

Payments for Environmental Services: A new instrument to address long- standing watershed and coastal issues in Indonesia?

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Payments for Environmental Services: A new instrument to address long-standing watershed and coastal issues in Indonesia?

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1. Introduction

Watershed and coastal management have long been priority areas for environmental conservation and development policies in Indonesia. Debates over watershed degradation on the island of Java and its possible effects on water flows and agriculture downstream can be traced back to the early decades of the 20th century. From early on, these debates were linked to forest policies; the aim of watershed protection served as a rationale for the expansion of state forest territories and was included in the Forest Law of 1920 (Galudra & Sirait, 2009; Lukas, 2015).

From the late 1960s, river basins were at the centre of development policies. The USAID-funded Citanduy I project, a river basin development project focussing on agricultural reclamation and irrigation in Central and West Java, marked the beginning of international development aid in Indonesia (Lukas & Flitner, under review). The strong political focus on river basins was also reflected in the country's first five-year development plan (USAID, 1976).

In the late 1970s and early 1980s, as erosion and the corresponding influx of sediments into rivers, irrigation schemes, reservoirs and coastal waters increasingly captured the attention of policy makers, the focus shifted from agricultural reclamation and intensification in the lower river basins to upland conservation (Lukas & Flitner, under review). Priority watersheds with "critical", i.e. erosion-prone, lands were identified throughout the country.

Watershed management has since mainly been associated with the aim of increasing tree cover and reducing soil erosion in the uplands. Related debates and policies have continued to be considerably shaped by forest policies. Centralised control of the state forests, which comprise more than 20 percent of Java's land area (Ministry of Forestry, 2014; Perhutani, 2015), and their professional management by the state forest corporation, a parastatal enterprise¹, has been framed as the epitome of sustainable watershed management by foresters (Lukas, 2015a). In line with this, watershed management has been institutionally associated with the Ministry of Forestry.

Outside the state forest territories, internationally funded development projects and nationally funded soil conservation and greening programmes have been the major watershed management interventions on the ground. The USAID-funded Citanduy II project, implemented from 1981-88, and the National Forest and Land Rehabilitation Program

¹ For a detailed historical account of forest management in Java, see Peluso (1992)

(GERHAN), which ran from 2003 to 2009, are just two examples of a very large number of interventions. All of them have built on the assumption that the land use practices of small-scale upland farmers on their private lands were the major cause of erosion and subsequent sedimentation of downstream reservoirs, irrigation channels and coastal areas. As a result, interventions focussed on terracing of farmers' agricultural lands and tree planting.

Substantial funds have been invested over the last forty years. Yet, many of Indonesia's watersheds continue to be regarded as highly degraded, with corresponding negative effects on coastal ecosystems. Priority watersheds with a large proportion of "critical" lands continue to be determined regularly (Ministerial decree number 284/1999). Their reported number steadily increased from 22 in 1984 to 42 in 2000 (Nugroho, Priyono, & Cahyono, 2004) and 118 by 2015 (Kurnia, 2015), reflecting not only changes in watershed conditions and evaluation criteria, but also increasing political commitment.

Political commitment is also reflected in attempts to reform national policies. These policies acknowledge the multi-sectoral nature of watershed issues and the necessity of involving the large range of different actors concerned. For example, Government Regulation 37/2012 on watershed management issued by the then Ministry of Environment highlights the multi-sectoral requirements of watershed management and the range of actors involved. The higher level 2014 Law on the Conservation of Soil and Water explicitly adopts an integrated watershed management approach. It stresses the need for engagement from different sectors, administrative units and communities. It also highlights the importance of taking a perspective which considers entire watersheds, from upstream to downstream areas. This increasing recognition of the multi-dimensional demands of watershed management is also reflected in the institutional structure of the Ministry of National Development Planning (Bappenas), which includes a Sub-Directorate for Watersheds and Conservation of Water Resources under the Directorate of Forestry and Conservation of Water Resources.

Yet, in practice, it has proven challenging in Indonesia to effectively translate high-level policy positions into action on the ground, let alone action which takes into consideration complex region-specific and historically grown socio-political realities. Furthermore, integration of watershed and coastal management, which is reflected in national-level policies² and has been promoted through internationally funded conservation and development projects (e.g. ADB, 1996b, 2006), in practice remains a major challenge.

² For example, the 2004 Law on Water Resources uses watershed as a planning unit and defines a watershed as including marine areas which are impacted by land-based activities.

As market-based approaches to environmental governance have increasingly gained traction in the policy sphere, payments for environmental services (PES) have emerged as a potential alternative or complement to state-led approaches. They are seen as one way of possibly linking the management of upstream-downstream processes. PES has also been hailed as a way of generating new sources of funding and improving efficiency (Ferraro & Kiss, 2002; Engel, Pagiola, & Wunder, 2008; Van Hecken & Bastiaensen, 2010).

Such approaches have been piloted in various watersheds in Indonesia. Given the limited effectiveness of earlier long-standing interventions and the increasing effort invested into hastily promoting and setting up PES, there are urgent questions to ask before such a policy approach is adopted:

1. What are the underlying causes of the long-standing watershed issues, and why have previous interventions failed to effectively address them?
2. What are the causes of high river sediment loads and coastal sedimentation and to what extent have they been addressed?
3. What are the challenges of managing these changes in coastal areas?
4. Are PES a suitable instrument to address these watershed and coastal issues?

We deal with these questions based on our research in the Segara Anakan Lagoon and its watershed area in Central and West Java and on watershed PES initiatives with case studies in East Java, Sumatra and Kalimantan. The Segara Anakan Lagoon and its watershed area constitute one of the long-standing priority areas for watershed management in Indonesia. Nowhere in Java are the effects of high river sediment loads on coastal areas more evident than in the Segara Anakan Lagoon. Since the mid-1800s, three quarters of the water area of the lagoon has silted up due to riverine sediment input (Lukas, 2014a). The lagoon is regarded as a unique ecosystem and comprises one of the largest remaining mangrove areas on Java. Despite longstanding research and investment, sedimentation and lagoon degradation are ongoing. This region is thus a prime example illustrating the major challenges of watershed and coastal management in Indonesia.

Our research in the Segara Anakan Lagoon region from 2008 to 2015 aimed at better understanding socio-ecological linkages between upstream and downstream processes and dynamics within the lagoon itself. It provided the opportunity to explore persistent assumptions upon which watershed management approaches are often based and to contribute to a more nuanced understanding of watershed and coastal processes, policy

approaches and potential management alternatives. The current paper summarizes the main results of this research and highlights their policy- and management-related implications.³

The research presented in this paper was conducted as part of the Indonesian-German research programme SPICE (Science for the Protection of Indonesian Coastal Ecosystems).⁴ The initial research, which was conducted as part of the second phase of SPICE, contributed to improved understanding of social-ecological dynamics, their drivers and related governance and management issues in the Segara Anakan region (Lukas, 2015a). Building on this, during the third phase of SPICE the focus turned to, among other things, considering the potentials of new governance mechanisms aimed at both watershed conservation and sustainable management of mangrove areas, with particular attention to PES approaches. Over the course of the research it became clear that in the case of the Segara Anakan region, as with other multi-functional watersheds in Indonesia, PES is not a panacea to solve long-standing issues, many of which are of a socio-political and institutional nature.

The paper continues with an overview of the Segara Anakan Lagoon and its watershed, considering the main environmental issues and past management approaches. Following this it presents the major policy-relevant research findings from the project, starting with the lagoon and its watershed, before turning to PES mechanisms. First, the focus is on better understanding the temporal dynamics of sedimentation of the lagoon. This is followed by an analysis of the drivers of sedimentation, which provides a much broader historical, spatial and sectoral perspective than has been taken before. The third and final section on results in the Segara Anakan Lagoon region examines tenure issues on newly emergent land resulting from sedimentation of the lagoon. Following this the paper presents the results of research on three PES schemes in Indonesia. The intention of this research was to contribute to an analysis of whether PES mechanisms might be an appropriate mechanism to address long-standing issues in the Segara Anakan Lagoon and its watershed.

The final section of the paper brings together the research in the lagoon and its watershed and PES experience in other areas of Indonesia to provide some careful recommendations that could strengthen development and environmental conservation policies in the area.

³ The material summarized in this paper is drawn from a number of publications resulting from the research. A complete list of publications is provided in the Appendix.

