indigenous groups with customary tenure system and the poor with temporary rights are often at highest risk of dispossession, displacement, resettlement, or even forced eviction. Among others, Cambodia and Laos with land governance system that strongly support large-scale investments since the 1990s. Myanmar's call for investments in the 2010s combined with strict top-down structure controlled by the military had driven insecurity in land, water, forest and other resources rights of the local communities. In the country, it is the continuity of serial, historical land grabbing practices as well as decades-old conflicts shaping and reshaping farmers' land use rights (Suhardiman et al., 2019). The ongoing land reforms in Cambodia and Myanmar are yet helping due to overlapping claims over lands and difficulties to register right (Suhardiman et al. 2019, Scurrah and Hirsch 2015).

In the region, the state is often the primary initiator and implementer of land reform. Such top-down manner in land registration, allocation and (re)distribution may limit the potentials of land reform to achieve desirable changes in land tenure and land use in practice (Sikor & Müller, 2009). At the end, the land reforms led by the interest to encourage private and foreign investment in agriculture to create wealth and reduce poverty could then become to formalize ongoing inequities and created new injustices (McCarthy S, 2018). Indeed, there is still a gap between the reform recognizing customary/communal land rights in the National Land Use Policy, and the ongoing land grabbing in Myanmar. Thus, as Oldenburg and Neef (2014) state, it risks perpetuating and aggravating resource conflicts, distributional inequities and tenure insecurity affecting the majority of the rural poor. Authors call for policy reform to move beyond the state's legal centric approach, which views farmers' land use rights, in the absence of a formal legal title, as illegitimate. Also,

Suhardiman et al. (2019) argue that the importance to understand that "... people may lack formal title to their land, yet, this does not mean that they lack the right to use the land..." and legal-centric approaches to land governance reform are unable to deliver justice.

Figure 13. Distribution of Literature across environmental changes and Populations. The intensity increases from green to yellow, orange and red with red have more studies in the relation; dark grey shows the potentially irrelevant relations.
Source: Authors' construction.

Distribution of Literature across environmental changes and Populations	Ethnic/Highlander	Poor	Farmer/smallholder	Fisher/Seafarer	Women	Children	Elderly	Migrant	Worker	Refugee/Non-ciitzenship	Indigenous	Communities	Disadvantaged	Rural people	Urban people	Others (SME, Elite, vendor), veterans
National park/Protected area	62	4	9	3	3				1		3	3		3		
Hydropower/Water infrastructure	25	10	11	7							6	58	1	33		
Climate change	9	53	72	3	16	5		2	8		4	43	5	3	7	
Resources reform/policy (land, water, forest)	82	38	75	12	19			2	2	5	17	5	4	9	2	1
Health issues-caused agent	5	13	8		10	6	2		5	3		10	6	8		
Agrarian change	17	7	34		6			2	1	1	1	3	1	3		
Pesticide	5		57	1	4	7	1		9			7		5		
Disasters (inc.extreme events)	17	47	41	6	12	8	7	8	7	1		84	20	27	15	3
Pollution (air, water, etc.)	2	5	4	1	2	23	4		11			40	4	17	18	2
Resources Depletion (Land, Water, fish, Forest)	22	14	13	8		6		1			1	2	1	8	1	
Resources Grab/ acquisition/Concession (land, water, forest, fish)	57	28	77	6	10	5	2	2		3	15	25	5	20		1
Mining	14	3	2	1	3	4			7		4	5				
Environmental changes	5	13			1	3		1			1	11				
Toxic	2	2	4	4	3	9			8			15	1	18	3	1

Considered to be forest destroyers, ethnic groups in the highlands are subjected to resettlement for national parks and protected areas (62 cases directly addressing the issue). Since the 1970s, protected area networks in mainland Southeast Asian countries have developed significantly, occupying 4–25% of their respective national areas (Déry & Vanhooren, 2011). Most of the areas locate in the mountainous domains of ethnic minority peoples. Such integration into larger national and international systems put local people into disadvantaged power position (ibid). In those 62 studies, 31 are about conflicts between communities and the government and their resistance (Figure 13). The notions of "our lands are our lives" (Park, 2019), "our forest, our life" (Conservation Alliance of Tanawthari, 2018) are predominant in such context. Protected area at the coast as mangrove reserve in Thailand, Vietnam, or water space reserve in Tonle Sap Cambodia also posed risk to the livelihood of local communities.

