Collective Action in Lake Management (CALM): an Indonesian stocktake

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Abstract. More than 500 lakes in Indonesia have been recognized as important parts of local economies and, at least in some cases, identity, but there is little literature on resource management and collective action. By reviewing literature and using a 'serious game', this paper aims to (1) review some of the currently used generic frameworks for understanding collective action in natural resource management, (2) recount some experiences in supporting collective action in Lake Singkarak, Sumatra and (3) describe early steps in using 'serious games' developed elsewhere to increase stakeholder understanding of how upstream land management affects lake quality and functions. Some important findings are that collective action is an important key to sustainable natural resources management and the lake as a complex social-ecological system also requires collective action of multi-stakeholders from upstream to downstream. We recommend the use of DPSIR and Javanese 'gunungan' frameworks together with 'serious game' to identify socio-ecological problems and build multi-stakeholder collective action. Based on our initial research experience in Lake Singkarak, this combination of methods has succeeded in finding various problems, especially different types of knowledge, ways of knowing, and learning styles from multi-stakeholders. These problems are then used as a basis for finding and forming a common understanding which is then transformed into collective action in lake management.

1. Introduction

Indonesia, a tropical archipelago country, is endowed with more than 500 natural lakes. Overall, they occupy more than 5,000 square kilometres or about 0.25 percent of the country's land surface. It is commonly stated that the area of most lakes in Indonesia is less than 1,000 hectares. Some of them are

large lakes with an area of more than 1,000 hectares spread over a number of main islands, such as Sumatra, Kalimantan, Sulawesi, and Papua [1]. A major review of Indonesian lakes 25 years ago [2] wrote "Indonesia has over 500 lakes, varying from deep tectonic basins to volcanic, glacial and ephemeral floodplain types, but the paucity of data is striking. Hydrological data, for example, are scarce, and information on aquatic fauna mostly consists of lists of commercial fish, many of which have been introduced. Indonesia's lakes are valuable assets. Flood-plain lakes such as those of the Ogan Komering (Sumatra), Upper Kapuas (Kalimantan), and Lake Tempe (Sulawesi) form the basis of important fisheries, which in the case of Lake Tempe are at least as productive as artificial fishponds. Volcanic lakes such as Lake Toba (Sumatra) and Lake Batur (Bali) are popular tourist destinations, and lake water resources are important for potable water, irrigation and hydropower. Large and ancient lakes often harbor endemics".

Lakes in Indonesia are often classified by their properties, such as size, depth, geological origin (tectonic vs volcanic), elevation, water quality, fish fauna, limnology, thermal properties, stratification in epi- and hypolimnion [1,2]. Compare to these biophysical attributes, institutional dimensions of a lake are insufficiently available, in particular the regimes of resource governance and management. Lake management depends on the collective action of A) all those living around and directly using the lake, B) all those living upstream and influencing changes to inflow quantity, quality, and flow regime, and C) those living downstream of the lake and depending on outflows [3,4,5]. Especially for the larger lakes, there may be no natural governing entity as lakes tend to cross borders between regencies. In this sense, lakes are similar to 'peat domes', which ecologically are shallow lakes filled in with vegetation. Collective action on peat domes is as relevant but challenging as that on lakes.

Again, quoting from 25 years ago [2]: "Without proper information, management of the natural lakes and reservoirs is fraught with uncertainties and dangers. For example, the vulnerable lakes may respond to additional nitrogen or phosphorus increases of as little as 1 µg/l. In Indonesia, the main constraint is simply the lack of background information and daily, short-term and long-term temporal, and spatial data". Indeed, as foreseen in the earlier studies [1,2] the expansion of cage-based fish culture has started to cause eutrophication and loss of water quality in Indonesian lakes [6], while engineering schemes for hydropower generation, interact with lakes in complex ways.

The objectives of this article are three folds. *First,* we review some general frameworks currently used for understanding collective actions in natural resource management. *Second,* this article also describes some of the first-hand experiences of successful efforts or interventions of external agents in instigating collective actions in the management of Lake Singkarak. *Third,* we describe initial steps in using 'serious games' developed elsewhere to enhance somprehentakeholder's scion of how upstream land management affects lake quality and functions.