⁴ SPICE was funded by the German Federal Ministry of Education and Research (BMBF). This research was conducted under phases II (2008-2011) and III (2012-2014). Martin C. Lukas started research in the lagoon and its watershed in 2008; Jill Heyde began in 2012, focusing specifically on the lagoon.

2. The Segara Anakan Lagoon region: A longstanding priority area for coastal and watershed management in Java

The Segara Anakan Lagoon is a shallow, mangrove-fringed coastal lagoon on the south coast of Java. It is protected from the Indian Ocean by Nusa Kambangan Island and forms the estuary of the Citanduy and a number of smaller rivers, including the Cibeureum and Cikonde (Figure 1). The watershed area of the Segara Anakan Lagoon covers about 450,000 hectares. It comprises volcanic and sedimentary mountain ranges and a plain to hilly central river basin. The major land uses comprise wet rice agriculture (*sawah*), rainfed agriculture (*tegal*), settlements with house gardens (*pekarangan*), small-scale farmers' (mixed) forests (*kebun campuran*), plantations (*perkebunan*), and state forests (*hutan negara*) (Lukas, 2017a). The region's tropical monsoon climate is marked by high-intensity rainfalls between November and April.

Rapid aggradation of the Segara Anakan Lagoon, the resulting loss of water area, and corresponding rapid ecological and social changes have received much political and scholarly attention (see, for example, Bird, Soegiarto, & Soegiarto, 1982; Ongkosongo, 1983; White, Martosubroto, & Sadorra, 1989; Olive, 1997; Ardli & Wolff, 2009; Jennerjahn & Yuwono, 2009; PSDA Jabar, 2010). The lagoon has been a hotspot of academic interest from both national and international researchers since the early 1980s. Both the lagoon and its watershed have been the focus of political programmes and large-scale development projects implemented with significant loan funding. Few other coastal areas and watersheds in Java and the whole of Indonesia have received as much political attention.

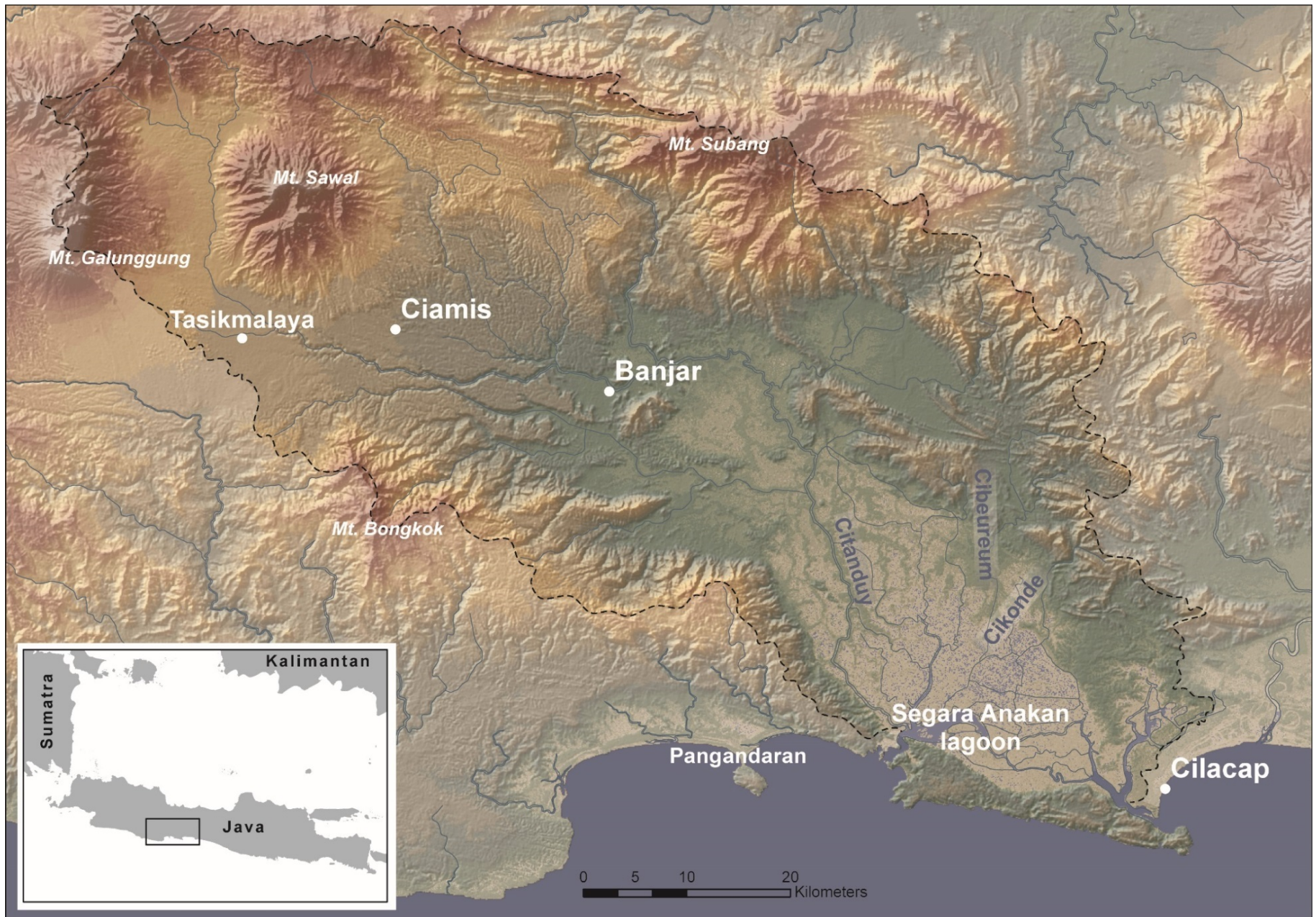


Figure 1: Location of the Segara Anakan Lagoon and its watershed on the south coast of Java (map adapted from Lukas 2014a)

2.1 Past management approaches

In 1969, a few years after the start of Soeharto's New Order regime, the Citanduy River was declared one of six rivers in Indonesia which would be a priority for development, "indicating its control was in the national interest" (USAID, 1976). Agricultural expansion and intensification in the lower river basin were at the core of the USAID-funded Citanduy I project, which started implementation in 1969, although there were other issues related to security and political stability underlying this designation (USAID, 1985; Lukas & Flitner, under review). This focus on the Citanduy River set in motion decades of state-led interventions in the Citanduy watershed and the Segara Anakan Lagoon (Table 1).

The approaches to management of both the lagoon and its watershed have shifted over time (Lukas & Flitner, under review). Up until the mid-1970s there was the tendency to view the mangrove and swamp forests and emergent land from sedimentation in the lagoon as wasteland, and there was serious consideration of plans to reclaim the lagoon for agriculture and fresh water fishery ponds through processes to accelerate sedimentation (for a summary, see PRC Engineering Consultants Inc., 1987). In the late 1970s and early 1980s, awareness grew of the importance of the lagoon and its mangrove areas for both in- and off-shore fisheries (Bird et al., 1982). Furthermore, sedimentation was found to impair drainage and increase flood risk in the newly reclaimed agricultural areas upstream (PRC Engineering Consultants Inc., 1987). Thus, approaches aimed at the conservation of the lagoon's water area, its mangroves, and its fish and shrimp stocks and spawning grounds started to gain prominence in policy and development discourses. Numerous watershed conservation projects and programmes have been implemented to reduce river sediment loads. An emerging issue is the protection of carbon stores and enhancing sequestration potential in mangrove areas in the interest of climate change mitigation.⁵

Following the issuance of a Master Plan for the Citanduy Basin in the mid-1970s and feasibility studies and first pilot projects for watershed conservation between 1976 and 1980, the USAID-funded Citanduy II project was implemented between 1981 and 1988. It aimed at upland conservation, and related interventions were focused on tree planting and field terracing programs on upland farmers' private plots (Lukas & Flitner, under review). In addition to upland conservation, flood protection and improvement of irrigation infrastructure in the lower watershed was a major focus of projects in the area over the period up to 1997.

⁵ The Segara Anakan Lagoon has been suggested as a potential REDD+ site (see, for example, Koran Tempo, 2012; Merdeka, 2014), although at the time of field research between 2013 and 2015 there seemed to have been no concrete action taken in that direction (Heyde, 2016).

