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Review Article

Evaluating mangrove conservation with the land management intervention equation based on selected cases from Indonesia

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Abstract

Mangrove wetlands serve multiple ecological functions, such as carbon sequestration. Yet, at the same time, they are also suffering from poor and non-transparent restoration and preservation management, resulting in unnecessary losses. This article assesses how and where responsible land management can address this problem based on three different cases in Indonesia. It evaluates the cases through the lens of a descriptive and normative land management analytical framework of (de Vries 2021) with the equation form (ΔLM = f(ΔG, ΔL, ΔS, ΔE, ΔP, ΔB), The goal of the evaluation is to evaluate to how and to which extent major land interventions and mangrove preservation activities could align, and with which particular land management aspects improvements in this relation should start. The findings demonstrate that the alignment should begin with a more comprehensive and systematic pre-evaluation of possible impacts and effects, for all aspects which are changed by the intervention. Relying on a framework of responsible land management could support a better preservation of coastal mangrove areas.

Introduction

From an integrated land and water management perspective, mangroves provide several practical and conceptual dilemmas. According to Rotich, et al. [1] mangroves are at the boundary of sea (or rivers) and land. The management consequence is mangroves are spatial and institutional units that fall under different legal and institutional responsibilities. Moreover, when land-related activities are expanding due to reclamation or simply urbanization, it may be at the expense of sea-related activities, such as ecological protection or fisheries. Spatially one could argue that land-based activities are increasingly encroaching on the sea and thus crossing both the spatial and ethical boundaries of mangroves as sea-related objects. Globally one can see these trends. Mangrove decline is caused by direct human activities, such as cutting and dismantling, which results in amongst others changes in water salinity, water pollution, erosion, and oil pollution. Mangrove areas suffer from poor and non-transparent preservation and/or restoration management, and from active land management interventions, such as land reclamation resulting in unnecessary losses and possibly dangers in coastal protection. Suman [2] indicates the biggest challenge for the preservation of mangroves is that despite the fact that mangroves only constitute a very small part of all tropical forest areas in the world they still provide substantial ecological and economic value to coastal populations. It is for that reason that maintaining mangroves is crucial for coastal regional development.

How to ensure the substance of mangrove areas in a responsible manner. Part of the problem lies in the fact that mangroves are often treated as boundary objects (following the logic of [3]). The definitions and their treatments draw on polyrationalities, leading to multiple and often contradicting insights into what constitutes responsible and sustainable management strategies. The most common definitions and conceptualizations of mangroves and the protection or restoration of mangroves are mainly found in forest and

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water management on the one hand and ecological discourses on the other hand. Notable is that the subject appears less in land management-related discourses. This is visible from various frequently cited definitions. A seminal paper by Alongi [4] refers to mangroves as *trees and shrubs juxtaposed between land and sea in the world's subtropics and tropics, with the largest percentage of mangroves occurring between 5° N and 5° S latitude*. Giri, et al. [5] furthermore mention that *Mangrove forests are distributed in the inter-tidal regions, located between the sea and the land between approximately 30°N and 30° S latitude.* From an ecological and biological perspective, Tomlinson [6] refers to mangroves as both the ecosystem and the plant families that have developed specialized adaptations to live in this tidal environment. [7] further defines it as *forests, occurring in marine or brackish environments along sheltered estuaries and river banks*. Biologically, Thompson, et al. [8] describes mangroves as the *most productive and biologically important environments (...) representing a complex and dynamic ecosystem with harsh settings like high salinity, temperature and sedimentation, extreme tides, and muddy anaerobic soils.* Crucial in these water and marine management points of view are the central focus on physical characteristics of complexities, and not so much the instruments of treatment and restoration.

As for the location of mangroves, Kathiresan and Bingham [9] specifically refer to an assortment of tropical and subtropical trees and shrubs that have adapted *to the inhospitable zone between sea and land*. In other words, mangroves are neither land nor water from a resource management point of view yet are heavily affected by both land and water management strategies and (discretionary) choices. Given these human components in protecting and managing mangrove resources as an integrated land and water management object, it is therefore crucial to define and conceptualize mangroves within the context of integrated land and water management strategies, such that they can also be managed in an integrated manner. Maintaining and sustaining mangroves is crucial, but how to do that responsibly differs per area (both in terms of practice of maintenance, norms and ideology of water and land tenure and associated rights, restrictions, and responsibilities).

This article thus focuses on identifying how from a land management perspective one can define and conceptualize mangrove management, with the aim to extend the debate on how to improve the overall mangrove management and better integrate the land and water management perspectives. The core research question is therefore: to which extent and how major land interventions and mangrove preservation activities can align better.