The method used to achieve the first goal is to conduct literature reviews of various related literature, including journal articles, books, and policy briefs. The second objective is achieved by reviewing the results of our previous research at Lake Singkarak. Then, the third objective is achieved by conducting initial research using "serious games" involving multi-stakeholders in Lake Singkarak. Our serious game design is built (modified) from RESORTES board game, a land-use game using a participatory approach that addresses the collective action process with social-ecological outcomes [7]. The entire process is carried out throughout 2020 and updated in early 2021.

2. Collective action in natural resource management

Collective action can be characterized as collective action taken by a community to pursue shared interests [8]. Members may act either by themselves or through an association. Even the determination and execution of rules for the use or non-use of a resource can be called collective action in the sense of natural resource management, and it can be enforced through common property regimes or through organized activities across individuals.

Collective action links to the sustainability of natural resources. Collective action is crucial for the management of forests, rangelands, fisheries, watersheds, or irrigation systems that serve more than a single farm. In some cases, the scale of the resource to be managed may go beyond what can be done

by voluntary collective action by a community. Federations of user groups may sometimes be able to manage larger resources, but often the state or even international bodies become critically important partners. In these cases, co-management between the community and government, rather than government management alone, often leads to better outcomes [9,10,11].

Collective action also affects natural resource management and agricultural production systems in interaction with other factors such as information, wealth, risk, labor, and marketing. Collective action and networks among community members can facilitate access to information and even allow farmers to participate in technology development. Collective action enables risk sharing and inspires mechanisms for collective self-help. Collective action and reciprocity arrangements offer ways to overcome labor shortages, especially for practices that require intense labor effort in concentrated periods [8].

Collective action occurs when more than one individual is required to contribute to an effort in order to achieve an outcome. People living in rural areas and using natural resources engage in collective action on a daily basis when they (1) plant or harvest food together; (2) use a common facility for marketing their products; (3) maintain a local irrigation system or patrol a local forest to see that users are following rules; and (4) meet to decide on rules related to all of the above. Frequently, however, it becomes difficult to exclude nonparticipants from benefiting from the collective action of others. This situation creates a collective action problem for the participants. When individuals seek out short-term benefits for themselves alone, they are better off when others contribute to the collective action and they do not. In this case, they benefit without paying the costs. Of course, if all individuals pursue short-term, self-centered benefits, no collective benefits are achieved [12].

In fisheries as are complex and interdependent ecological and social systems that require integrated management approaches. The actions of one person or group of users affect the availability of the resource for others. Managing such common pool resources requires conscious efforts by a broad range of stakeholders to organize and craft rules enabling equitable and sustainable use of the resources for everyone's benefit. Collective action is often a prerequisite for the development of community-based institutions and the devolution of authority that is required from central to local authorities. Collective action can help to empower poor communities, as the example of San Salvador Island shows [13].

Collective action has been a key feature of organizational arrangements for co-management. Collective action assists in co-management by reducing the number of people that forest agencies must deal with and by bringing together different groups to play complementary roles in forest management. Local people who organize collectively are better able to mobilize resources and negotiate for desired benefits. Collective action, both within communities and together with outside groups, thus helps local people become more influential stakeholders in co-management arrangements [14].

3. Frameworks for understanding change in lakes as social-ecological systems

Public discussion in natural resource management issues often starts with (negative) impacts of the current (or expected) system state on local livelihoods. Corrective action, however, requires that underlying pressures (direct causes) and drivers (indirect causes) are understood, as otherwise, action might focus on 'symptoms' only, not on dealing with (or preventing the recurrence of) illnesses. A recent portrayal of the Driver-Pressure-System State-Impacts-Responses as a multiphase feedback loop (Fig. 1, [15]) suggests that 'adaptive' responses (reducing negative impacts) be distinguished from 'mitigative' ones (that reduce local pressure), 'transformative' ones (that change the pressures generically) and 're-imaginative' ones that modify the drivers.