Starting in the mid-1990s, the Asian Development Bank (ADB) funded Segara Anakan Conservation and Development Project aimed at reducing lagoon sedimentation mainly through dredging and river diversions. The project also funded additional upland conservation measures and aimed at improving the livelihoods of lagoon residents through aquaculture development. Various nationally funded programmes have since continued the upland conservation and lagoon management efforts.

Table 1 provides an overview of major state-led donor funded initiatives implemented in the lagoon and its watershed. In addition to internationally-funded projects discussed here, there has been significant investment in the area in the frame of nationally funded programmes and projects. The table captures the magnitude of investment and attention that the area has received since 1969. For example, USAID provided loan support of at least 10.8 million USD for the Citanduy I project, which had an estimated total value in the range of 25 million USD (loan plus Government of Indonesia contribution) (USAID, n.d., 1976). Loan and Government of Indonesia investment as part of the Citanduy II project was in the range of 39.9 million USD (USAID, 1980, 1985; Tim Koordinasi Wilayah & Tim Koordinasi Pusat, 1989). The ADB contributed loans totalling at least 82.6 million USD for projects in the lower Citanduy area, with total project values reaching approximately 125.7 million USD (loan plus Government of Indonesia) (ADB, 1996a, 2001). The total investment for the Segara Anakan Conservation and Development Project was approximately 37 million USD, of which 22.8 million USD was loan funding from the ADB (ADB, 2006).

Overall, the achievements of more than four decades of research and interventions in the watershed and lagoon appear to have been rather limited. Whereas conversion of the lower river basin into a rice bowl has been a success in terms of food production, the efforts aimed at reducing watershed degradation and lagoon conservation have had limited effects. Despite very significant investment of funds and effort, many of the issues leading to watershed degradation, sedimentation of the lagoon, and mangrove degradation persist. High river sediment loads and lagoon sedimentation continue to be seen as a major threat by local fishers, governmental representatives and academics. Engineering measures to reduce riverine sediment input (river diversions) and lagoon dredging only partly materialised, led to social conflicts and had negative or only temporary effects. Mangrove degradation continues, and the success of mangrove reforestation initiatives is limited. The establishment of shrimp ponds as an alternative livelihood option hardly benefitted lagoon residents whose portrayal as victims of lagoon sedimentation served as a rationale for the intervention (Reichel, 2007). The ponds were subsequently plundered and were largely abandoned.

A large amount of money has been spent; project reports and research results related to the region fill entire book shelves, but the basic issues persist. Trying to better understand the reasons for this was one of the motivations of the research presented in this paper.

Table 1: Major state-led donor funded initiatives in the Citanduy watershed and Segara Anakan Lagoon (adapted from Heyde 2016)

Initiative ⁶	Executing agencies	External Funder	Financing ⁷	Objective(s)	Sources
Citanduy I (1969-1981)	Publics Works; Agriculture	USAID	USD 25,374,000	Elimination of annual flooding by the Citanduy and Ciseel Rivers, agricultural reclamation, and expansion of irrigation schemes to increase production of rice and other crops.	(USAID, n.d., 1976, 1978)
Citanduy River Basin Master Plan (1971-1975)	Public Works	USAID	N/A	Comprehensive study to determine an optimal pattern of utilization of water and land resources in the Citanduy River Basin which will lead to increased agricultural production and the attendant improvement in the standard of living of the inhabitants of the area.	(PRC Engineering Consultants Inc., 1975; USAID, 1976, 1978)
Feasibility studies and pilot projects for the management of the upper Citanduy watershed (1976-1980)	(Preparation of Citanduy II)				
Citanduy II (1981-1988)	Public Works; Internal Affairs; Agriculture; Forestry	USAID	USD 39,920,000	Implement effective watershed management and foster upland agricultural development. Increase agricultural productivity and reduce erosion and sediment reduction.	(PRC Engineering Consultants Inc., 1980; USAID, 1980, 1985; Tim Koordinasi Wilayah & Tim Koordinasi Pusat, 1989)
Lower Citanduy Irrigation Project (1981-1989)	Public Works	ADB	USD 90,700,000	Improve income and employment opportunities and rural water supply facilities and rural roads. Expand irrigation schemes. Contribute substantially towards achieving the third five-Year development plan's (REPELITA III, 1979/80 - 1983/84) goal of food sufficiency.	(ADB, 1996a)
Lower Citanduy sub-project of Integrated Irrigation Sector Project (1990-1997)	Public Works; Internal Affairs; Agriculture; Forestry	ADB	USD 35,100,000 (est)	Support to Government of Indonesia's development goals in the agriculture sector under the fifth five-year development plan (Repelita V).	(ADB, 2001)
SAL Environment Monitoring & Optimal Use Planning Project (1982-1985)	Institute of Hydraulic Engineering	Partly by ADB	N/A	To prepare a definitive plan for ensuring adequate drainage of the lower Citanduy Irrigation Project area; evaluate the feasibility of using engineering measures to control the future of the Segara Anakan Lagoon.	(Ecology Team, 1984; PRC Engineering Consultants Inc., 1987)
ASEAN-US Coastal Resource Mgmt. (1986-1992)	ICLARM	USAID	Full amount: N/A; Grant: 5,800,000 USD	Increase national capabilities within ASEAN for developing and implementing comprehensive, multidisciplinary and environmentally sustainable coastal resource management strategies. Project implemented in six ASEAN countries; Segara Anakan Lagoon was the Indonesian pilot site.	(Thia-Eng & Scura, 1992)
Preparation of Segara Anakan Conservation and Deveopment Project (SACDP) (1992-1995)	Public Works	ADB	Full amount: N/A; Grant: 1,700,000	Preparation of SACDP.	(ADB, n.d.; PRC Engineering Consultants Inc., Delft Hydraulics, & P.T.Exsa International. Co., 1994)
SACDP (1997-2005)	Public Works; Internal Affairs	ADB	USD 37,020,000	To conserve and develop the Segara Anakan Lagoon and mangrove complex and enhance and protect the related ecosystem; to improve the livelihoods of lagoon residents.	(ADB, 2006)

⁶ Where possible, information based on loan documents or documents from funder.

⁷ Estimates based on project documentation; figures are for actual disbursements.

2.2 Summary of major research findings

2.2.1 Sedimentation of the Segara Anakan Lagoon

Sedimentation of the Segara Anakan Lagoon has been regarded as one of the major issues in the region for decades. It has been a significant driver of the rapid social-ecological changes in the lagoon that have prompted much research interest and a focus of the management efforts outlined above. Yet, we found that knowledge about the longer-term dynamics and drivers of lagoon sedimentation was limited. While much scholarly attention focussed on the lagoon, barely any research was conducted on sediment sources in its watershed prior to our research programme.

Knowledge about the longer-term dynamics of sedimentation is an important basis for determining its drivers. However, historical time series of river sediment loads are either unreliable or do not exist (PRC Engineering Consultants Inc., 1987; Seckler, 1987). This applies to the whole of Java. Using a combined analysis of historical maps and recent satellite images, our research has drawn the most comprehensive picture to date of the temporal dynamics of lagoon sedimentation (Lukas, 2014a, 2015c, 2017a). From the mid-1800s until 2013, the water surface area of the lagoon decreased from approximately 8,600 hectares to slightly more than 2,000 hectares (Lukas, 2014a, 2017a, see Figures 2 and 3).⁸ This temporal analysis was an important starting point for further inquiry into the drivers of lagoon transformation, as described in Section 2.2.2.

⁸ Different estimates of the current expanse of water areas can be found in the literature on Segara Anakan Lagoon. These can be attributed to how rivers, channels and the different portions of the lagoon were incorporated into the calculation.