Addressing this question starts by identifying and discussing how land management and land tenure relate to mangrove management. It then explains the analytical perspective with which one can identify aspects of land management interventions and the effects thereof. This section introduces the so-called land management intervention equation. After this follows a short description of three case studies of mangrove areas that were affected by land interventions, and which can thus be described through the land management intervention equation. The results section explains which type of changes most significantly affected mangrove areas. From these results, I derive a conclusion on which aspects of land management interventions are most significant for changes in mangrove areas and the management, preservation, or restoration of mangrove areas.

Theoretical background connecting land management to mangrove management

Land management can be regarded as the set of activities that maintain, secure, change, register, and govern the land, which includes land tenure, land rights, land restrictions, land responsibilities, and land use. This occurs through proactive tools such as land registration, land use planning, land use zoning, land development, and land reclamation, amongst others. The crucial element of land management is what kind of land tenure exists through formal registration or which tenure prevails in certain areas without any form of formal acknowledgement. Land management interventions can address how this land tenure can be sustained or modified. Traditionally, land tenure is categorized as state, open access, private and common property.

For mangrove areas such land tenure is not always properly registered or regulated. Bell-James, et al. [10] call therefore for new or adapted regulatory and even legal frameworks. The implication of this gap is twofold: the first is epistemic. Mangroves and ownership or tenure are not key topics of interest in land management discourses. These tend to focus on either the land management tools and interventions, or the effects of land tenure security, but not on the security of areas that may not necessarily be defined as land. The second is practical and operational. It is not always clear who carries the responsibility to allocate or define the ownership. As forests they are often the responsibilities of forestry ministries, when defined as water then water authorities have a mandate, as land or land under development, both ministries of land and economic development play a role, but as resources of space, there is a key mandate for ministries of spatial planning, city administrations or development authorities.

For mangrove areas one must define therefore land tenure as the legitimate (i.e. societally accepted and condoned) rights and responsibilities to the integrated mangrove wetlands ecosystem consisting of mangrove forests, mudflats, aquaculture ponds converted from mangroves, and all other marine organisms. Given that the land tenure may not be formally regulated, tenure security lies therefore in a person's perception that his/her rights to land are recognized and protected when confronted with specific challenges. People with insecure tenure are threatened by competing claims and even eviction, which affects their livelihoods [11,12].

If land tenure refers to both formal and informal (yet legitimate) rights, then one can also assume a bundle of rights and responsibilities that may belong to several different entities [13], which can be simplified as use rights, control rights, and transfer rights. Schlager and Ostrom [14] present a conceptual framework for arraying property rights regimes of

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natural resources in which they classify five types of property rights: access and withdrawal rights, management, exclusion, and alienation rights. Additionally, they differentiate between de jure and de facto property rights, "de jure rights" are rights existing in formal law, and "de facto rights" are rights existing. Following this, the (GLTN (Global Land Tool Network) [15] speaks of a continuum of rights, reflecting a co-existence of multiple rights between the de jure and de facto and between formal and informal rights.

For natural resource management, including the management of mangroves the classification of [16] is useful, which is partially based on the framework of Schlager and Ostrom [14], yet also reflects the current reality of actors who tend to be involved in the conservation and protection of natural resources, such as NGOs and communities as social actors, besides government, statutory bodies, private developers and farmers.

Sikor, et al. [16] proposed three types of categories (use, control, and authoritative rights), which each have certain subclasses. Table 1 presents such rights. There are two types of "use rights": "direct use rights" and "indirect use rights". The former refers to the rights that enable the right holder to obtain direct benefits derived from a resource (which includes amongst others, harvesting timber and collecting shellfish). The latter refers to rights that generate indirect benefits associated with resources, such as cash payments, public goods, and in-kind support. Control rights refer to the ability of a right holder to decide on transactions, inclusion, exclusion, and use. For example, a control right holder may determine whether to use or harvest the resource themselves or whether to share the use with others. Monitoring rights refer to the right to monitor the use of benefits (e. g. use pattern, benefits distribution) and the condition of the resources (e. g. forest cover change) [16]. Finally, "Authoritative rights" refer to the highest level of rights, as these right holders can both determine how to control, allocate, and transfer rights, and thus exhibit the possibility for discretionary decisions. For example, a central government as a right holder of mangrove forests may restrict the right of harvesting resources from mangrove areas by designating the mangroves as protected areas or for limited production. Alternatively, a central government as an authoritative right holder may allocate or devolve the management of mangroves to local communities under the state property regime.

Table 1: Property rights typology.

