World Agroforestry Centre

Reconciling multiple ecological knowledge systems in designing payments for watershed services in the uplands of Indonesia

Photo: Degi Harja

RUPES series

Watersheds are areas of land that contribute part of the rainfall they receive to a specific river system and which influence the quantity, quality and regularity of water flow that is important to downstream inhabitants and users. Land-use and land-use changes in the upper reaches of a watershed can influence the behaviour of the river and hence the downstream services provided by the watershed. Economic incentives to upstream land users, operating within their land-use rights, may help to align the interests of all stakeholders. However, a common knowledge and language of watershed services is a pre-requisite for effective negotiations. We analysed knowledge systems in watersheds in Indonesia as an example.

Key findings	Implications
• Current watershed policies and plans in the uplands of Indonesia are not aligned with scientific understanding of hydrology nor with local ecological knowledge.	• Stronger links with science are needed for realistic expectations of what can be achieved while better links to local knowledge are needed to gain legitimacy for actions undertaken in a watershed
• Appreciating differences and potential synergies between knowledge and the perceptions of key stakeholders (public/policy, local, science-based) can help clarify 1) how a watershed service is provided; 2) who is responsible for providing the various services; and 3) how the services are affected by current or possible future land uses.	• Incentive systems require legitimacy of science and a common platform for discussing the role of land uses and negotiating changes towards a desirable direction.
• Early and thorough analyses of the multiple knowledge systems involved in planning, designing and negotiating incentives for enhancing watershed services can help increase the quality and sustainability of emerging policies and payments for watershed services (PWS) schemes by providing credible and legitimate forecasts of how ecosystem services will respond to watershed management.	• The presence of trust among all stakeholders must be a basic condition for negotiations and compliance by all partners to agreements.
• The recognition, appreciation and use of multiple knowledge systems in the early stages of planning and designing a PWS scheme allows for effective communication strategies and helps intermediaries and project managers facilitate negotiations between ecosystem services' providers and beneficiaries in order to establish operational and sustainable payment systems.	• Appraisal methods need to explicitly focus on the multiple knowledge systems in the early stages of a negotiation process rather than on scientific knowledge only

Introduction

Schemes for economic incentives ('payments') for watershed services are emerging across Indonesia. In four of them, we applied a rapid hydrological appraisal method and can now reflect on the findings and lessons we have learned.

Two of the study areas—in Singkarak, West Sumatra province, and Sumberjaya, Lampung province—were 'action research' sites of the Rewards for, Use of, and Shared Investment in Pro-poor Environmental Services (RUPES Phase 2) project coordinated by the World Agroforestry Centre Southeast Asia in collaboration with local NGOs and governments. The other two sites—in Kapuas Hulu, West Kalimantan; and Talau, East Nusa Tenggara—were coordinated by the World Wildlife Fund Indonesia in collaboration with the consortium of Equitable Payment for Watershed Services of CARE International and the International Institute for Environment and Development.

The tension between economic demand and watershed conservation is a persistent problem in maintaining healthy watersheds because economic demand risks overstretching carrying capacity and degrading the land. This prompts a shift in land managers' values to incorporate conservation, which can occur through policy instruments such as public investment and market-based instruments. Public investment in environmental restoration is probably unavoidable but preventing degradation in the first place is important: 'prevention is better than cure'.

Following Costa Rica's change of its forest subsidy scheme to a 'payment for ecosystem services' (PES) model in the 1990s, scientists and environmentalists have been experimenting more with payments and markets for watershed services as a policy and institutional option to manage watersheds. However, path-dependency approaches regarding forest subsidy schemes show potential to improve ecosystem services. This involves support for collective action at the local community level and addressing the issue of fairness for all involved. Improvements begin with analyzing the different knowledge and perspectives of all stakeholders during the planning (and continue through implementation) of any payment scheme.