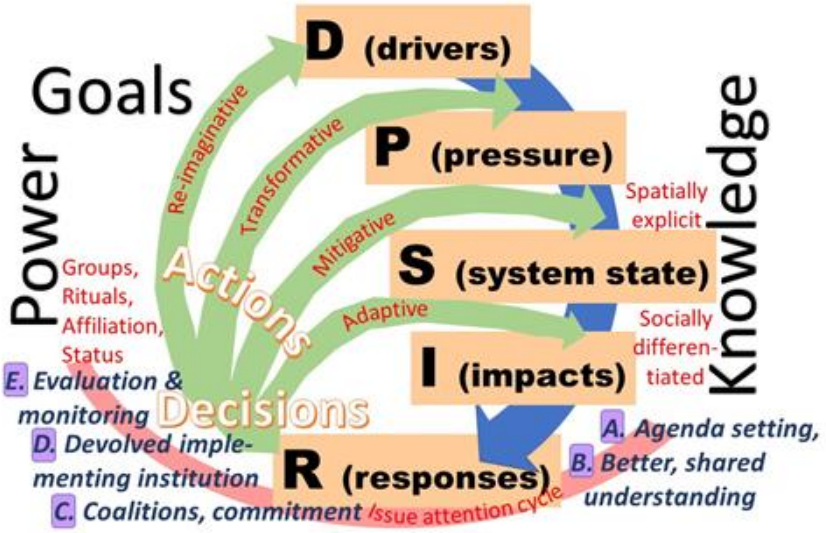

Figure 1. Drivers, pressures, system state, impacts, and responses (also known as DPSIR) of landscape-level change, with a decision cycle (A–E) closing various feedback loops interacting with knowledge, power, and human sociality and its GRASP determinants [15].

Natural resource management thus has to deal with multiple scales: I) the local one where identity and culture interact with ecological and economic realities, II) a wider surrounding landscape where markets and livelihoods (including decisions to migrate temporarily or permanently) function in relation to rights, know-how, local and global ecosystem services, and III) a national/global scale at which legal frameworks, knowledge systems interact with the planning of land and water resource use, climate action and trade reform (Fig. 2, [15]).

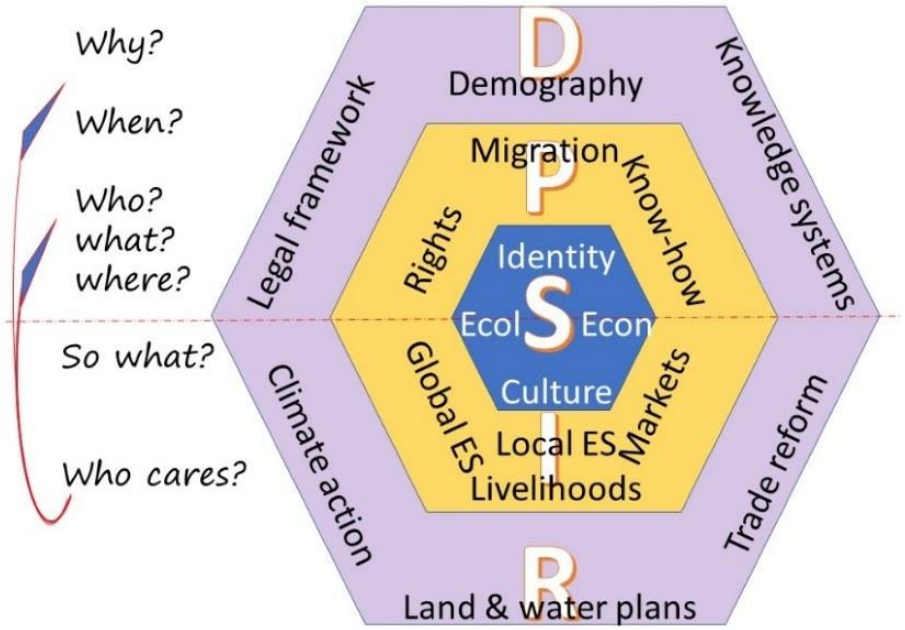

Figure 2. State variables and processes relevant for change in eco-hydrological-social systems in the forest–water–people nexus grouped in a DPSIR (drivers, pressures, system state, impacts, responses) framework [15].

As the last part of a management framework, we may need to understand the complex concept of 'value' in the eyes of the various stakeholders. Current understanding distinguished between 'instrumental' values (assisting in achieving human goals, such as the set of 17 Sustainable Development Goals), and 'relational values' that bring 'Nature' into the framing and language of human social relations. Figure 3 suggests that the Indonesian wayang tradition with a 'Gunungan' symbol that has a harmonious side (where spirits, animals, a tree of life and a house coexist) and a conflict or disaster one, associated with fire and angry spirits, can symbolize both types of values. We thus need to go beyond the 'provisioning' (e.g., fishing, hydropower) and 'regulating' (e.g., local climate) parts of 'ecosystem services' or 'Nature's contributions to people', to appreciate the effects Lakes (can) have on the quality of life and local identity. The latter may be the prime motivation to 'care' and take action.