Property rights	Definition
Use rights	The right to enjoy benefits
Direct use	The right to obtain benefits directly derived from a resource
Indirect use	The right to obtain indirect benefits associated with a resource
Control rights	The right to determine the scope of use rights
Management	The right to regulate the use and transform the resource
Exclusion	The right to define who has use rights
Transaction	The right to handle the activities required for the realization of benefits
Monitoring	The right to monitor the use of benefits and the status of the resource
Authoritative rights	The right to define control rights
Definition	The right to define the discretionary space for the exercise of control rights
Allocation	The right to assign control rights to particular actors

Source: [16]

Specifically for mangroves, Rotich, et al. [1] identify different land tenure regimes in mangrove areas, using international examples and cases, and how these tenure rights arrangements might influence mangrove management outcomes. In most countries mangrove habitats are located on communal or state-owned land [17]. Case studies show that state-led mangrove management has been mainstream, but a transition to community participation through devolution is happening, be it not always properly recognized [1]. Experience demonstrates that devolving tenure rights to communities improves management outcomes and communities' welfare, especially when connected to specific activities beneficial to communities, such as ecotourism [18]. In contrast, disrespect for customary rights leads to tension between local communities and official institutions [19,20].

To address land tenure and land management conflicts in forest areas, including mangrove forests, there need to be more integrated policies and implementation strategies. This requires on the one hand better insights into how people perceive the management of tenure and the management of mangroves [21,22]. More specifically for the Indonesian context, in which this article focuses, in 2021, the government of Indonesia enacted social forestry regulations that connect forest areas, including mangroves, to land tenure. Under these regulations smallholder farmers or communities have the right to cultivate land in forest areas owned or regulated by the State [23].

Methodology

The evaluation draws on three cases of Mangroves in Indonesia which were affected by land management interventions, and which required either restoration or conservation activities. The question hereby is how the land management interventions either incorporated such activities or simply significantly affected these. The data collection for the cases followed a thorough literature review and document analysis. The search started with seeking relevant documents via a university facility called Gateway Bayern (https://www.gateway-bayern.de), complemented by seeking relevant articles included in scientific repositories, such as the Web of Science, the Directory of Open Access Journals (DOAJ) and the OICRF. The latter is a study and documentation center for Cadaster, land administration, and affiliated fields of interest. It is one of the permanent bodies of the International Federation of Surveyors (FIG). OIRCF is the abbreviation for Office International du Cadastre et du Régime Foncier. The keywords for searching included "mangroves", "land rights", "land tenure", "land reclamation", "community forest management" and "Indonesia". These words were also translated to seek publications in Bahasa Indonesia. The selection was limited to the last 25 years, hence 1999 until

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2024. Many of the retrieved documents consist of technical reports of government agencies, private companies, and NGOs, and were not always public information. Some of these were also scientific articles in Indonesian journals.

Having retrieved the documents, and zooming in to the specific case areas, the analytical choice for evaluating aspects of mangroves is the so-called land management equation of de Vries (2021). This equation reads as follows: (ΔLM = f(ΔG, ΔL, ΔS, ΔE, ΔP, ΔB), whereby ΔLM represents a change in land management intervention, which is essentially the resultant effect of a land management strategy leading to a change in land status (of rights, restrictions and responsibilities as well as physical changes in the land size, shape or form). The origin of the formulation of this equation lies in explaining what happens before, during, and after land mobilization and/or land consolidation [24]. When acquiring land for a road for example, there is often a change of authority over the land which is needed for the road. The authority changes from a ministry of land to a private road company for example during the time of the road construction. Additionally, this changes the degree of influence and power this road company may have in the re-shaping and reallocation of the adjacent land parcels of the road. This combined change in authority, power, and influence reflects a change of governance (ΔG). Similarly, the road construction itself may require both voluntary and involuntary removal of houses and other structures. This creates a new pattern of physical structures and a new geography of where people depending on those physical structures live and work. This change reflects a change in socio-spatial relations (ΔS). de Vries [24] infers from these examples that any land intervention leads to and is dependent on changes in 6 factors: governance (ΔG), legal relations (ΔL), socio-spatial relations (ΔS), economic relations and dependencies (ΔE), perception on land-related issues (ΔP) and behavior with regard to the affected land (ΔB).

Cases

Jakarta Bay, Muara Angke Mangrove Case: The northern coast of the Jakarta area on Java exhibits a large mangrove ecosystem system [25] which is affected by multiple reclamation projects developed over a period of over 40 years [26-29]. Hilmi, et al. [30] estimate that the entire ecosystem in the Jakarta Bay area has an area of roughly 490 km2, stretching a coastal length of 40 km and an inland depth of 15. It consists of the Angke Kapuk Protection Forest, the North Jakarta Mangrove Ecosystem Area, the Mangrove Arboretum Area, and the Muara Angke Mangrove. The latter, the main case in this region, has an area of more than 1000 ha. The mangrove area itself is heavily affected by reclamation occurring in this area, as can be seen by a decrease of 44% in size between 2010 and 2015. There is therefore a need for either restoration or a new type of management in the area to secure the sustenance of the mangrove. The Department of Marine Affairs and Agriculture declared in 2011 that approximately 30% representing 98 ha of the area designated for a mangrove green belt still needed to be greened. Nevertheless, the reclamation Island also benefitted from a natural expansion, caused by sediment deposition.