Further, negotiation is key to establishing a conservation agreement among stakeholders that can lead to an effective PWS scheme. Comprehensive and symmetric information among the providers, beneficiaries and intermediaries of PWS schemes is integral to guaranteeing a relatively conflict-free agreement and to avoid a tedious negotiation process. During negotiations, the flow of knowledge can be upward—from land managers as ecosystem services' providers and intermediaries to downstream stakeholders as beneficiaries—and also downward:

Better links between science and local knowledge are needed to gain legitimacy for actions undertaken in the watershed (photo: ICRAF Sumberjaya team)

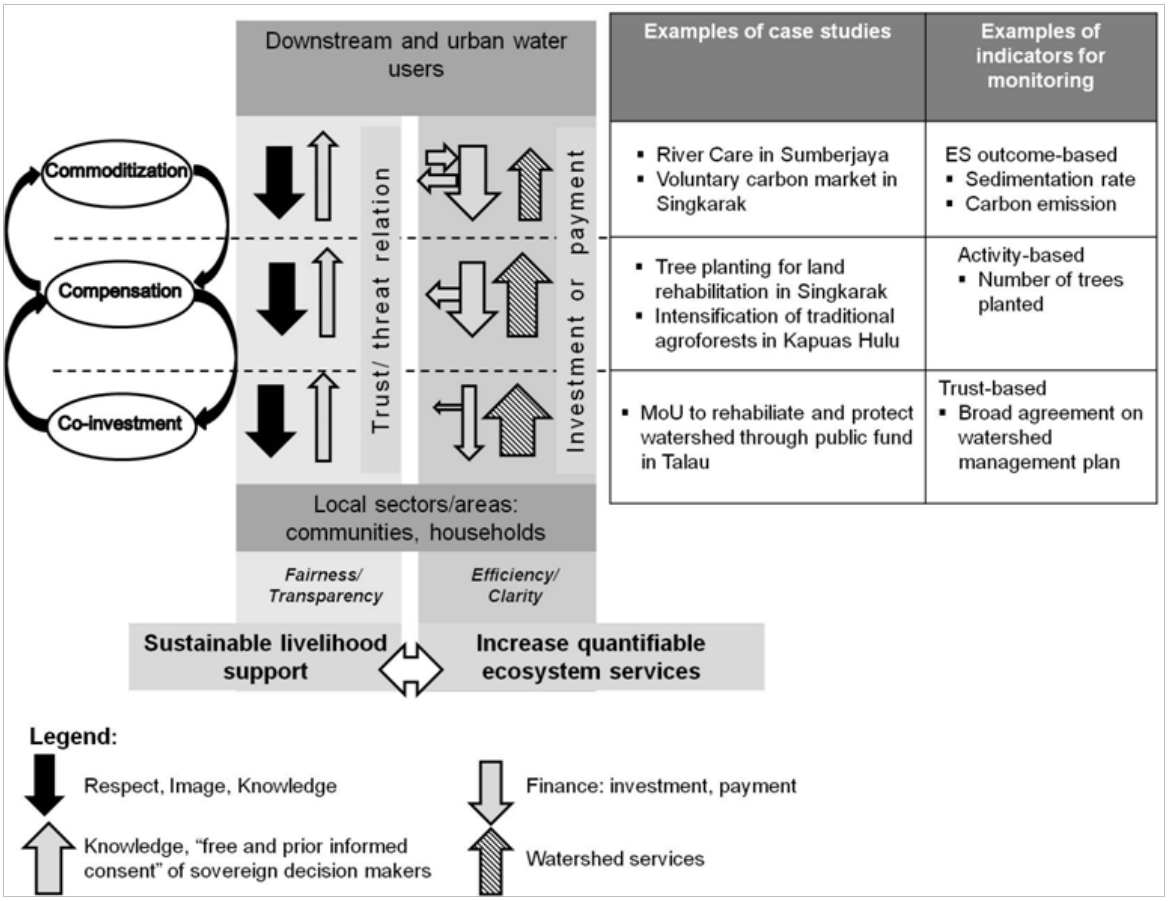
from downstream stakeholders to upstream communities. The interaction between them can potentially be enriching, with the understanding that knowledge is a non-consumable good not reduced in value by its use.

Van Noordwijk and others (2001) proposed the concept of a 'negotiation support system' (NSS) in integrated watershed management. An NSS works to 'optimize the way in which multiple objectives could be achieved and then make decisions for various actors and stakeholders'. Integrated natural resource tools used with the NSS concept were created to respond to the fact that any multi-stakeholder process will engage a large number of individual decisions coming from different perspectives and accessing different sources of knowledge and information.