Reaching up to the remote highlands, when doing top-down, often appears to be state territorialization of the land and forest (Lestrelin 2011, Woods 2019, Ramcilovik-Suominen 2019, Suhardiman et al. 2019, Vandergeest and Peluso 1998). It is part of the state agenda to incorporate the people in the remote and highland areas into the general state-managed space. It is in the context of land and forest rights, literature had recorded movements, resistance from the ethnic groups. Heated protests and movements with the supports of NGOs had flooded literature and media in Thailand and Myanmar. Conflicts and resistance relations are spotted in mainly cases of protected area, land and water policies and grabbing (Figure 14). For some, it is the "Struggle for life", stated by Diepart et al. (2019).

Figure 14. Distribution of evidence across environmental changes and inequalities. The intensity increases from green to yellow, orange and red with red have more studies in the relation; dark grey shows the potentially irrelevant relations.
Source: Authors' construction.

	Wellbeing						Conflicts and Rights						Gender	Risk and capacity				
Distribution of evidence across environmental changes and inequalities	Health issue	Poverty	Wellbeing	Life cost	Migration	Displacement	Land/Water/Fish/Forest RIGHTs	Eviction	Human-right violation	Access reduction	Conflicts/Resistance	Social Disruption	Gender-deviated impact	Vulnerability	Health risk	Adaptation (capacity)	Resilience (capacity)	Inequality/Injustice
National park/ Protected area		3	15	1	1	5	10	1	8	8	31	1	2					
Hydropower/Water infrastructure	3	1	73	1	1	19	2		5	9	13	4	3	8	2	2		3
Climate change	8	9	58	4	18	5	1			2		1	8	79	13	33	6	2
Adaptation policy			3															
Resources reform/policy (Land, Water, Forest)		12	58		2	5	75		6	14	52	16	4	2		3		17
Health issues-caused agent	33	5	12	5								4	1	6	29			1
Agrarian change	3	8	30		2		9			2	6	15	3	1	2	5		1
Pesticide	31		1											2	62			
Disasters (inc. Extreme events)	24	14	64	13	7	5	4		3	7	4	3	5	99	8	24	14	
Pollution (air, water, ...)	37		10		9					1	2			5	73	1	1	
Resources Depletion (Land, Water, fish, Forest)	1	5	30		1		5			8	12	6		2	4		1	1
Resources Grab/ Concession (Land, Water, Forest, Fish)	7	1	52		2	8	56	8	24	10	49	6	1	4	6	1		7
Mining	7	1	14				5	2	3		4	1	1		8			
Environmental changes	3	4	12		1	2					6	1		5		3	1	
Toxic	19		1								1				52			

4.2. Trending interest on climate change and Disaster impact research

Around the world, climate change and its impacts are at the center of attention. It is also illustrated in this systematic mapping in the Mekong region. As UNESCAP (2018) confirms, natural disasters cause disproportionately greater impacts on poorer countries and households and therefore exacerbate inequalities among countries, but also between the rich and the poor; and climate change magnifies the risk of disasters. Existing studies capture various relevant aspects such as exposure and/or vulnerability to climate change, disasters (eg. Flood, drought, heat, storm, extreme event, erosion, and so on), and their impact on livelihoods and wellbeing of different groups (Figure 14). Local community in general, the poor, smallholders are the most populations discussed (Figure 13). There is a growing interest on how women are affected differently by the climate change and disasters. In some rare occasion, land right dispossession after tsunami (Cohen 2011, Bristol 2009) is also highlighted. It shows the growing interest on the topic, yet studies are still limited in number.