The establishment of coastal reclamation was an idea to overcome land scarcity in Jakarta. The reclamation of Jakarta's north coast is written in Presidential Decree No. 17 of 1994 on the Sixth Five-Year Development Plan 1994/95-1998/99. With that, there is the National Capital Integrated Coastal Development (NCICD) programme which is a mega-project that is a continuation of the Jakarta Coastal Defence Strategy Project (JCDS) to address the urgency of extreme land subsidence occurring in the northern part of Jakarta. Whilst the Jakarta city administration initiated the reclamation of the former landfill area (Pluit Reservoir) a private developer, Dharmala Group (currently known as the PT Intiland Development Tbk) is responsible for the execution [31].

Batam City, Rempang and Galang Island Mangrove Case: These are mangroves in the vicinity of the Indonesian islands of the province of Riau, located close to Singapore [32]. The mangroves of these islands are affected by both internal and external factors [33]. A major external factor and what can be considered a land management intervention (because it establishes new rules for how to use the land and also affects the mangrove areas) is the Indonesian Law No. 1 of 2014 which refers to the management of coastal zones small islands. The scope of Law No. 1 of 2014 also addresses coastal and small island reclamations, which are meant to enhance the benefits and/or added value of coastal areas and small islands from technical, environmental, and socio-economic perspectives. Coastal reclamation activities are not necessarily encouraged by the law but may be carried out while adhering to the provisions outlined in the Minister of Public Works Regulation No. 40/PRT/M/2007 concerning Guidelines for Planning Coastal Reclamation Areas. Yet, Mangrove forest restoration in Batam City faces various complexities in land ownership and land status as policies of central and local governments do not always align [34].

Semarang City, Tugu and Genuk Sub-district: The area of the mangrove ecosystem in Semarang City is 68.13 ha and is divided into damaged 36.12 ha, damaged 14.51 ha, and undamaged 18.70 ha [35,36]. Utami, et al. [36] describe the degradation of these mangroves caused by an expansion of ponds, development of industrial areas, trade, and settlements, and not that it lost its ability to act as a natural coastal barrier and provide room for marine biodiversity. as a spawning ground. It has been degraded and decreased up to an area of 242.66 ha (82.97%). Moreover, the *remaining 17% (49.78 ha) of mangroves have resulted in widespread tidal flooding, reaching 271.5 ha in a period of 33 years* [36].

Results

Governance arrangements and changes (ΔG)

In the Jakarta Bay area, the legal administrative basis for the construction of the reclamation project is the Decree of the Governor of DKI Jakarta No. 1685/2015 on the determination of the trace, and the Presidential Regulation No. 3/2016 that the NCICD project is a national strategic project. The political justification for this decision is to reduce and prevent flooding in the nation's capital by building three lines of sea defence

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that will be completed over a period of 20-30 years starting in early 2016. According to the Coordinating Ministry for Economic Affairs Economic Affairs, 2014, the NCICD is the government's attempt to address not only flooding issues but also add and improve much-needed urban infrastructure such as transport facilities, clean water needs, green open spaces, housing. The Jakarta Bay activities put however also a strain on the trust and reliability of such mega-projects [31]. The argument here is that out of the originally granted permission to build 17 reclamation islands the permits of 13 island developments were revoked, changing the spatial planning process drastically [26]. The root cause of this withdrawal of permits was both the fact that developers did not meet their obligations to start constructing within a given time limit but also implicitly that the permits did not follow an approved zoning plan. This contradicts Article 17 paragraph (1) of Law No. 1 of 2014 on the Management of Coastal and Islands of Small Islands which requires zoning plans before any permit can be given to intervene in coastal areas and small islands. Hence, there were both procedural contradictions and political ones. The main conflict of authority remains between the managers of the project(s) and the migrant fishermen on the one hand, and the managers of the project(s) and the Jakarta Provincial Government on the other.

In the Riau islands case, a major governance change resulted after a visit of senior government representatives to 4 locations in this area in 2023. These four locations were sealed because they are suspected of carrying out activities that violate regulations and destroy forest areas or mangroves, invoking Article 50 Paragraph 2 letter (a) of Law Number 41 of 1999 concerning Forestry as amended by Law Number 6 of 2023 concerning Job Creation, perpetrators of forest area encroachment and destruction of mangrove ecosystems. From a governance perspective one could argue that the project resulted in a wrong re-allocation of authority, which can be revoked and result in the old status quo. Yet, assessing (a change in) governance also involves (a change in) the legitimacy of authoritative actions. One could infer that trust in the way the government and the private developers prepare and implement such projects is seriously hampered, also because it intervened in many informal rules of fishers and timber harvesters who amongst themselves might have certain mutually accepted rules [37]. Once this trust is lost, it will be difficult to regain it.