A priority in creating effective PWS schemes is to understand what impact any upstream land-use changes and external drivers will have on downstream communities, both positively and negatively. External stakeholders, such as policy-makers and downstream users, utilise environmental policy tools that are decisive (for example, regulations), incentives (PES) and facilitating (moral persuasion) to modify upstream land-use practices to produce positive externalities.

At least four aspects must be considered to produce policy tools such as PWS schemes.

1). Shared perceptions of the way identifiable watershed functions are influenced by upland land use and affect downstream interests.



Examples of case studies	Examples of indicators for monitoring
▪ River Care in Sumberjaya ▪ Voluntary carbon market in Singkarak	ES outcome-based ▪ Sedimentation rate ▪ Carbon emission
▪ Tree planting for land rehabilitation in Singkarak ▪ Intensification of traditional agroforests in Kapuas Hulu	Activity-based ▪ Number of trees planted
▪ MoU to rehabiliate and protect watershed through public fund in Talau	Trust-based ▪ Broad agreement on watershed management plan

Conceptualisation of the cross-scale exchanges in the "fairness" and "efficiency" domains of watershed service payments.

2). The existence of trade-offs between the local utility of upland land-use decisions and the identifiable watershed functions.

3). The presence of community institutions that effectively facilitate collective land-use decisions and which can secure compliance with agreements.

4). The presence of trust among all stakeholders as a basic condition for negotiations and compliance by all partners to agreements.

Methodology

This study employed a combined qualitative and quantitative research methodology encompassing both primary and secondary analyses of empirical evidence from cases in Indonesia. The four case studies were based on hydrological assessment, gathering information and synthesizing three knowledge systems: local people's ecological knowledge; public policy-makers' ecological knowledge; and hydrological modellers' ecological knowledge.

The local people and public policy-maker knowledge acquisition method was modified from the knowledge-based system approach. It started with stakeholder analysis to identify the people involved in watershed management.

The next step was to articulate knowledge through capturing the perceptions of local people and policy-makers of hydrological functions, water movements and the consequences of land-use decisions on the landscape. Local people are the land managers who interact daily with the watershed. Policy-makers at the district and provincial government levels are people who have a mandate to control and manage watershed areas. We assume that the policies they create have a strong influence on the present and future conditions of a watershed.

Hydrological modellers' knowledge is composed of existing data available in the public domain. It refers to the generic characteristics of hydrological modelling, ensuring that the approach can be replicated across sites within different climatic zones.

Case studies

Singkarak, West Sumatra province

Singkarak Basin is a watershed that forms part of the Bukit Barisan mountain range, consisting primarily of volcanoes, with Lake Singkarak situated in the middle of the basin. A hydroelectric plant located in the downstream section of the watershed has diverted most of the lake's outflow from its natural outlet, the Ombilin River, to the Anai River that flows westward into the Indian Ocean near the city

of Padang. Dryland agriculture and fisheries provide the main income sources for the majority of people around Lake Singkarak. Ten percent of the people still practise swidden agriculture or shifting cultivation.

Local people's and public-policy makers' viewpoints

In Singkarak, communities in the Paninggahan area observed that overall water availability is sufficient but becomes slightly scarce in the dry season. They also observed that flooding around the lake—which inundates paddy fields—has increased since the construction of a dam by a hydroelectric power company at the water's exit point. People surrounding the lake also have water quality problems caused by domestic pollution that contributes to a decreasing catch driven largely by over-fishing.

The common pine tree (rather than broadleaf species) is perceived to have an effect on the total availability of water in the soil and water flowing downstream owing to the amount of evapotranspiration from its foliage. Local people claim that soils have 'dried up' after pines were planted in areas previously under natural forest. In recent years, pine has been used extensively in reforestation programs in the area. Government officials, however, mentioned the season, land cover, soil type and tree type as factors influencing water availability. The main concern is whether the upstream watershed can retain enough water to provide a stable flow during the dry season of around two to three months.

Hydrological modelling findings

Hydrological modelling revealed that the presumed positive relationship between reforestation and water availability for the hydroelectric plant did not exist. Climatic variation influences the performance of the hydroelectric plant more than land-use changes in the basin.

In addition, decreasing water quality is triggering eutrophication in the lake. Although this condition will not affect the overall debit of the lake, it will reduce the production efficiency of the plant. Therefore, maintaining water quality in the lake is important for all stakeholders.