A limited amount of works had mentioned and discussed the inequalities of climate and disaster mitigation and adaptation policies. It shows a lack of knowledge in the field. Although the policies aim at transitions of the rural or urban spaces in adapting to climate change and other environmental stressors, they often include resettlement of communities which cause disturbance of livelihood and social life. Top-down planning is showing its limits by not accommodating the various needs of the resettled households. In addition, due to the attention in climate change, governments and studies tend to focus solely on the issue of climate change. Climate change, however, is only one of numerous problems facing modern urban systems with dense urban conditions often making the system more sensitive to changes and intensifying climate impacts (Storch et al. 2016, Revi et al. 2014, Pelling et al. 2015, Eriksen et al. 2015). To integrate adaptation into 'development-as-usual' paradigms thus risks reproducing the system that creates vulnerability in the first place (Eriksen ibid).

4.3. Pollution, Migration and migrant as a growing concern

Air pollution like haze, water pollution, toxic issues such as arsenic, lead, cadmium risk from mining sites are the next in line of representation in our database (Figure 13, Figure 14). In Asia, researches show that air pollution is estimated to claim over 4 million lives per year, mainly in developing countries and the poor and disadvantaged groups are also disproportionally impacted by pollution (UNESCAP, 2018). Health issues and health risks are the main concern. The higher number of studies focusing on health risks implies the need of evidence to conclude on the impact of pollution to different groups of people. Also, it is worth noticing the majority of works on pollution are from Vietnam and Thailand. It recalls the regional imbalance of research facility as well as awareness of local, researchers and decision-makers in the countries to the importance of environmental impact of human wellbeing.

While international and internal migrations (eg. Rural – urban migration) in the countries have been studied, environment-induced migration are less represented. Despites of the evidence of huge number of environmental migrants and refugees worldwide (Myers, 1993), migration is not a cross-cut matter as environment is one factor intertwining with many

others in the decision to migrate. Migration in the literature mapped is also expressed in the urban life of migrant in their vulnerability to disaster and policy/reform in the urban settings. In the current literature, migration gains little attentions when compared to the phenomenon of large-scale cross-border land acquisitions – or 'land grabs' (Gorman & Beban, 2016). That is the case of Vietnamese in Cambodia whom cross the border and engaged in international migration for the purposes of accessing land for production. Gorman & Beban (2016) conclude that on the Cambodian borderlands, Vietnamese migrants have strived to ameliorate these underlying sources of precarity and strengthen their access to land through the active cultivation of new social relations; whether such relations will be enough to maintain their access over the long term in such a dynamic environment remains to be seen. Similarly, while researches in conflicts between low and highlanders are visited, less attention focuses on why and whether environmental issues play a role in the migration of the lowlander in the first place.

4.4. Community-based resource management as alternative

Knowledge production and policy making in the region has increasingly expanded to the direction of finding alternatives for resource management and conservation. In the last decade, Thailand and Vietnam have "opened up" the protected spaces for community-based management (Huy 2006, N. Pinthukas 2019, Sikor et al. 2013, and many other works). Indeed, it is not unusual for community-based management systems for water to arise in part because of the failure of state-based arrangements (Lebel et al., 2005).

Despite these attempts, lack of participation and lack of recognition towards the role of local communities and embedded inequality are hindering the progress. As a larger problem, global discourse of conservation in the last decades have stereotyped some communities as 'ecological sinners' causing public prejudices (Tomforde, 2003) and disregarding their changing practices. A research in the 2000s shows how decentralization and devolution of forest management to communities were generally slow and given lesser attention despites of the outcry from the communities (Benjamin, 2008). Scientific scholars continue finding evidence to prove the benefits of property rights on protecting resources at the same time with improving the livelihood of local communities. For instance, Chankrajang (2019) asserts that securing communal property rights and exploiting nested layers of governance from the state to the local communities could enhance the governance of the commons and lead to better environmental outcomes. Other policy to protect forest and at the same time sustain the livelihood of local communities is payment of ecosystem services. The idea has been discussed in various forms such as "Payments for pollution control" where the payments serve as a complement or alternative to the "polluter-pays" principle, and "Payments for the conservation of natural resources and ecosystems" (PES). However, as Neef & Thomas, (2009) conclude that further development, testing and refinement of viable, effective and sustainable PES mechanisms in the context of the diverse conditions found in Southeast Asia will be a complex and long-term process.