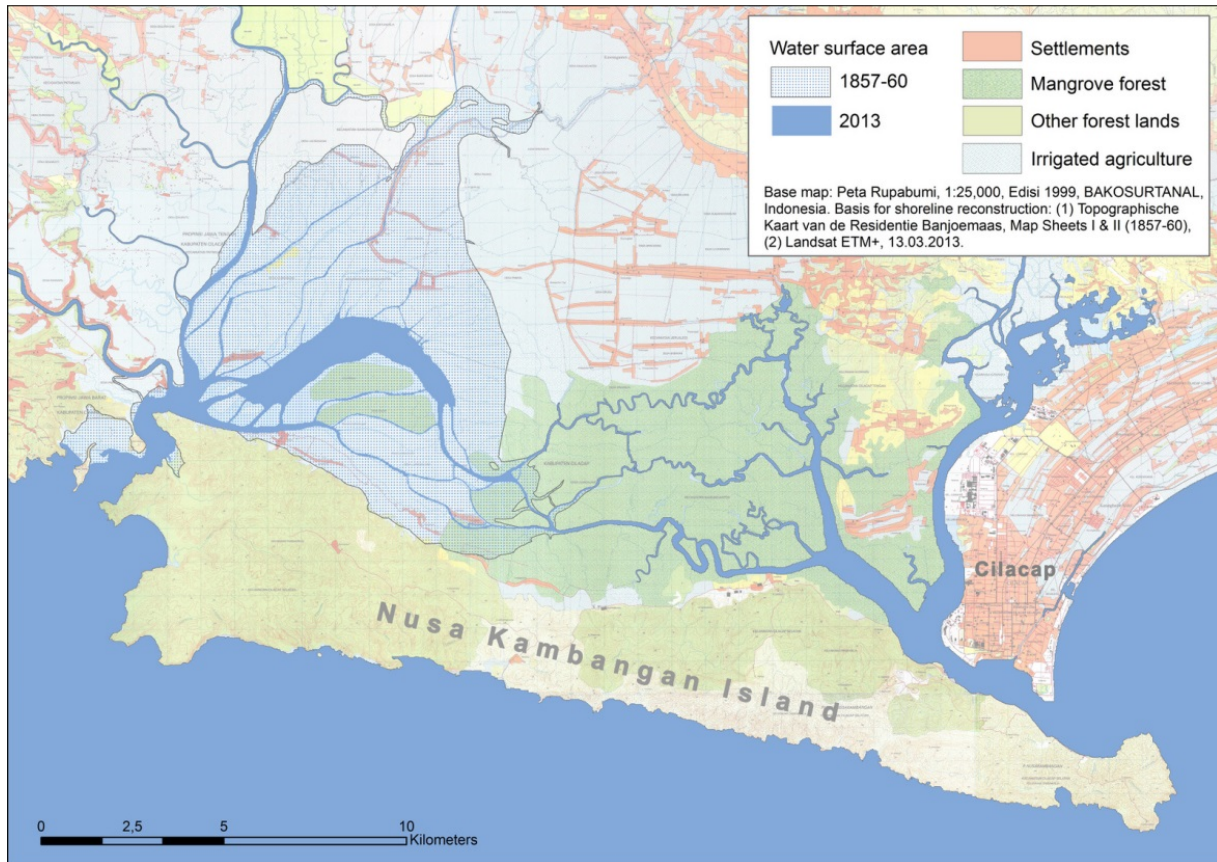


Figure 2: Change in the water surface area of the Segara Anakan Lagoon between 1857/60 and 2013 (Source: Lukas, 2014a)

2.2.2 Drivers of lagoon sedimentation

Prior to our research, no watershed-wide analysis of sediment sources and their causes has been undertaken. In the absence of concrete knowledge, lagoon sedimentation has mainly been linked to erosion on upland farmers' private plots. This corresponds to simplistic assumptions about the causes of high river sediment loads and coastal sedimentation in the whole of Java. Related debates have for decades focussed on upland farmers' private plots (e.g. Repetto, 1986; Donner, 1987; Magrath & Arens, 1989; Palte, 1989; Barbier, 1990; Rudiarto & Doppler, 2013; see Lukas 2015a for a review). The knowledge of other sediment sources and related societal drivers is scarce. In line with the common assumptions, watershed management interventions have focussed on encouraging and assisting small-scale farmers to plant more trees and terrace their agricultural fields. The effects of these efforts on river sediment loads are regarded as limited (see Lukas 2015a for a more comprehensive discussion).

Doubts about the effectiveness of watershed management programmes were already expressed in the 1980s and 1990s. Failure of the programs and continued high levels of river sediment loads have been attributed mainly to shortcomings in programme design and implementation, land tenants' limited scope to invest into soil conservation, and price guarantees for cassava (USAID, 1984, 1985; Huszar & Cochrane, 1990; Purwanto, 1999; Van Dijk, 2002; ADB, 2006; Lukas, 2015a). Only a few experts have directed attention to other sediment sources beyond upland farmers' private agricultural lands (Schweithelm, 1988; Diemont et al., 1991). Yet, despite these doubts regarding their effectiveness, ongoing watershed management efforts have continued to focus on upland farmers' private lands.

The assumption that farmers' private plots represent the single-most important sediment source provided a clear-cut narrative for political intervention and rendered inquiries into other causes of high river sediment loads seemingly unnecessary (Lukas, 2015a). Our research in the lagoon's watershed has shown that farmers' private agricultural plots are in fact only one of numerous sediment sources. In addition, there is a broad range of other historical and contemporary drivers of lagoon sedimentation that have been neglected to date (Lukas, 2017a, Figure 3).

Among the most important of these drivers are conflicts over land and forest resources. While tree cover has increased on farmers' private lands since the early 2000s, it has declined on state forest and plantation lands (Lukas, 2015b). Satellite image analysis and land cover mapping identified these areas as hotspots of land cover change and soil erosion (Lukas, 2015a). Social-scientific case studies in these areas established causal links between political struggles over the access to and control of land and forest resources and land cover change and soil erosion (Lukas, 2015a). Some of these conflicts are rooted in historical displacements of people and entire villages in the wake of political insurgencies and counter-insurgencies in the 1950/60s and the incorporation of these areas into the state forest territory (Lukas, 2014b). Other conflicts are rooted in displacements of small-scale farmers as a result of illegitimate expansions of plantations lands in the 1950s (Lukas, under review). At that time, former Dutch plantations were transferred into Indonesian ownership. Some of the new owners – mostly representatives of the state, the military or local elites – expanded the plantations at the cost of small-scale farmers' lands (Lukas, under review). These displacements, and a history of repressive, exclusive forest management by the state forest corporation throughout Java (see Peluso, 1992 for a historical account) erupted in large-scale forest violence following the fall of President Suharto in 1998 (Lukas & Peluso, under review). In the wake of this violence, many forest and plantation lands were cleared (Lukas, 2015a; Lukas & Peluso, under review).