Figure 3. Instrumental as part of relational values of nature from a human perspective as exemplified in the Javanese *'gunungan'* representation with its idyllic harmony and fearful disaster side, and the UN Sustainable Development Goals; NCP = Nature's contributions to people, PCN = People's contributions to nature [15].

4. Lake Singkarak as a case study in local resource management

Lake Singkarak is one of the highland lakes in the Bukit Barisan mountain range stretching along the island of Sumatra. Inflows to the lake come from a number of rivers and rivers whose springs are in the watershed which covers an area of 1135 km^2. Several streams, before reaching the lake, form a number of smaller natural lakes that serve as buffers. The watershed is home to 440,000 people with the main source of living from agriculture. The upstream reaches are dominated by intensive horticultural farming, while some types of extensive rice farming are agricultural practices commonly found in the downstream reaches [16,17].

This lake is located across two districts (Solok and Tanah Datar). The lake provides opportunities for fishing (an endemic fish, overfished due to high demand), year-round water supply for surrounding villages, and tourism. The outflow of the lake provides irrigation water for downstream farmers and hydropower for West Sumatra Province. With annual rainfall ranging from 1700–3200 mm there is enough water for the hydropower plant in average years, but in years with long dry seasons there is a shortfall, as dropping the water level in the lake disturbs local livelihoods. The West side of the lake

is dominated by forest, mixed gardens (agroforests), and agricultural fields, but the East Side is drier and dependent on the natural outflow from the lake that was disturbed by the construction in the 1990s of the Singkarak Hydro Electric Power Plant [16].

There have been some reforestation projects implemented with the main goal to increase the extent of forest cover area [17] and the local village surrounding the lake have undertaken several measures to protect water quality and to conserve endemic fishes by setting up village regulation. Understanding the water allocation management (between water flows in the original riverbed flowing East), supporting traditional rice farmers, and the use of hydropower and irrigation schemes west of the mountain range.

5. Serious games as a pathway to a shared understanding

Serious games can be used as tools in multi-actor decision-making processes linking research and action (Figure 4). This action research approach facilitates learning through interactive sessions mediated by serious games [18]. The approach encompasses various learning processes including single-loop learning (acquiring knowledge for problem-solving; [19]), double-loop learning (reflecting one's assumptions; [18]) and third loop learning (transforming contextual setting; [20,21]), experimental-learning (learning through experience; [22]), and social learning (learning by observing and interacting with others; [23,24]. In the field of serious gaming, all these learning processes aim at triggering so-called forward-looking or anticipatory learning [25]. While most forms of learning primarily look at the past, anticipatory-learning explicitly focuses on the future and aims to strengthen one's ability to anticipate change and respond appropriately.

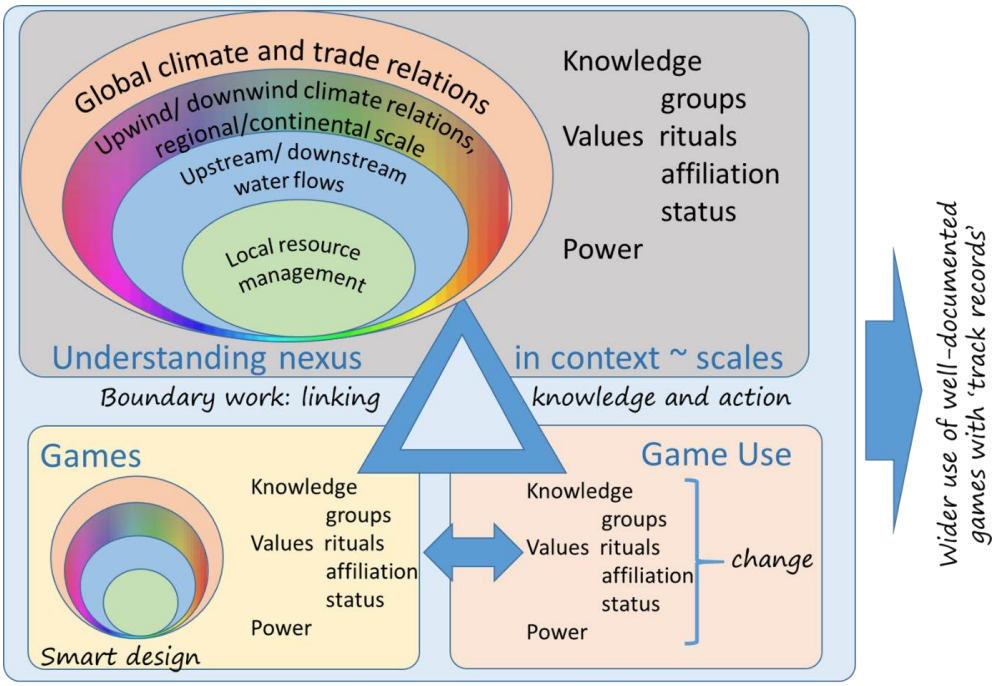

Figure 4. Conceptual framework of how smart game design, game use, and understanding or the Forest-Water-People nexus are linked [15].