In land governance sector, researchers have warned the government on how active involvement of local people is essential in planning, implementing, monitoring and evaluating development and conservation programs in swidden lands (commented by Cramb et al., 2009 for Cambodia, and Suhardiman et al. 2019 about Myanmar). The recent announcements made by Cambodian government to cancel economic land concessions and reallocate land to smallholder famers are positive steps. However, Diepart (2016) argues that the process need to materialize quickly as re-appropriation of land which is already being undertaken by corporate and individual actors who have been taking advantage of the absence of a clear vision, policies and mechanisms. All in all, giving communities a role in the strategy development could open a new process and modalities of land reform which was not available in the top-down state-driven system.

4.5. Conclusion on the knowledge gaps

With the present systematic mapping of scientific and grey literature in 5 Mekong countries, we identify several domains in which more research and attention are needed.

Researches on environment that link to fisher, seafarer, migrant, refugee, gender issues, and non-traditional groups of research such as small and medium enterprises, elite, street vendor are needed. It could be both exposure and access inequality of those groups to environmental changes and resources, the impacts of land, water, climate changes and policy impacts on their rights to access and use the resources to sustain livelihood. Urban and peri-urban poor are only in focus recently and more works are needed.

Researches and policy discussions on the impacts and alternative strategies for environmental and resources governance are urgently needed. Conventional strategies of development that is strongly shaped by international discourses of infrastructure investment, commercial agriculture and resources conservation are showing their limits. Current studies on the community-based management also shed some lights in the matter, thus, continuing researches are needed. It should take into account the inequalities embedded and acknowledge the changes in livelihood and needs of communities as they have evolved strongly in the last decade.

Inequality, inequity or injustice, in the relation with the environment, are new terminologies and only limited number of researched directly mentioned and worked on the matter. As defined with the experts, our search evaluated the sense of inequality by including works that demonstrates the marginalization, the vulnerability, the lack of capitals (one or more amongst human, physical, financial, social and natural capitals) of certain group in compared with other group or standing out as a researched target themselves. Direct discussion of environmental inequality in both research and governance arena could enhance the awareness and chance for discussing transformative strategies.

5. Implications for research and practice

This paper presents the results of the systematic mapping on the relation between environmental changes and inequalities in Cambodia, Laos, Myanmar, Thailand and Vietnam. With 2355 out of 6042 items included as relevance, we provide an overview of the knowledge available and knowledge gap as well as a set of database for further exploitation. Researchers, policy makers, and institutions could rely on this analysis to further work on: (1) themes that have available data for content analysis which could already bring in direct advices for policy actions (eg. Tenure and right issue, climate change and disaster and inequalities, pollution and inequalities), (2) gaps of knowledge that need more work of research and development projects in developing the knowledge pool and provide bases for policy recommendations. Taking inequality into account is indeed the only way to make sure policies reach of target and promise for SDGs; as Lebel (2013) states "for marginalized groups, adaptation should be about pursuing social justice in development—empowering and providing options and opportunities to exercise choice". As of 2019-2020, under the new shock and environmental stress such as Covid 19 pandemic, inequality and social differentiation are revealing in some contexts that were not seen before.

Based on the available data analysis, we recommend particular considerations for policy making and researches in the region.

- Upcoming policy and development project should be aware of and take into account the root causes: the nature of ethnicity identification bias (as forest destroyers in forest conservation policy), the current structure and statehood where real participation are not in place, and the undervalued consideration of indigenous, local livelihood compared to trending investment gains. This is crucial for both the climate and biodiversity policy agendas.

- Research institutions should focus more on the notions of equality, equity and justice, which will hopefully facilitate direct research dynamics and discussions on the topic. Scientific and policy-built institutions should enhance connection and development of research on environmental inequalities toward sustainability. Sustainability science and perspective could be the gateway for the upcoming period.