In the Semarang case, the governance arrangement followed a deliberate choice to establish a Semarang City Mangrove Working Group (KKMKS). The Semarang City Mangrove Working Group was established in 2010 based on Decree No. 0504/446 on the establishment of Semarang City Mangrove Working Group issued by the Mayor of Semarang on December 22, 2010. Mangrove ecosystems in the Tugu area have existed since 1980. Prior to the establishment of the Semarang City Mangrove Working Group, mangrove ecosystem management was in the hands of the local community and the Semarang city government.

Legal changes and transactions (ΔL)

For Jakarta Bay, the establishment of coastal reclamation was part of the Presidential Decree Number 17 of 1994 concerning the Sixth Five-Year Development Plan (REPELITA VI) 1994/95-1998/99. However, the implementation of reclamation was met with resistance from various parties because reclamation has the potential to have a negative impact on the environment, such as the destruction of the livelihood of fishers. A Decree of the Minister of Environment No. 14 of 2003 was issued explaining the Infeasibility of the Reclamation and Revitalisation Activity Plan for the North Coast of Jakarta. After several court cases, the Supreme Court ruled that the reclamation of the North Coast of Jakarta was legally valid, as explained in Supreme Court Decision No. 12 PK/TUN/2011. Adharani, et al. [26] and de Vries and Rudiarto [31] describe that the legal disputes result in uncertainty about the validity of the rules and the subsequent decisions, as apparently multiple frameworks are governing the intervention, and as these rules also contradict, i.e. either supporting the intervention or rejecting the intervention.

The original settlers on the Riau Islands are traditionally from multiple ethnic groups who amongst themselves used informal rules to guide the land and access to the sea's resources. In recent years the islands have however also attracted new labour migrants who are either working in new industries or who are 'forensic' laborers in Singapore or Batam. This has created tension between those who still rely on informal transactions of land and resources and those who rely on formal transactions. Business owners in Batam dare to reclaim protected forests, and river estuaries, and massively hoard mangrove trees as well as reclamation activities in the Berlian Pantai area, Small Sembakau Island, allegedly carried out by PT DIP and PT PJL in Belian Village, Batam Kota Subdistrict, as well as reclamation activities or land maturation for housing in Jalan Pajajaran, Batu Besar Village, Nongsa Subdistrict, allegedly carried out by PT RS, which was known due to the agenda of the DPR RI's inspection together with the Ministry of Environment and Forestry, Ministry of Marine Affairs and Fisheries, Peat and Mangrove Restoration Agency for two days in Batam City, July 5-6, 2023. There is a large-scale shrimp farm in a forest area that destroys mangroves in Rempang, Batam City that has been operating. Not only on Rempang Island, but also on the small island in front of the inspection site. The coastal forest on the island, including mangroves, has been cleared and turned into shrimp ponds. There are indications that these shrimp ponds violate the criminal forestry law because the ponds are located in a production forest area that can be converted, but there is no release permit from the Ministry of Environment and Forestry, so this is considered an illegal pond. Shrimp ponds also violate Law 27 of 2014 related to the management of small islands and coastal areas, which states that logging, destruction, and conversion of mangrove forests are prohibited. The actions taken by the company include criminal acts, based on both Criminal Law No.41/1999 on Forestry and Law No.18/2013 on Prevention and Destruction of Forests and also based on Law No.31/2009 on Protection of Environmental Management. In addition, a layered article will be applied with Article 98 Paragraph (1) of Law Number 32 of 2009 concerning Environmental Protection and Management, the perpetrator can be convicted and

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threatened with imprisonment for a minimum of 3 years and a maximum of 10 years with a maximum fine of Rp10 billion.

For Semarang, the mangrove management policy at the local level is a translation of various policies at both the national and regional levels, such policies are presented in Presidential Regulation No. 73 of 2012 on the National Strategy for Mangrove Ecosystem Management and Semarang City Regional Regulation No. 14 of 2011 on the Spatial Plan of Semarang City 2011-2031. In general, the mangrove ecosystem management instructions in Presidential Regulation No. 73 of 2012 concerning the National Strategy for Mangrove Ecosystem Management are the authority of each regional level government, both provincial and regency/city, which is autonomously responsible for forming mangrove working groups in each region according to the existence of the mangrove ecosystem. The development of a community-based mangrove ecosystem management action plan that focuses on disaster risk reduction was analyzed descriptively and qualitatively based on the results of participatory mapping, the Central Java Province Coastal and Small Island Zoning Plan (RZWP3K) 2011-2021, Semarang City Regional Spatial Plan (RTRW) 2011-2031, and Semarang City's regional tourism strategic plan.