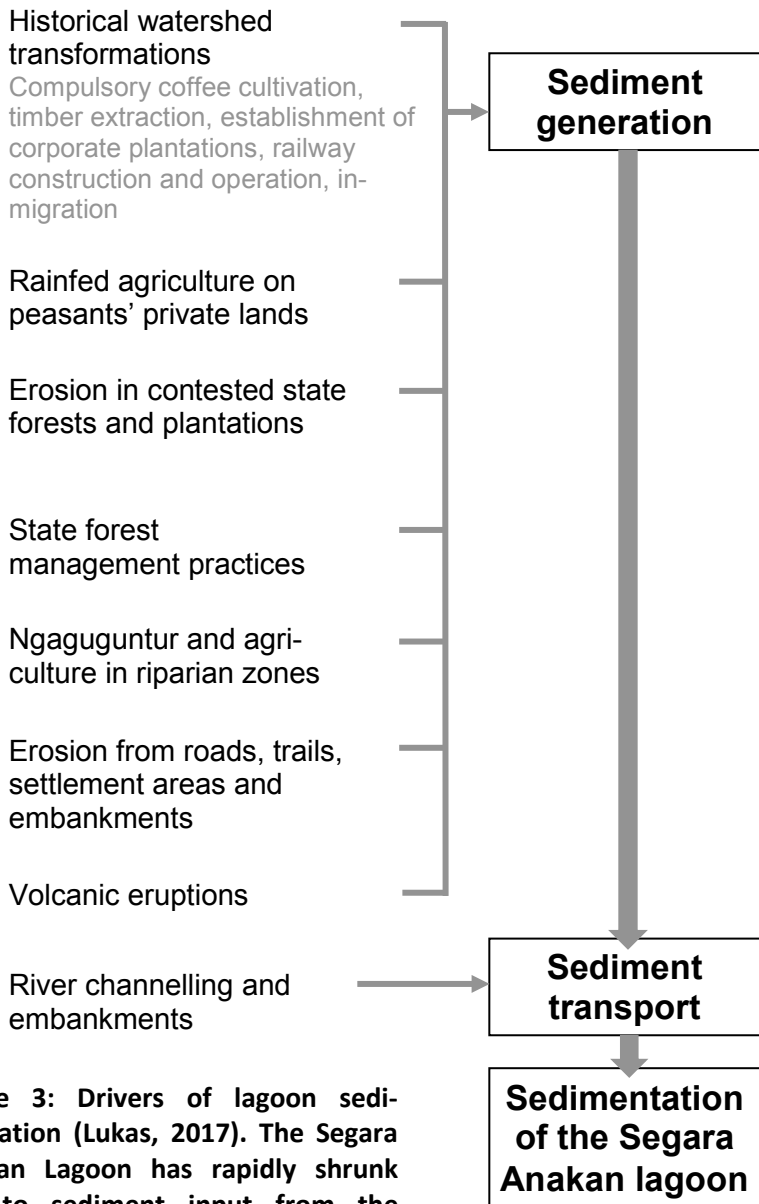
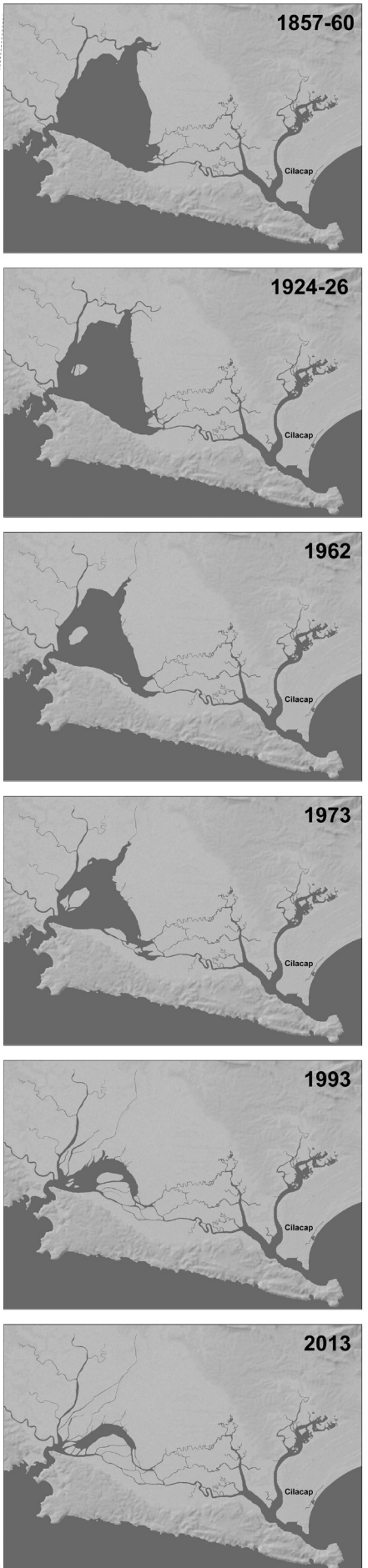
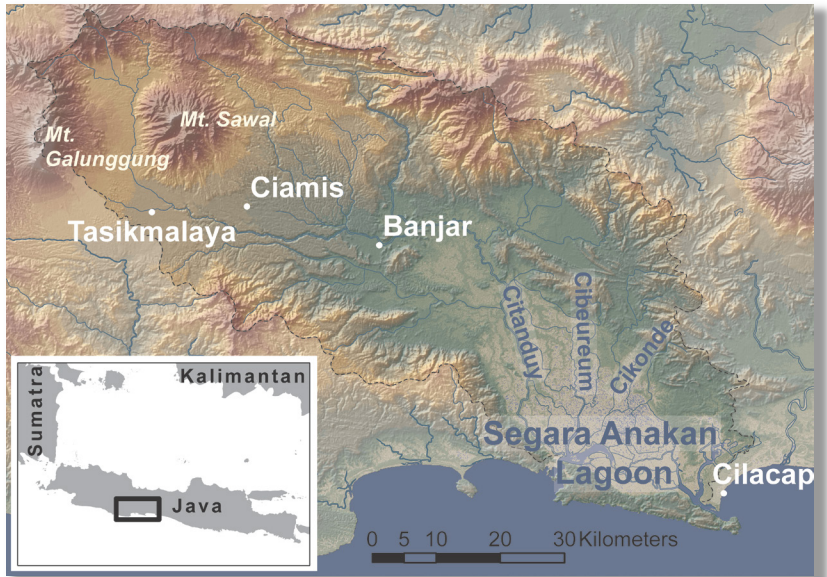


Figure 3: Drivers of lagoon sedimentation (Lukas, 2017). The Segara Anakan Lagoon has rapidly shrunk due to sediment input from the Citanduy, Cibereum and Cikonde Rivers. This is the result of a broad range of drivers that have increased sediment generation and transport. The map series illustrates the change in the water surface area of the Segara Anakan Lagoon over time (for more details see Lukas, 2017a).

On some contested forest and plantation lands, ongoing struggles over access and control between farmers and the state forest corporation and plantation operators have since limited the scope for reforestation. These struggles comprise strategic acts of contestation, such as forest clearing and burning, tree planting, crop cultivation, or the uprooting of seedlings.⁹ Land use and land cover change is the means and outcome of such strategic acts (Lukas, under review; Lukas & Peluso, under review). These contestations have turned some forests or plantations into widely treeless landscapes, which resemble “scars” in satellite images (Lukas, under review). These “eroding battlefields” (Lukas, 2014b) are hotspots of soil erosion; they are an important cause of lagoon sedimentation that is not openly debated. Lack of trust, open communication, and transparent institutions impede conflict resolution. Hence, environmental degradation is a result of unresolved historical political events, of political repression and upheaval, of injustice, of problematic power relations and a lack of trust and communication (Lukas, 2015a).

Community forestry programmes, initiated by the state forest corporation as a strategy to resolve conflicts show limited success.¹⁰ This is related to a number of factors, including historically rooted distrust (Lukas, 2015b). In a few cases, where land conflicts were resolved through granting land titles to farmers, our research documented the conversion of erosion-prone conflict lands into mosaics of terraced rice fields and mixed forests – a clearly less erosion-prone landscape (Lukas, under review).

In addition to these conflicts, the satellite image analysis and observations on the ground revealed the state forest corporation’s management practices, which involve regular large-scale clear cuts, also on steep slopes and in close proximity to water courses, as an important cause of land cover change, erosion, and high river sediment loads (Lukas, 2017a).

Observations and interviews also identified slope cuts (*ngaguguntur*) to enlarge agricultural fields in valley floors, agriculture in riparian zones, and erosion in settlements and on roads, trails and embankments as major sediment sources (Lukas, 2017a). In addition, various historical land use and watershed modifications appear to have contributed to lagoon sedimentation. These include compulsory coffee cultivation, timber extractions, establishment of corporate plantations, railway construction and operation, and the opening

⁹ Such acts of contestation have marked forester-villager relations throughout Java since colonial times (Peluso, 1992). The fall of President Suharto in 1998 and the political reformation thereafter enhanced the scope for such acts of contestation and opened the door for (still ongoing) renegotiations of forester-villager relations (Lukas & Peluso, under review).

¹⁰ In 2001, the state forest corporation issued a decision on Joint Community Forest Management in an attempt to improve relationships between the corporation and villages bordering state forest areas all over Java.

up of new agricultural land as a result in-migration in the late 19th and early 20th century (Lukas, 2017a). Furthermore, volcanic eruptions have been an important source of river sediments loads (ibid.).

In addition, river straightening and embankments and agricultural reclamation of the floodplains of the lower river basin in the frame of various government and donor-funded interventions have accelerated lagoon sedimentation, particularly since the 1960/70s. Having been straightened and embanked, the Citanduy and Cikonde Rivers no longer deposit portions of their sediment loads in the alluvial swamp lands upstream from the lagoon during storm water flows. Instead, the entire sediment load, which is especially high during storm water flows, is transported into the lagoon (Lukas, 2017a).

To sum up, sedimentation of the Segara Anakan Lagoon is the result of a broad range of historical and contemporary drivers. Debates and management interventions have to date focussed on only one of these factors: upland farmers' private agricultural plots. The neglect of other sediment sources has a priori limited the effectiveness of watershed management (Lukas, 2017a). Historically rooted conflicts over the ownership, access and control of plantations and state forests have both contributed to lagoon sedimentation and impeded open debates over its causes and management alternatives. Watershed management has been entangled with forest policies and the state's and its forest corporation's interest in maintaining control over the state forests. The unchallenged framing of the state forests as the epitome of watershed protection has contributed to the persistence of the simplistic discourses described above and prevented open debate over some of the core issues (Lukas, 2015b; Lukas & Flitner, under review).