6. Limitation of the review

Despite of method aiming at comprehensiveness, this systematic mapping has limitations. First, there are difficulties to gather literature in Laos and Cambodia. The low amount of documents could both represent the lack of knowledge produced directly linked to facility limitation and be due to the shortage in data collection. Second, literature in local languages were collected, yet not being included in the screening due to time constraint. Third, by looking at inequality itself, we do have bias in excluding the discussion on positive impact of changes such as a potential land and forest policy. The papers on positive trials and cases were included in the discussion of this and will be incorporate in the upcoming analyses.

Also, terminologies might be overlapped in the categories of populations. They could be merged in future research or more analysis based on this database. Separating them at the moment also reveal the schools of thought and focuses in research which would be interesting to further analyses. One example is the use of indigenous term in some research which might overlap with ethnic group or local people.

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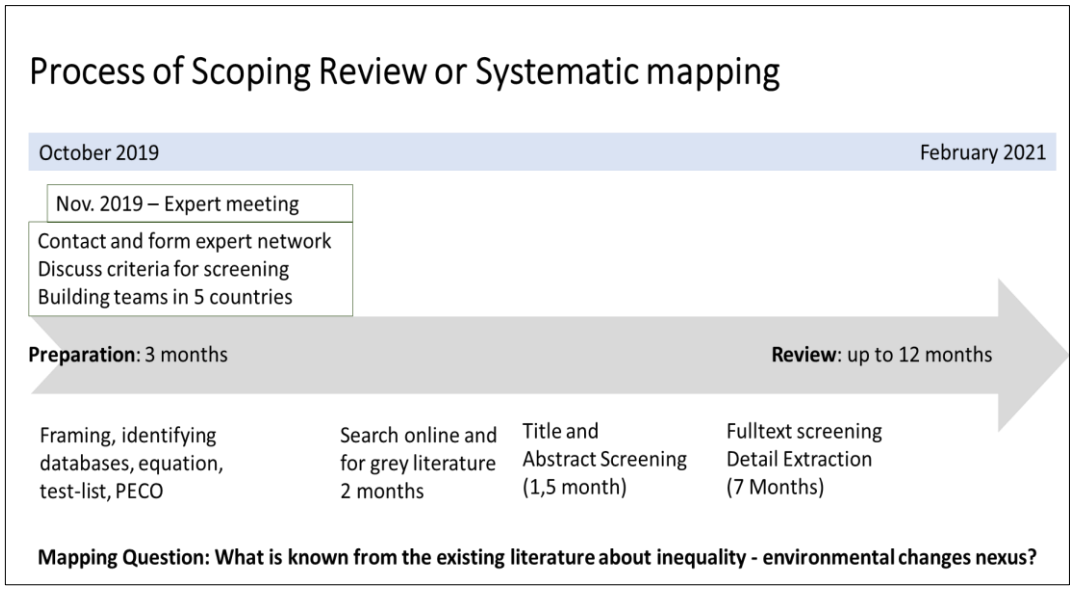
Annex 1:
Timeline of research program, search record

Repository of data – abstract-included items
https://www.zotero.org/groups/2366065/mekong_equality/collections/EWDLR984;

It provides a full collection of those relevant works for future uses. Those excluded in the current mapping with the set criteria are kept as its potential relevance for further analysis on the three dominant themes (see result part) and/or with adjusted criteria for different line of discussion.