Socio-spatial changes (ΔS)

The socio-spatial changes in the Jakarta Bay area can be largely attributed to the purpose of NCICD's activities, which is both protecting and enlarging the Jakarta residential and industrial area as well as creating new opportunities for transportation and tourism infrastructure. Both of these activities are attracting new residents as well as work facilities for tourism, recreation, and other services. Hence, where people live and work and what sort of spatial footprint this creates is one of the direct effects of the reclamation. The other effect is for the original workers and residents in the areas close to the reclamation areas. The Jakarta Bay reclamation has resulted in several socio-spatial changes, such as the direct impact of loss of livelihood of fishers who have not only lost their place to work, but also their place to live. From a socio-spatial perspective they would have to find this somewhere else, or take up another type of income source. In both cases this creates a new socio-spatial footprint through changing claims of land and sea. [26].

In the Riau islands social-spatial changes arise from fundamental conflicts in insights between traditional coastal communities, the Ministry of Environment and Forestry and environmental NGOs advocate how mangrove management should be carried out and whose responsibility this is [23]. Coastal communities have been traditionally economically dependent on harvesting fish, charcoal, and seagrasses from mangrove areas, and are thus most affected when either the mangroves' resources get depleted or are converted into land reclamation areas, which would lead to socio-spatial changes.

In the Semarang area the regional land use planning aims to regulate the socio-spatial changes. Semarang City's Regional Medium-Term Development Plan (RPJMD) policy forces coastal areas outside the industrial and maritime (port) zones to develop mangrove ecosystems 100 meters inland. Consistent implementation of this policy has its own socio-spatial challenges, as it requires some residents and workers to change both their location and type of work. One example concerns those who manage fish ponds directly adjacent to the beach. They would have either to convert their ponds to mangroves, and move their ponds elsewhere or find alternative solutions to adhere to the zoning plans by adapting their ponds or the surroundings of their ponds. In both cases it leads to a change in the scio-spatial footprint of work and residence. The current solution is to adhere to the development plan by developing the mangrove ecosystems around ponds whilst adjusting the type of vegetation planted to protect the ponds.

Economic changes (ΔE)

Related to the Jakarta Bay development the total budget of the giant sea wall is an estimated Rp 1.38 trillion, whereas the investment value of the entire development of 3.044 trillion Rupiah. On the one hand the economic benefits for Jakarta as the core economic hub of Indonesia are tremendous. It can potentially serve the need for housing and entrepreneurial activities in a relatively scarce space. Given the enormous investments required for reclamation there is also criticism and skepticism on its relevance and appropriateness as a solution to handle scarce space, and possibly attract more migrants to the city. In the long term, the investment also requires the government to reforest mangroves on the north coast of DKI Jakarta and its surroundings because the construction of sea walls is very expensive [38]. Hamasy [38] argues that the longer it takes to build the giant sea wall and the longer the coastline it needs to protect in the long run, the higher the costs will be in the future as well. These include not only the cost of constructing the protection, but also the cost of maintenance, as well as the cost of possibly having to elevate the embankment at some point in time if sea levels continue to rise. A much cheaper alternative than coastal protection for urban expansion and for basic protection of the current urban area may therefore be to conserve and enhance the mangrove areas as natural protection, as mangroves do not only prevent tidal floods but also prevent coastal abrasion and seawater intrusion. Additionally, one may seek other spatial solutions to cater to economic opportunities and social residence. This may include devolution of economic functions to other areas than Jakarta, and creating a more spatially just distribution of economic opportunities in other regions, which would prevent the migration to the city.

For the Riau islands, and in particular the development of Rempang and Galang Islands, the Batam Concession Agency aims to make the two islands a new economic development area that can bring in investors to improve the regional economy in the future by carrying out the concept of "Green and Sustainable City". Foreign investment of several hundreds of trillions of Rupiah in a period of five years was foreseen, in line with a detailed spatial plan for the development of the area and plans to make the area the largest glass production site in Asia. As local residents of the area got hold of this information, protests arose against the construction of these

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plans, as it would imply relocating 7500 local inhabitants, who had been living on the island for generations, yet without any legal land ownership [39]. Having to relocate these residents would not only deprive them of their current economic source of income but also create a new economic dependency for them. Adharani, et al. [26] raise therefore the question of to which extent such changes '*benefit the interests of the public or those of the owners of the capital*'. The economic benefits and opportunities of the new developments are predominantly for non-resident investors, and not for indigenous peoples. An additional effect of these development may be an increase in transaction costs for society, as these resident will have to find other jobs and locations in areas which similar economic competitions already exist.