2.2.3 Tenure contestation in the lagoon

Like watershed management, government-led interventions targeting the Segara Anakan Lagoon have been based on narrow assumptions and a limited understanding of realities on the ground. Furthermore, like in the watershed area, tenure contestation also limits the scope for more sustainable environmental management in the lagoon.

Lagoon sedimentation has been seen as a threat by government representatives and academics since the early 1980s. As a result, sediment reduction has been the aim of a number of interventions targeting the lagoon. At the same time, since at least the 1970s, local residents and newcomers to the Segara Anakan Lagoon have used various processes to reclaim muddy emergent land and transform it for agricultural use, homes and other village infrastructure. Traditionally residents were heavily dependent on the fishery sector, but as fishing livelihoods became more insecure due to lagoon sedimentation and subsequent loss of fishing grounds, people started to turn to farming (Olive, 1997; Heyde, 2016).

In this way, riverine sediment input has not only had profound effects on the area of land and water in the lagoon, but has impacted social-ecological conditions and dynamics, and in particular land use. Mangroves tend to rapidly colonize emergent land, and areas on the landward side of the mangroves become drier, leading to changes in land cover and potential use.

Small scale reclamation initiatives by local residents have hastened the transition from water to land. As described in more detail by Heyde (2016), over time people have used at least three different micro reclamation approaches: i) transporting soil to build up land for homes and village infrastructure, ii) constructing dikes to block salt water intrusion into agricultural fields, and iii) intentional channelling of riverine sediment into low-lying fields to enhance agricultural potential.

As new land was brought into use and gained value, tenure contestation between state agencies and local residents started to intensify. This highlights the disconnect between state approaches to land tenure issues in the Segara Anakan Lagoon and the on-going claiming of land by lagoon residents (Heyde, 2016). Tenure changes have slowly occurred in the lagoon despite attempts by different state agencies to block them. Efforts over the decades to use and claim emergent land in the Segara Anakan Lagoon were met with at times heavy handed attempts by state authorities, and in particular the Nusa Kambangan prison authorities and the state forest corporation, to restrict such efforts. Over time, however, de facto land rights have solidified, and have also received formal backing (Heyde, 2016).

Different actors have used different strategies over time to strengthen their claims to emergent land. Such claims have been both direct and indirect. They have been based on strategies such as legal and spatial justifications, attempts on the part of the state forest corporation to assert institutional control, and incremental recognition of land tenure through usage rights and tax payments (Heyde, 2016).

The legal status of emergent land in Indonesia is rather unclear, a situation which has provided the opportunity for different actors to stake claims based on different justifications. These tend to revolve around whether the land should be designated as part of the national forest estate. The Ministry of Forestry, through the state forest corporation, is interested in having emergent land recognized as state forest in order to help in meeting the requirement that 30 percent of each province should be classified as forest land. This target has not been reached yet in Central Java, where the Segara Anakan Lagoon is located. Claims on the land are based in part on the argument that emergent land should be managed by the authority which controls the land next to which the new land emerges. Since the state forest

corporation manages land surrounding the old boundaries of the western side of the lagoon, the corporation claims the new land (Heyde, 2016).

Many local residents on the other hand, are of the opinion that since in the past they had traditional rights to the waters of the lagoon (*hak ulayat*), as the water turns to land, rights to the land should rest with residents (Heyde, 2016). Additionally, there is an argument which builds on the understanding that forest land can be legally converted to non-forest land, but there is no mechanism to transform non-forest land to forest land. Since emergent land was never categorized as forest land, it is therefore non-forest and cannot be claimed as part of the state forest area (Heyde, 2016).

Despite the lack of legal clarity, the de facto usage rights of residents to the land have been increasingly acknowledged over time. Initially this occurred by village governments granting usage rights to land. These were then acknowledged by the district, although not with full ownership certificates (Heyde, 2016). Now people using the land are increasingly incorporated into the local taxation system. In the early 2000s a cadastral survey was conducted in the western part of the lagoon. Following this, homes and their surrounding gardens became eligible for full certification (ownership). At the time of field research in early 2015, agricultural land was not eligible for certification (Heyde, 2016).

Since the mid-2000s the state forest corporation has twice tried to establish village-level institutions associated with the Joint Community Forest Management programmes in the Segara Anakan Lagoon. In both cases the institutions were rejected by local residents (Heyde, 2016).

Like in the lagoon's watershed, this failure points to a persistent lack of trust and weak communication and coordination between actors in the lagoon. This is not just between the state forest corporation and local residents but also the district government and different agencies at the district level. There is no forum for coordination of state agencies and little opportunity for non-state actors, such as local residents, to engage in issues related to lagoon management (Heyde, 2016).

3. Payments for Environmental Services in Indonesian watersheds

As the analysis in the sections above highlights, despite decades of concerted attention and millions of dollars of investment, the main environmental issues in the Segara Anakan Lagoon and its watershed have persisted. These include on-going erosion and subsequent sedimentation of the lagoon. The loss of water area in the lagoon and mangrove degradation are understood to have had serious impacts on both the in- and off-shore fisheries and local livelihoods. The desire to protect mangroves both for their above and below ground carbon

storage and sequestration capacity is also gaining increased attention. Ongoing political debates over future management options reflect that the region continues to be a priority area for environmental management.

At the same time, PES is being promoted as a new, promising governance instrument globally and particularly in Indonesia. Before PES is considered and implemented in the Segara Anakan region, its actual potential needs to be explored on the basis of a careful analysis of prevailing social-ecological issues, their causes and existing governance structures. In this context, building on our analysis of watershed and coastal dynamics in the Segara Anakan region, our research considered the potential of new instruments in coastal and watershed governance and in particular PES, to enhance watershed conservation and sustainable management in the area.

The concept of PES has gained increasing prominence in environmental policy circles globally (Jack, Kousky, & Sims, 2008; Stanton, Echavarria, Hamilton, & Ott, 2010). Such mechanisms have also been piloted in different areas of Indonesia. At their simplest, PES schemes can be conceived of as ways of incentivizing land and resource practices which are thought to have positive effects on the environment. They represent a change from government led command-and-control approaches to ones that try to directly link providers and beneficiaries of environmental services in a mutually beneficial relationship. In a watershed context, the focus is often on how to connect changes in land use aimed at reducing sediment originating from upland areas with the interests of downstream actors.

Research on PES conducted as part of the research project presented here aimed at understanding how watershed PES schemes have been conceptualized, established and implemented in Indonesia, and what this has meant for land rights and resource access (Heyde, Lukas, & Flitner, 2012; Heyde, 2016, 2017), and to what extent PES are a suitable instrument to address long-standing watershed issues in Java.

The research focused on three watershed PES pilot schemes – one in the uplands of the Brantas watershed in East Java, one in a highland watershed in West Lampung, and one in Kapuas Hulu in West Kalimantan (see Table 2). Each case aimed to reduce river sediment input to downstream beneficiaries, in two cases to hydropower reserves, and in one case to municipal water supply. Activities to achieve this included a combination of tree planting, soil conservation interventions such as terracing steep slopes, and small check dams to catch sediment. The upstream suppliers of the services were small scale farmers, and in each case the downstream beneficiaries were parastatal organizations.

Table 2: Summary characteristics of PES case studies (as of early 2013)

Characteristic	Brantas	West Lampung	Kapuas Hulu
Duration	Implementation of pilot initiative 2004-2006	2006-2013 (three stages in different locations; on-going at the time of field work)	Implementation of pilot initiative 2009-2012
Current status	Inactive	Active	Inactive
Scale	Small scale	Small scale	Small scale
Land tenure	Private property	Mixed, private property, protection forest (state land)	Mainly untitled traditional land used by individuals
Environmental services targeted	Reduced sediment input to hydropower reserves	Reduced sediment input to hydropower reserve	Reduced sediment in municipal water
Activities to enhance services	Tree planting, soil conservation interventions	Tree planting, soil conservation interventions, check dams	Tree planting
Incentive type	Mixed	Mixed	Mixed
Suppliers	Small-scale farmers	Small-scale farmers	Small-scale farmers
Beneficiaries	River Basin Operator	State electricity company (PLN)	District water company
Donor	DFID (UK development cooperation)	International Fund for Agricultural Development for work up to 2012, then purely PLN	DGIS and DANIDA (Netherlands and Danish development cooperation)

Source: Heyde, 2016

The schemes were initiated or planned in the mid-2000s, during a period of high donor interest in the potential of PES to improve environmental governance. Implementation of each of the schemes, except the third phase of the West Lampung scheme, was led by non-local organizations. At the time of field research in 2013, two of the schemes were already inactive, while one was on-going. Each scheme was small scale and short term.