Current PWS scheme

Priority action is to focus on the rivers and streams that currently carry the highest sediment, nutrient and organic pollutant loads, most noticeably the Sumani River, which drains the largest area of intensive horticulture and passes by a medium-sized town.

Starting in 2010, farmers have managed 49 hectares of degraded land under a voluntary carbon market agreement with a private company from the Netherlands. The scheme used participatory tree-selection with the farmers to rehabilitate their degraded land, taking into consideration their knowledge of tree species and their market potential. In the same year, 12 local leaders surrounding Lake Singkarak submitted a proposal to the Ministry of the Environment proposing various management techniques adjusted to the needs of each locale.

Sumberjaya, Lampung province

Sumberjaya watershed, the main contributor to the Way Besai River, is located around the Bukit Rigis mountains that cover West Lampung

A non-financial incentive can be considered as a reward in the PWS scheme. Here is a microhydro powerplant awarded by the electricity company to the local farmers for their effort to reduce sedimentation in Sumberjaya watershed (photo: Chandra Wijaya)

Appreciating differences and potential synergies between knowledge and the perceptions of key stakeholders helps to clarify watershed services and develop legitimate PWS schemes (photo: RUPES team)

district. Downstream of the Way Besai River, a hydroelectricity company produces about 480–2042 MWh of electricity daily that is distributed to three provinces in Sumatra. Multi-ethnicity characterizes the Sumberjaya communities, which consist of the Semendo ethnic group and Sundanese and Javanese migrants from neighbouring Java Island. The Semendo people mostly practise swidden agriculture while the migrants manage permanent, coffee-based plantations on the hill slopes and paddy fields along the riparian strips.

Local people's and public-policy makers' viewpoints

In Sumberjaya, farmers cultivated coffee on steeper, erosion-prone land and paddy fields along the riparian area that experienced flooding and riverbank abrasion. They converted primary and secondary forests to monocultural and multistrata, or agroforestry, coffee gardens. They applied a range of erosion-restraint measures in their coffee gardens, such as terraces, trenches, ridges and pits. They selected certain tree species, such as Gliricidia, and manipulated the plant components to improve soil management. Farmers were aware that an enthusiastic regime of soil cultivation on steep ground will risk soil loss if other conservation measures were not put in place.

In 1998, the local government and its forestry department found that uncontrolled deforestation and conversion to coffee led to a tremendous increase of erosion and reduced the discharge of the Way Besai River. This negatively affected the operations of the newly constructed Way Besai hydroelectricity dam and reduced the availability of water downstream for irrigated paddy rice. The enforcement of forest boundaries led to the eviction of thousands of farmers between 1991 and 1996. Evicted farmers were resettled on the infertile, acid lowland or converted swamp forest of northeastern Lampung. After Indonesia's political reformation in 1998, farmers needing work returned to the area, often with the silent approval of the local government, which was interested in economic development.

Hydrological modelling findings

A time series of daily rainfall and discharge (water flow) data showed that although average rainfall remained constant over the years, the average discharge had increased, with the likely cause being the conversion of forests to coffee gardens, which reduced evapotranspiration. A real decrease in the low flows in the Way Besai in the dry season occurred, however, the number of years with a prolonged dry season also decreased.

In Sumberjaya, we tested the rate of erosion under various land-use types (forest, bare soil, multistrata and monocultural coffee systems) in two plots between 2001 and 2005. The research revealed that soil properties had a greater influence on the rate of erosion than the intensity of tree cover. The first plot showed that the rate of erosion was between 4 tonne per hectare per year for forests and 30 tonne per hectare per year for bare soil. The second plot showed that the rate of erosion ranged between 0.1 (forest) and 4 tonne per hectare per year (bare soil) under the same treatment. The rate of erosion of coffee gardens was in-between the rates for bare soil and forests. The research showed that catchments with relatively high forest cover (more than 30% coverage) were also the ones with the highest sediment yield.

Current PWS scheme

In 2001, the Ministry of Forestry promulgated a community forestry decree. The decree provided guidelines for community forestry (Hutan Kemasyarakatan/HKm) contracts that required farmers to form organizations and follow management guidelines approved by local forestry officials. A HKm permit in a 'protection forest' area could be considered as a payment for watershed services since a condition for farmers joining the voluntary program was to plant a minimum 400 trees per hectare.