In the Semarang case, the socio-economic conditions of coastal communities are minimal. Most residents work as industrial and other laborers, with incomes far below the Semarang City Regional Minimum Wage of IDR 2.810.025 [40]. Only a small portion of the community earns a living as traditional fishermen, fish farmers in ponds, small-scale fish processors, or households. small-scale fish processors/ households. Data from the Semarang City Marine and Fisheries Agency shows that sea level rise has caused losses of 729 million rupiah per year. A total of 2,889 ha of ponds were damaged causing a loss of 110 million rupiah and 10,425 houses were damaged with an estimated loss of up to 5.6 billion rupiah due to sea waves attacking mangroves.

Changes in perception (ΔP)

de Vries and Rudiarto [31] argue that the perception of the need for reclamation in the Jakarta Bay area significantly changed over time due to changing political frames and priorities on the one hand, and the changing relationship between the communities, developers, and government, on the other hand. The original frame justifying the reclamation was to handle the city's land scarcity and create opportunities for both expansion and develop a waterfront city. This frame gradually changed to a need to cater to international trade and services, and only the recent years did the frame of having to protect the coastal environment emerge as well as handling social conflicts. Current results demonstrate that this latter frame has failed to succeed [27], as critical concerns about both environmental and socio-economic risks were systematically concealed as more openness might also reveal how hidden deals generated development permits. Whereas developers continue to pursue the economic benefits arising from the reclamation, communities represent multiple interests (based on their individual socio-economic dependencies and interests), and the government has changed their positions according to the new frames and key aims in the discussions.

In the Riau case, local communities drastically changed their perceptions of investments and spatial plans due to the proposed Rempang eco-city development by foreign investors [41]. In fact, it led to a revival of older conflicts of local residents - most of whom are coastal communities - against non-local ones, both in terms of access and use of land and in terms of fairness in benefitting from economic opportunities. Hence, it changed the perception towards land interventions itself (that communities should be better involved in any spatial planning) and the trust in the fairness of the local government towards local communities. To many, it felt like an intrusion of a human (land) right violation that indigenous people were deprived of opportunities and benefits. The rejection continued to grow, not only from the indigenous people of the old villages affected by the relocation but also from the fishermen around the small islands in Rempang, who were concerned about the environmental impact of the Rempang Eco-City project. On the other hand, the Batam National Land Agency did not yet issue certificates to the Rempang area even though the indigenous community consisting of Malay tribes, sea tribes, and various other tribes have occupied Rempang Island for more than 200 years on the land. The community affected by the Rempang Eco City project would be compensated in the form of new houses. In line with its development, Rempang Eco City, the relocation area also includes green and blue spaces, including mangrove forests, greening areas, and beaches [42]. This has however not significantly changed the perception of the project intervention by the local communities.

Changes in behavior (ΔB)

The most severe change in behavior due to the loss of mangroves is the ability to fish for local fishermen. Mutia and Asteria [27] estimate the economic losses for fishermen in Jakarta Bay alone at some 13 million euros per year (Rp. 207153292610) and add that a deterioration of environmental conditions contributes to further economic losses. This forces the fishers to look for alternative sources of income and behave geographically in a different location and in a different manner. In Batam, one of the Riau islands, Landsat imagery shows that Batam had 5,873 hectares of mangrove in 1990, as compared to only 2,395 hectares in 2023. These changes result in a decline of catch for coastal community fishers as the fish habitat is also decreasing [43]. The overall result is a compulsory change of behavior of fishers, who will either need to expand their fishing areas or change jobs. The same happened in Jakarta Bay [44], which reported on social problems arising from disruptions of social networks in which they had been actively involved, which not only provided some sort of social identity but also functioned as guardians for continued subsistence. This concerned for example shared use of boats, and the provision of facilities for traders and the line. If such networks no longer exist, there is also a potential risk for social cohesion amongst local residents.

For the Semarang case, the disaster risk reduction policy framework in Semarang City aims to guide the behaviour in consultation with the communities. The plans emphasize the utilization of existing resources in the surrounding environment as a capacity in disaster risk reduction efforts through empowering communities with Disaster Preparedness Village and Disaster Resilient Village programs.

Discussion

The assessment reveals that the management of mangroves touches upon basic land governance arrangements (ΔG).

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Currently, the management of mangrove forests follows national laws but also tends to follow either local or informal open-access regulations. This leads to a dual system of local and central governance, which can in theory operate simultaneously, but more frequently lead to uncertainties of responsibilities of both governments and local communities. The results of such management systems can be that they fail in preventing overlapping land and resource claims and conflicts, may lead to depletion of resources, and free-riding problems for individuals who may simply not follow any rule.