Timeline of systematic mapping on Environmental changes and inequality



Expert list

1. Bạch Tân Sinh - SUMMERNET
2. Chayan Vaddhanaphuti – Chiang Mai University
3. Christophe Gironde – Graduate institute of Geneve
4. Chung Hoang Chuong – freelance expert about Mekong Delta
5. Daniel Hayward - Mekong Land Research Forum
6. Dewan Ashan – Southern Denmark University
7. Duong Thi Nga - Vietnam Union of Science and Technology Associations
8. Grazia Pacillo - CIAT
9. Jean Christophe Castella - CIRAD
10. Jean Philippe Venot - French National Research Institute for Sustainable Development Cambodia
11. Jean-Christophe Diepart - University of Liège - Gembloux Agro-Bio Tech
12. Karine Peyronnie - French National Research Institute for Sustainable Development IRD Laos

13. Nam Nguyen - CIAT
14. Nguyen Dinh Giang Nam – Can Tho university
15. Olivier Evard - IRD Thailand
16. Pascale Hancart Petitet - French National Research Institute for Sustainable Development
17. Thomas Krause GIZ – Vietnam Union of Science and Technology Associations
18. Thomas Vallée – French Embassy in Phnom Penh
19. Tran Duc Trinh – RMIT HaNoi
20. Trinh Thi Long – WWF Vietnam
21. Vu Xuan Viet - OXFAM Vietnam

Testlist

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Table 1. Record of Search: Systematic mapping on environmental change and inequalities in the Mekong region, search between 12.2019 – 3.2020

Date	Sites	Equation	Search on	Retrieval
11.12.2019	Web of science	(Mekong OR Laos OR Cambodia OR Vietnam OR Thailand OR Burma OR Myanmar OR Southeast Asia) AND (Environment* OR land* OR Land grabbing OR swidden OR green grabbing OR Subsidence OR Land degradation OR Agriculture OR Agrarian OR Cropping pattern OR Aquaculture OR Fish* OR air OR air pollution OR air quality OR haze OR water OR water pollution OR waste OR pesticide OR contamination OR erosion OR salinization OR flood OR storm OR typhoon OR extreme event OR drought OR water supply OR hydropower OR water regime change OR irrigation OR groundwater OR climate OR climate change OR sea level rise OR heat OR temperature OR Hazard OR Ecosystem OR biodiversity OR fauna OR biological services OR National park OR protected zone OR Forest OR mangrove OR Deforestation OR conservation OR community-based OR biosphere OR resources OR nature OR coast OR anthropogenic degradation OR Agro-forestry OR mining OR gas exploitation OR sand OR sediment transport) AND (Urban OR rural OR poor OR rich OR beneficiaries OR Woman OR children OR farmer OR smallholder OR peasant OR Fishermen OR Vulnerable OR Marginalized OR disadvantaged OR minority OR highlander OR indigenous OR lowlander OR ethnic* OR communities OR Hill-farmer OR Forest people OR disabilities OR downstream OR upstream OR Equality OR Inequality OR Equity OR Social injustice OR justice OR Climate justice OR environmental justice OR Economic OR income OR Poverty OR livelihood OR well-being OR debt OR education OR health OR Access OR Social OR society OR resettlement OR risk OR Migration OR Class OR Occupation OR employment OR job OR Cultural OR Culture OR perspective OR belief OR Political OR politic OR participation OR Governance OR wealth OR Resilience OR Adaptation OR Mitigation OR Knowledge OR information OR Identity OR right OR citizenship OR gender OR aging OR generation OR Geography OR conflict OR human-ecology OR Political ecology OR Displacement OR moving) – **Equation F**	Title	2617

04.03.2019	Web of science	(Mekong OR Laos OR Cambodia OR Vietnam OR Thailand OR Burma OR Myanmar OR Southeast Asia) AND (Health* OR Disease OR Sickness) AND (Urban OR rural OR poor OR rich OR beneficiaries OR Woman OR children OR Elder OR kid OR child OR Old OR Equality OR Inequality OR Equity OR Social injustice OR justice)	Title	546
11.12	Sage pub	Various short keywords	Abstract	111
11.12.2019	Land depository	Various short keywords	Title	610
18.12.2019 Extra. 04.3.2020	Science direct	(Mekong OR Laos OR Cambodia OR Vietnam OR Thailand OR Myanmar) AND (Environment* OR land* OR Agriculture OR air OR water OR hydropower OR climate OR Ecosystem OR Forest) AND (poverty OR Vulnerable OR ethnic* OR Equality OR justice OR livelihood OR Adapt*)	Title, abstract and keywords	3042
18.12.2019	Wiley Online	**Equation F**	Everywhere	875
04.2.2020	Taylor Francis	**Equation F**	Everywhere	418
04.2.2020	Sprinerlink	**Equation F**	Everywhere	676
04.2.2020	JSTOR	(Mekong AND (Environment* OR land* OR Agriculture OR air OR water OR hydropower OR climate OR Ecosystem OR Forest) AND (poverty OR Vulnerable OR ethnic* OR Equality OR justice OR livelihood OR Adapt* OR Resettlement OR Migration))	Abstract	3099
07.2.2020	SSRN: Social Science Research Network	Environment AND Inequality		27
12.2019 – 02.2020	Various institutions sites, databases	Various keywords		6265