Kapuas Hulu, West Kalimantan province

Kapuas Hulu Basin in the northern part of West Kalimantan province is the source of most of Kalimantan's rivers flowing to Central Kalimantan province and Sarawak, Malaysia. In the upstream part of Kapuas Hulu lies the Betung Karihun National Park, a 'hotspot' biodiversity area and one of the last frontiers of natural habitat in Kalimantan. Forest is the dominant land cover in Kapuas Hulu, covering 90% of the total watershed. Farmers cultivated their horticultural lands more intensively in Sibau catchment, while in Kapuas the main livelihoods were gathering forest products and extensive local agroforestry practices.

Local people's and public-policy makers' viewpoints

In Kapuas Hulu, people in the upstream tended to have fewer permanent dwellings and farm using subsistence practices with less technology. They perceived that erosion and landslides caused by logging activities in the upstream areas and riparian zones led to high economic loss. In Sibau and Mendalam, people blamed the establishment of shortcuts across riverbanks to speed water transportation as a cause of sedimentation. The Endalam people were also concerned about the recent establishment of a forest concession company in the area.

The Dayak people in Kapuas Hulu used their own customary law to manage the forest. The law limited the provisioning service of the forest solely to domestic uses with permission granted by the adat (customary) leaders for activities such as timber and animal harvesting. Mendalam planned to establish an adat forum on watershed management.

The Public Water Service (PDAM) of Putusibau in the capital of Kapuas Hulu indicated that turbidity was problematic and had resulted in a decrease in the water quality for domestic uses.

Local people and policy-makers mentioned that the environmental problems in this area were forest degradation, river siltation, lack of fresh water and high levels of water pollution. River siltation leading to river shallowness could disturb river transportation as boats were the main vehicle in this area.

Hydrological modelling findings

Between 2001 and 2004, the forest area in the Kapuas Hulu basin decreased by about 130 km2 and the total area managed by farmers increased by around 42 km2. This change was insignificant in the context of the total basin area but it represented a substantial relative increase in agricultural land. Most of the land changes occurred along the river outside the national park.

Exploration into the effect of forest conversion on the landscape water balance revealed that reducing the forest cover in the area would increase the surface run-off and reduce the soil quick-flow. The landscape water balance analysis also showed that up until 2004, the run-off fraction in the Kapuas Hulu Basin was low, revealing the ability of the Kapuas Hulu basin to maintain its watershed function, particularly in relation to maintaining river flow. However, there were already signs of degradation at a smaller catchment scale.

Current PWS scheme

Current progress showed that the facilitators were focusing on rehabilitation along the riparian zone and the establishment of a local agroforestry system to reduce sedimentation in five villages in the Mendalam sub-watershed. The district government allocated about USD 20 000 annually to each village through its village budget program. The fund was available for allocation to both individual participants of the PWS program and to village revenue. The percentages of both allocations have not been decided yet.

Talau, East Nusa Tenggara province

The Talau watershed straddles the border between Indonesia and Timor Leste. Rivers from the Talau watershed drain to the Ombai Strait in Timor Leste. Springs are the main source of water for people in the area. The two important sub-catchments of Lahurus and Motabuik represent respectively 2% and 15% of the total watershed area. The Lahurus sub-catchment provides water to domestic users and the Public Water Service of Atambua (PDAM Atambua). The Motabuik sub-catchment is the uppermost in the catchment for which data on river flow are available. Grassland is the dominant land cover (66%) and forest constitutes only 1% of the area.

Local people's and public-policy makers' viewpoints

Local knowledge on the seasons and climate is tightly linked to knowledge of the planting calendar because of the long dry season (eight months) and the short rainy season (three-to-four months). The severe dry season influences the selection of plants grown by local people, who believe that the forest plays an important role as a groundwater provider, regulator and also as a source of livelihoods. Local people have a well-articulated understanding of the relationship between vegetation, soil and water availability. They say plants

that are suitable in the spring area are species that have deep roots that can hold water in the ground, such as betel nut, mahogany and candlenut. Local people said teak was not good to plant close to springs because it takes a lot of water but does not keep water in its roots or stem and instead releases water into the air. The local people have institutionalized the protection of water sources, access to water and water allocation. Sub-groups or clans treated springs as sacred groves, controlling and regulating their use and protecting the surrounding forest from livestock and loggers.