Interactive serious games and simulation facilitate participants to learn to anticipate change (=anticipatory-learning) through strengthening their understanding of the complex dynamics of tropical (agro) forested landscapes (=single-loop-learning) and by interacting with peers (=social-learning). By exploring responses to change (=experiential-learning) within the game, initial perceptions will be

reframed (=double-loop-learning). The interaction with peers will stimulate discussion, thereby questioning and ultimately improving the context in which decisions are made (=triple-loop-learning).

Smart game design and smart game use are instrumental in learning about the Forest-Water-People nexus through gaming. By exploring the specifics of the connection among the three interacting concepts i.e. forest, water, and people, in a variety of social-ecological contexts with actors from various governance levels will facilitate a deeper understanding of the novel concept of Forest-Water-People nexus (Figure 4.).

The specific local contexts of the social-ecological systems that the game participants are part of shape all the elements of Smart game design, Game use, and the Forest-Water- People nexus. By developing smart games that are sensitive to contextual knowledge, values, and power relations among participants, serious games will allow and stimulate equal participation and decision-making power among stakeholders while creating learning opportunities taking into account and groups, rituals, affiliation, and status of actors [26].

Speelman *et al.* [7] has been designed a land-use game methodology using a participatory approach (RESORTES board game) that addresses the communal decision-making process with ecological and social outcomes. This game session created an open and active discussion on concerned land-use issues of Chiapas's farmers in real life and stimulate the active involvement of individual farmers to express their idea. The outcome of the game is essential to inform strategies and involvement of the community in a complex socio-environmental context.

RESORTES game was applied in Ngantang, Malang, Indonesia to evaluate the preference of farmers on contested agricultural land-use systems in the landscape [27]. During the game session, farmers actively involved and interacted with each other in the discussion by giving comments and share their strategies in real life. Almost half of the participants changed their land-use choices from crop-based land-use systems to the tree-based land-use system and vice versa after receiving inputs and learning from other participant strategies. Economical benefit and maintenance of the land-use system type may become the main consideration of land use decision making. However, good communication, relatedness, and the role of local leadership in the community also became the determinant factor that influences the farmer's decision-making process. This finding can be useful for the policymaker to inform the involvement of the community and the pattern of farmers' decision making on the contested land-use system and to be used for agricultural landscape planning.

6. Conclusion

Management of lakes as common property resources must be carried out in a sustainable manner through collective action involving multi-stakeholders from upstream to downstream across various areas. As a social-ecological system that is complex and continues to change, appropriate approaches are needed to understand the changes from the lake. By understanding change properly, collective actions can be planned, developed and implemented by multi-stakeholders. We recommend DPSIR (drivers, pressures, system state, impacts, responses) as one of the frameworks that can be used. In addition, to link collective action, lake management and the achievement of sustainable development goals, we offer the Javanese 'gunungan' as a framework. These two frameworks together with the RESORTES game are currently being used in our research involving multi-stakeholders in Lake Singkarak.

We can convey some provisional conclusions from this research in the following sentences. The interests among these stakeholders tend to be different; there is no single authority because the lake crosses the boundary of two districts and involves many villages around the lake perimeter. Conflict can arise from increased use of the lake for cage fish farming which generates income but can lead to eutrophication of the lake and loss of other functions, including scenic beauty and tourism. Other conflicts arise from a lack of control of waste in the rivers that feed the lakes, as well as high levels of sediment, nutrients and pesticides that enter from areas with intensive agriculture or horticulture. The development and use of 'serious' has been successful in reaching different types of knowledge, ways of knowing, and learning styles of different stakeholders. This forms the basis for building a shared

understanding of the resource relationships involved and the instrumental and relational values the lake provides. This mutual understanding is then transformed into collective action in lake management. The important results and findings of this research will be presented in the next publication.

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