	Water alternative MRC Publications https://data.opendevelopmentmekong.net/ World Inequality Database https://www.conservation.org/places/greater-mekong http://www.iwmi.cgiar.org/publications/other-publication-types/books-monographs/externally-published/ Social mobility project OXFAM MDRI – work on MIF – Oxfam CSDR – Center for social development research in Hue WWF (Climate change working group) ISET – resilience city Earth right program in Chiang Mai Growing Campaign International river Inclusive Myanmar - K4DM https://asean.org/resources_cat/asean-publications-3/ https://library.wmo.int/index.php?lvl=publisher_see&id=785 Mekong Delta Climate Resilience Program (MCRP) SUMERNET. https://www.sumernet.org/ ACCCRN. https://www.rockefellerfoundation.org/our-work/initiatives/asian-cities-climate-change-resilience-network/ Database at SIWRR (Southern Ins.of Water Resources Research, Vietnam) Database about Vu gla Thu Bon up to 2018 Center for Natural resources management for SEA M-POWER Program SEA - USER project http://www.mangrovealliance.org/ https://www.lift-fund.org/ iwaponline www.mrlg.org http://ckcvietnam.org/ UNESCAP Publications https://www.sei.org/publications/ https://actiononpoverty.org/vietnam-livelihoods-climate-vi/ https://www.thiennhien.net/ https://www.mekongeye.com/ http://www.vngo-cc.vn/ ISEE MDRI Pan Nature Voice for Mekong Forest Project The center for People and Forest - RECOFTS Institute for Development Studies (IDS) International Institute for Sustainable Development (IISD) https://pubs.iied.org/ https://www.odi.org/features/progressia/environment-versus-equality https://www.cabdirect.org/cabdirect/abstract/20113350638	Search conducted by the main reviewer and research teams in 5 countries. Search retrievals were based on manual pick of the researchers. Majority of items retrieved from the network of LaoFAB and MYLAFF document Repositories.

	LaoFab Document Repository MyLAFF Document Repository Worldfish WLE Mekong region future institute ICEM CIAT Mekong Region Land Governance Repository https://cgspace.cgiar.org/ Project Muse World Bank Open Data	

Table 2. Detailed coding for included documents

		Codes to enter the excel file	To describe
The title and author	**a.** Title: in full **b.** First author		
Bibliographic information	**a.** Publication type	Book Book section Journal article Thesis Report Media Conference Unpublished/other	
	b. Year		
	c. Geography	Thailand Vietnam Laos Cambodia Myanmar Mekong Southeast Asia Asia Global	
Information relating to inclusion criteria	**a.** Population I: Human population (affected by environment changes)	Ethnic/highlander Poor Elite Farmer/smallholder Fishers/Seafarer Women Children Elderly Migrant Worker Refugee Non-citizenship Indigenous Communities at risk in general Disadvantage/ Marginalized people Rural people Urban people Urban dweller small and medium enterprises	E-II-0 – Human Population

	b. Population II: Environment affected by human activities	Water Air Forest Land Climate	
	c. Population III: Location of exposure/affected (impacted)	Mountain/highland Rural Urban Sub-urban/peri-urban Delta/Lowland Coastal Multiple locations Catchment/River basin	If it is multiple locations, please elaborate
	d. Population IV: Activities/ condition of human population (at exposure)		*Described: swidden, opium, medicinal plant collecting, living closed to polluted site …* Financial capital (asset, access to credit, …) Social capital *(relationship, network)* Physical capital *(eg. transport and communication systems, shelter, water and sanitation systems, and energy, healthcare, access …)* Human capital *(health, knowledge, skills and motivation)* Human perception/ behavior Capacity to adapt/cope