As Table 2 shows, the schemes were implemented in areas with different land tenure arrangements. In Brantas the land was privately owned by small-scale farmers. In West Lampung there were mixed tenure arrangements. In the first two phases the scheme was implemented in areas of state protection forest, while the third phase was in an area of privately owned land. In Kapuas Hulu both statutory and traditional land tenure arrangements were present. Although the tenure arrangements across the schemes differ, each pilot project was implemented in an area of uncontested tenure. In the Brantas case, for example, a different site had been considered for the pilot activities due to its high potential for erosion reduction impacts but was ultimately rejected because of land tenure conflicts. This case underpins the relevance of land tenure conflicts as a major cause of environmental degradation in Java and illustrates the limited potential of PES in this context.

In addition to land tenure conflicts in the Citanduy watershed and the challenges these would pose to implementing PES in the area, other findings also point to the limited potential of PES as a mechanism for addressing sedimentation of the Segara Anakan Lagoon. Any such

intervention would need to address sediment sources at a watershed level over the longer term. As the results of the research show, however, each of the watershed PES initiatives explored as part of the research were small scale and of relatively short-term time scale. At the time of the research, this was typical of watershed PES initiatives in Indonesia.

Additionally, in the Segara Anakan case there is no clear institutional beneficiary of a potential PES scheme. This is in contrast to the schemes that have typically been implemented to date in Indonesia (for example, a beneficiary might include the state electricity company or a district water company). A case could be made that the beneficiaries in the Citanduy/ Segara Anakan Lagoon case are small-scale fishers in the lagoon, or off-shore fishers who indirectly benefit from the nursery functions of the lagoon. In the former case, local fishers are adapting to the changing situation in the lagoon and increasingly turning to farming. It is also difficult to imagine how they could provide adequate incentives to meaningfully change the behaviour of upstream land users. In the case of off-shore fishers, the links, both scientific and institutional, are less direct and the provision of adequate incentives would also likely be problematic.

Each of the case studies was initiated as part of a different donor-funded initiative. In two of the three cases, the end of donor funding marked the end of the scheme, although efforts remained to find ways to continue. Under these conditions, it seems fair to say that the potential of such schemes to be self-sustaining over the longer term and at a broader geographic scale is still very uncertain in the Indonesian context. This would be a significant barrier to implementation of PES in the Citanduy/ Segara Anakan Lagoon area.

4. Conclusions and recommendations

The research results presented in this paper have a number of implications for development and environmental conservation policies in the Segara Anakan Lagoon and its watershed. These flow from our focus on better understanding the following issues: i) the underlying causes of the long-standing watershed issues in Java, and why previous interventions have failed to effectively address them, ii) the causes of high river sediment loads and coastal sedimentation and to what extent they have been addressed, iii) the challenges of managing these changes in coastal areas, and iv) whether PES approaches are suitable to address these watershed and coastal issues.

When considering upstream-downstream linkages, there are a number of temporal, spatial and sectoral factors that need to be considered, and a range of actors with different, often conflicting interests (Heyde, 2016, 2017; Lukas, 2017a). Our research shows that debates,

research and political action can remain confined to very few factors for an extended period of time, while neglecting a large range of others.

In the Segara Anakan region, the persistence of simplistic political discourses, and related management approaches continues to undermine the aim of improved watershed protection. Discourses on upland erosion and sedimentation downstream and the interventions that have been implemented in the watershed have one-sidedly focussed on farmers' private lands, while neglecting a broad range of other sediment sources (Lukas, 2017a). The entanglement of watershed management with forest policies and the unchallenged framing of the state forests as the epitome of watershed protection have contributed to the persistence of those simplistic discourses and prevented open debate over some of the core issues, which have hence not been addressed (Lukas, 2015b; Lukas & Flitner, under review). Core issues include widespread historically rooted conflicts over plantation lands and state forests. These conflicts are a major cause of erosion. Historically grown distrust and the lack of open communication and transparent conflict resolution mechanisms impede their resolution (Lukas, under review, 2014b). In addition, the state forest corporation's management practices require critical appraisal, and there are several other important causes of high river sediment loads that have not been debated and addressed to date (Lukas, 2017a).

We also found that some of the same long-standing societal issues that undermine watershed management pose major challenges to more sustainable coastal management. One of the major issues in this context are problematic land and resource tenure relations (Heyde, 2016). As in the uplands, the blindness to tenure conflicts in policy circles is evident when considering coastal resource management approaches, for example, within the context of new land which emerges as a result of sedimentation. Such land is frequently claimed and used by small-scale farmers or aquaculturists. These claims are often tolerated on the one hand and weakly recognized by the state on the other hand. This messy situation is further complicated by the fact that the jurisdiction of these lands is disputed between different government agencies, and the degree of recognition of small-scale farmers' claims also varies between government agencies. As in the watershed, conflicting tenure claims and uncertainty complicate and impede efforts to sustainably manage coastal resources.

Globally and in Indonesia, PES is being promoted as an instrument that could contribute to addressing long-standing environmental problems by incentivizing land use practices that have positive environmental effects. However, based on both the experience with PES in other parts of Indonesia, and the context of the Segara Anakan Lagoon region specifically, it is evident that PES has limited potential to address the major social-ecological issues in the Segara Anakan area.

Based on the persistent problems that have been identified in the Segara Anakan Lagoon and its watershed, we conclude with six recommendations that should be considered in order to strengthen development and environmental policies for the area.

Recommendation 1: Planning of initiatives to reduce river sediment loads needs to consider a broader range of sediment sources than has historically been the case.

When planning soil erosion and sedimentation reduction initiatives, it is critical to take into consideration the full range of sediment sources. In the Citanduy watershed, our research has shown that these include: large-scale historical watershed transformations; rainfed agriculture on small-scale farmers' private lands; erosion in contested state forests and plantations; state forest management practices; slope cuts; and agriculture in riparian zones; erosion from roads, trails, settlement areas and embankments; and volcanic eruptions. River channelling and the construction of embankments have also contributed to increased transport of sediments into the Segara Anakan Lagoon.

To date the design of initiatives in the watershed has been founded primarily on reducing erosion from the activities of small-scale upland farmers on their private plots. The assumption that small-scale farmers' private lands constitute the single-most important sediment source has been the basis for watershed projects in the Citanduy watershed as well as in other watersheds in Indonesia since at least the 1970s. Management interventions based on such narrow assumptions can lead to disappointing results. It means that other opportunities for reducing erosion and sedimentation are not addressed, and this limits the effectiveness of environmental management.

Recommendation 2: Conflicts between farmers and state agencies and plantation companies over land and forest resources in the watershed need to be addressed.

Our research in the watershed of the Segara Anakan Lagoon has shown that some of the most erosion-prone areas are sites of conflict over land and forest resources between small-scale farmers and the state forest corporation and plantation companies. Addressing these difficult issues needs to be part of efforts to reduce soil erosion and river sediment loads. Many of the conflicts are historically rooted. In these conflicts, simplistic explanations about the unsustainable agricultural practices of farmers have served as justification for keeping them away from the state forest territories.

As a first step to addressing the conflicts, it is important to understand and acknowledge the complex histories underlying them. This will require the use of social scientific research methods, including in-depth interviews with local actors in a non-threatening environment. If simplistic explanations and prescriptive responses on the part of state agencies persist, the conflicts are likely to persist, too. Once there is understanding of the conflicts, transparent mechanisms should be developed to address them. Such mechanisms should strive to ensure representation of the different actors involved and reflect the differing local contexts across the watershed. Furthermore, debates over watershed protection should be linked to renegotiations of forest access and control.

Recommendation 3: Lagoon sedimentation should be regarded as a transformation of the ecosystem to which society can adapt, rather than as a threat that must be combated at any cost.

Our analysis of the longer-term dynamics of lagoon sedimentation, the drivers of this process, and the approaches and effects of management interventions to date suggests that watershed management which takes into account the broad range of sediment sources combined with a resolution of the long-standing conflicts over land and resource tenure has the potential to reduce river sediment loads in the future. Yet, it does not seem realistic to expect that watershed conservation will reduce the rate of sedimentation of the Segara Anakan Lagoon to the levels of the mid-19th century.