It is furthermore clear that social-spatial aspects (ΔS) play a role in the effectiveness of mangrove preservation and conservation. There is some evidence that enhancing land rights for communities living near the mangrove areas could improve preservation and mitigation. At the same time, the role of perception (ΔP) is important for motivation to deal with preservation. Incentives for local communities remain limited, causing few people to identify and feel responsible for the preservation and conservation outcomes. More often, the perceptions are negatively affected by a loss of trust in government actions. This prevents a collaborative attitude towards co-management of the areas.

In some cases, there is nevertheless also evidence that suggests that different forms of co-management regimes could generate higher degrees of respect and recognizability, and implicitly a more balanced social and economic outcome. The results confirm that discussions on mangrove protection cannot be seen in isolation from project investment and interventions in land. This could thus positively influence the aspects ΔS and ΔE. What remains still unclear is which factors could significantly change the operant free-riding behavior (ΔB) when entering and using the mangrove areas, or in other words, for which circumstances either stronger legal enforcement or stronger self-management would be more influential.

The major changes in governance of the mangrove areas follow from on the one hand narratives of narrational coastal protection and top-down decisions on land use and land use restrictions. There is, in other words, an absence of alternative governance narratives, such as shared responsibilities of governing and managing the locations. Instead, mixed use of the area and illegal use are the key drivers for change in mangrove management. Despite this, the management of the mangroves is affected by several initiatives supporting more shared responsibility. The involvement of local communities in mangrove ecosystem management is a national strategy for mangrove ecosystem management based on Presidential Regulation No. 73 of 2012 of the Republic of Indonesia on the National Strategy for Mangrove Ecosystem Management. In 2002, the Ministry of Marine Affairs and Fisheries approved Integrated Coastal Zone Management (ICZM) as a new paradigm in coastal area management. The goal of community-based mangrove ecosystem management is to identify the capacity and vulnerability of communities accurately and comprehensively to coastal hazards, so that they can develop mangrove ecosystem management plans according to their needs and forecasts, which are jointly decided with the involvement of all parties. Apparently, there is an ongoing governance conflict between two types of narratives and priorities.

Regarding the impacts of land interventions on users of mangrove ecosystems and residents near these systems, the findings from the Riau Islands case reveal that the larger intervention projects typically rely on formal legal structures to convert land ownership and licenses, whereas local residents typically rely on generations of customary or informal land tenure systems. This underscores the need for more transparency and more open communication of procedures related to land interventions and more inclusive decision-making which takes the rights and interests of local communities better into account. In other words, although the Legal changes and transactions (ΔL) follow legitimate paths, they may result in inappropriate Socio-spatial changes (S), if these rely on involuntary eviction. Changing perceptions (ΔP) remains difficult once these negative perceptions have been fixed by local residents.

The political and practical contexts and frames in which mangroves are either conserved, protected, or destroyed and how this is the result, or the cause of changing land rights and restrictions differs for each case. In some instances, disaster protection frames are used to justify certain land-related decisions, such as major dams, whereas in others socio-economic benefits are used as keyframes, such as new cities or urban expansion. For communities, this may be perceived as either inconsistent or untransparent, which may thus also influence their cause of action or change in behavior - such as opting for community-based actions of self-governance, seeking closer connections to government and decision-making processes, or reversely, opting for high-profile protests and political advocacy.

Conclusion

The core research unknown prior to the investigation was to which extent and how major land interventions and mangrove preservation activities could align. The land management equation helps to make this relation more insightful. By focusing on evaluating how each of the aspects in the equation is effectively altered, the relation between the context of project interventions and effects on mangrove preservation as well as on the socio-economic environments of coastal communities becomes clearer. Nevertheless, there are still some issues which require further in-depth research. On the one hand, this concerns the land management interventions themselves. Often these follow multiple laws, regulations, and decrees from the side of the governments as well as various levels as well as from project plans from external investors. It remains unknown to which extent the processes of these sufficiently and systematically incorporate the broad scale of ecological and societal concerns. In this quest it could be supportive to study how to incorporate a framework of responsible land management [45] in land intervention preparations. Secondly, the role of local governments in developing a sustainable land strategy is often hidden and possibly not properly understood. Local governments play both a brokering role, but also hold

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discretionary powers. These two roles and how and when they interact, should be further studied, not only in the context of mangrove preservation, but also for other types of land interventions.

A limitation of this study is that it had to rely on documented evidence rather than direct empirical evidence. Implicitly, this brings in the interpretation from others which one has to re-interpret once again. Ideally, this needs to be updated and further expanded with additional empirical data on all aspects of the equation. A second limitation concerns perhaps the conditions under which the land management equation is significant. Although the construction of the equation itself is justifiable, there is still insufficient comparative research that focuses on both the conditions for the equation and the results generated by the equation. This is therefore a recommendation for further research.

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