Exposure or Intervention	**e.** Exposure I: group of environmental changes	**Human-induced** Land reform/policy Land grabbing/acquisition National park/Protected area Land concession Land availability Water reform/policy Resettlement Agrarian change Air pollution (haze) Water pollution Soil Pollution Nuclear Pollution Pesticide Hydropower Mining Resources extraction Biodiversity loss (including fish stock reduction) Forest degradation Forest fire Deforestation **Reforestation** Erosion **Natural-caused** Climate change Sea level rise Heat Health issues-caused agent Flood Landslide Land subsidence Tsunami Extreme events Drought Salinity intrusion Arsenic in groundwater Toxic (*orange agent, mercury, cadmium, ...)* Storms Earthquakes Volcano eruption	Please describe: Policy affecting land: tourism, OR agriculture, infrastructure, hydropower project Other factors: war, ...

	f. Exposure II: Human activities hindering environmental protection	Financial capital Natural Capital Social capital *(relationship, network)* *Power* Physical capital *(eg. transport and communication systems, shelter, water and sanitation systems, and energy)* Human capital *(health, knowledge, skills and motivation)* Human perception/behavior Lack of participation Participation	E-II-0 – Human Population *Barrier to adopt environmental-protection measures* *Eg. Community-base conservation* *Community-based forest management* *Community-based REDD*
	Population in this case	people with decision-making power/elite	
	h. Outcome I: Types of human impact	Health issue Health risk Poverty Livelihood insecurity Wellbeing Land tenure insecurity Mortality Migration Displacement Eviction Human-right violation Conflicts Social differentiation Social cohesion disruption Gender-deviated impact Access reduction (*to land, food, water, forest products …)* Trafficking Vulnerability Adaptation (capacity) Resilience (capacity)	*Described: health, poverty, mortality, displacement, resettlement, Migration, trafficked …*

	i. Outcome II: Types of environmental impact	Land Degradation Water shortage Water pollution Forest degradation Biodiversity degradation Ecosystem degradation Park/protected area degradation Wetland degradation Air quality Waste Resources degradation *(fish, land, plant, …)* Resource conservation Disease outbreak Forest conservation/restoration Biodiversity conservation/restoration Climate change mitigation Disease related changes	*Described:*
	j. Comparators	Between before and after event Between period of time Between groups of people Between regions Between nations	Elaborate If it is between periods of time, please describe whether they show the impacts of environment or human activities or inequality.
Information related to the study	**a.** Study type	Non-empirical Empirical Project Implementation	
	b. Study design	Quantitative Qualitative Integrated	*Sample size; approach, …*
	c. Data source	Primary Secondary Both	
	d. Timescale		*Duration of investigation Before or/and after (how far) from the event? The period that is investigated (eg. From 1900s til 2015)*

	e. Other factors affecting the outcomes		The factor that cause bias to the conclusion; other factors that are not combined in the analysis that might change the outcome.
Additional information	**a.** The extent of relevance	Main theme of the study researched; One aspect of the study *(i.e. Environment as one of many reasons for migration);* Theme as the background *(i.e. capacity building project for vulnerable group to climate change);* Outcomes as risk prediction only	
	b. Disciplinary	Anthropology - Ethnic and cultural studies Economic Sociology Health science Political/Political Ecology Social ecology/ Human geography Environmental Science Behavioral science Sustainability/Development study	

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What is AFD?
Agence Française de Développement (AFD) Group implements France's policy on development and international solidarity.
Comprised of AFD, which finances the public sector and NGOs; Proparco, which finances the private sector; and soon, Expertise France for technical cooperation, the Group finances, supports and accelerates transitions towards a more resilient and sustainable world.
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