When discussing environmental management alternatives in this context, lagoon sedimentation could be regarded not necessarily as a threat, which must be combated at any cost (including through dredging), but as a transformation. It alters but does not automatically destroy the lagoon ecosystem and local livelihood opportunities. Recognition of this reality needs to be integrated into development and environmental planning for the area. Unsustainable resource uses, which are linked to contested and uncertain resource tenure and the inconsistent and contradictory approaches and claims of governmental agencies, appear to be a more relevant cause of environmental degradation in the lagoon than sedimentation. Hence, addressing these issues should be a political priority. In contrast, lagoon dredging, which continues to be considered an option by some state agencies, appears to be a futile intervention causing ecological damage and social conflict.

Recommendation 4: The spatial plan for the lagoon needs to be updated to take into account claims to and usage of emergent land, and the changing environmental services of the lagoon.

Changes in resource tenure in the lagoon have been on-going since at least the 1970s. Over that time there have been few opportunities for small scale resource users to meaningfully give input into environmental management decisions. There are also indications of a persistent lack of trust between actors, and in particular between local residents and the state forest corporation. These issues of representation in environmental management and trust building are ones that will need to be addressed in the context of future management of the Segara Anakan Lagoon.

The incremental recognition of tenure to emergent land in the western part of the lagoon highlights the mismatch between regulations, planning and the reality on the ground. While at the time of field research much of the area was still designated for conservation in the district spatial plan, residents were farming in the area, and their rights to the land were being increasingly recognized through usage rights and tax payments. These rights were not, however, fully recognized by government agencies, and in particular the state forest corporation, leading to simmering contestation and occasional outbreaks of open conflict. Thus, there is a need to update the spatial plan for the lagoon to one that moves beyond a focus on conservation and recognizes the current multi-functional usage of land and water in the area. The process should be open and provide the opportunity for lagoon residents to provide meaningful input. Ideally spatial planning should also be based on updated information about the fisheries and other environmental services provided by the lagoon.

Recommendation 5: Coordination between state agencies involved in lagoon management needs to be strengthened.

At the time of field research there was limited coordination between different government agencies involved in management of the lagoon. At a basic level, this was evident from the lack of consensus about which areas of emergent land fell under the authority of the district government and which areas were the responsibility of the state forest corporation. Contributing to this was the lack of an agreed map showing the relevant boundaries; different actors referred to different spatial information as the basis for their authorities. There was little evidence of meaningful communication aimed at resolving the issue.

Beyond this, there appeared to be no functioning mechanism to ensure an efficient and transparent flow of information between different agencies involved in land and resource

management in the lagoon – for example, the district agency responsible for marine affairs, fisheries and management of the Segara Anakan Lagoon, the district land office and the Cilacap office of the National Land Agency. The role of the national government was also unclear. This raises the risk of confusion and deadlock, as was shown, for example, through the lack of clarity about which agency was responsible for ultimately deciding for which areas of emergent land ownership certificates could be issued.

In order to address these challenges and avoid a repetition of past interventions which reflected a mismatch between planned interventions and the realities on the ground, coordination between state agencies at all levels, from the local to national and across sectors, needs to be strengthened.

Recommendation 6: Payments for Environmental Services should not be prioritized as a means of addressing issues of soil erosion in the watershed and of lagoon sedimentation and degradation.

Research conducted on three pilot PES schemes in Indonesia provided interesting input when considering the potential of watershed PES mechanisms as one way of addressing persistent problems in the Segara Anakan Lagoon region. The results lead to the conclusion that under current conditions, PES would likely have limited impact on soil erosion in the watershed and sedimentation of the lagoon.

Rather than introducing PES, governance efforts should be directed at resolving long-standing socio-political issues and conflicts in both the watershed and the lagoon (Recommendations 1-5). If these issues are allowed to persist, they will continue to undermine any efforts to improve environmental governance in the area.

Some of the issues have been addressed separately above. For example, tenure conflicts are a core challenge in both the watershed and the lagoon. In the lagoon, the mismatch between government policies and programs and the situation on the ground has been a major problem. Conflicts between different government agencies related to jurisdiction over emergent land in the lagoon, and a lack of information sharing are additional concerns. Also, until the historically rooted lack of trust between small scale resource users both in the lagoon and its watershed and state agencies is resolved, it will be difficult to address persistent governance challenges. Under these circumstances, an introduction of PES could exacerbate rather than contribute to resolving environmentally detrimental conflicts over resources.

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Appendix

List of publications prepared by the authors based on field research in the Segara Anakan Lagoon and its watershed during the research programme SPICE, Phases II and III:

- Heyde, J. (2017). Conditionality in practice: Experience from Indonesia. In S. Namirembe, B. Leimona, M. van Noordwijk, & P. A. Minang (Eds.), *Co-investment in ecosystem services: Global lessons from payment and incentive schemes*. World Agroforestry Centre. http://www.worldagroforestry.org/sites/default/files/Ch26%20Conditionality%20In%20Practice_ebookB-DONE.pdf
- Heyde, J. (2016). *Environmental governance and resource tenure in times of change: Experience from Indonesia*. Ph.D. thesis, University of Bremen, Bremen, Germany, <http://elib.suub.uni-bremen.de/edocs/00105588-1.pdf>
- Heyde, J., Lukas, M. C., & Flitner, M. (2012). *Payments for Environmental Services in Indonesia: A review of watershed-Related Schemes*. artec-Paper 186, Research Center for Sustainability Studies (artec), University of Bremen
- Lukas, M. C. (under review). *Tenure contestation: An important cause of land cover change*, Manuscript under review
- Lukas, M.C. (2018). *Narrow views: Struggles to protect a shrinking coastal lagoon in Java*. In: Hempel, G., Hempel, I., Hornidge, A.-K. (eds.): *Scientific partnership for a better future. Bremen's research along tropical coasts*. Falkenberg (in press)
- Lukas, M.C. (2017a) *Widening the scope: Linking coastal sedimentation with watershed dynamics in Java, Indonesia*. *Regional Environmental Change*, 17(3), 901–914. <https://doi.org/10.1007/s10113-016-1058-4>
- Lukas, M.C. (2017a). *Memperluas jangkauan: Menghubungkan sedimentasi pesisir dengan dinamika daerah aliran sungai di Jawa, Indonesia*, *Regional Environmental Change*, 17(3), Online Resource 1
- Lukas, M.C. (2017b). *Konservasi daerah aliran sungai di Pulau Jawa, Indonesia: Terjebak dalam dikotomi kepemilikan lahan*. artec-Paper 212, Research Center for Sustainability Studies (artec), University of Bremen
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- Lukas, M. C. (2015a). Reconstructing contested landscapes. Dynamics, drivers and political framings of land use and land cover change, watershed transformations and coastal sedimentation in Java, Indonesia. Ph.D. thesis, University of Bremen, Bremen, Germany. <http://elib.suub.uni-bremen.de/edocs/00106383-1.pdf>
- Lukas, M. C. (2015b). Watershed conservation in Java, Indonesia: Trapped in a tenure dichotomy, Manuscript contained in Lukas (2015a)
- Lukas, M. C. (2015c). Neglected treasures. Linking historical cartography with environmental changes in Java, Indonesia. *Cartographica*, 50(3), 141-162. <https://doi.org/10.3138/cart.50.3.2891>
- Lukas, M. C. (2014a). Cartographic reconstruction of historical environmental change. *Cartographic Perspectives* 78, 5-24. <http://dx.doi.org/10.14714/CP78.1218>
- Lukas, M. C. (2014b). Eroding battlefields: Land degradation in Java reconsidered. *Geoforum*, 56(0), 87–100. <https://doi.org/10.1016/j.geoforum.2014.06.010>
- Lukas, M. C. (2013). Political transformation and watershed governance in Java: Actors and interests. In R. Muradian & L.M. Rival (eds.), *Governing the provision of ecosystem services* (pp. 111-132). Dordrecht, New York: Springer
- Lukas, M. C., & Flitner, M. (under review). Fixing Scales. Scalar Politics of Environmental Management in Java, Indonesia, Manuscript under review
- Lukas, M. C., & Peluso, N. L. (under review). Negotiating Forest Control through Land Use Change: Transforming relations in Java's political forests, Manuscript under review.