Hydrological modelling findings

From the limited information available, the overall pattern of the Talau river flow can be described in three phases: 1) the early part of the rainy season, when soil and landscape storage is recharged; 2) the second part of the rainy season, when a larger proportion of the rainfall is transmitted to the river; and 3) the dry season, when the river and spring flow depends on the gradual release of stored water underground. The buffering capacity of the Talau watershed is less in years with high rainfall and consequently high total water discharge.

Current PWS scheme

In 2007, an MoU was signed between the Belu district government and the community group of Lasiolat representing seven villages in the Lasiolat sub-district after facilitation of a PWS scheme by CARE and WWF. The MoU stated the general roles and responsibilities of both parties: the community would be actively involved in the watershed conservation program; while the local government would actively support, and jointly implement, the program. As a result, the local government allocated some funds through their forestry and plantation services for watershed conservation as part of its annual budget. In 2008, they allocated about USD 48 000 and projected a similar amount annually up to 2011.

Comparison between the sites

Multiple ecological knowledge and its implications for PWS

Most of the upstream communities in the study sites used water for domestic consumption and smallholding agriculture, such as paddy cultivation, fish ponds and tree plantations. They recognized the importance of their ecosystem services, such as forests and rivers. They saw that these services benefited their livelihoods, including cultural rituals. Therefore, their perceptions of the hydrological problems were mostly through processes that influenced their daily activities and income.

Communities perceived that they could suffer from watershed problems caused by the presence of external stakeholders, such as the construction of hydroelectricity plants that worsened flooding; the presence of a municipal water company reducing water supplies for local use; and the presence of a concession company carrying out extensive logging upstream.

Local community members sought location-specific solutions to their watershed problems. They were aware of, and applied, a variety of techniques to solve them. However, the solutions demonstrated some consistency between sites even though the sites were geographically

Incentive systems require legitimacy of science and a common platform for discussing the role of land uses and negotiating changes towards a desirable direction (photo: RUPES team)

The perspectives from multiple knowledge will provide clearer direction towards what actions must be done to overcome the problem in the watershed area (photo: RUPES team)

far apart. For example, people at all sites consistently mentioned mahogany as an example of a tree species that retained water but they had different opinions about teak.

The general public and policy stakeholders referred to generic solutions to ensure forest protection and rehabilitation. They believed reforestation was an important action to respond to floods, soil erosion and riverbank abrasion. However, mass reforestation by planting pines to solve watershed problems could cause other problems, such as reducing water resources owing to the high evapotranspiration rate of the pines.

Way forward

The case studies showed that understanding the multiple knowledge systems was a prerequisite to increase the quality and sustainability of PWS programs. The review found that the factors influencing the design and implementation of PWS programs varied and went beyond the availability of multi-perception ecological knowledge and scientific data.

Potential ecosystem services' buyers or consumers may have intrinsic motivations based on common myths, such as that planting trees in the upper watershed can increase the volume of the stored water in a lake downstream or, even more extreme, many believed indisputably that planting trees could solve all environmental problems.

Revelation of the scientific fact that planting trees, conversely, can actually reduce the base flow owing to an increase in evapotranspiration, as shown in the Singkarak case study, may reduce investors' motivation to participate in any PWS scheme if the buyers' interest is water quantity.

Moreover, an incomplete understanding of forest versus watershed problems can produce undesired result, namely, a misconception that reforestation is not important.

Intermediaries as benevolent environmental agencies might deter the disclosure of these 'contradictory' facts and would carefully consider the strategic use of scientific-based information and avoid creating reduced moral motivation in buyers engaging in the scheme.

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For further information please contact::
Beria Leimona (l.beria@cgiar.org)

World Agroforestry Centre
ICRAF Southeast Asia Regional Program
Jl. CIFOR, Situ Gede, Sindang Barang, Bogor 16115
PO Box 161, Bogor 16001, Indonesia
Tel: +62 251 8625415; Fax: +62 251 8625416
www.worldagroforestry.org/regions/southeast_asia
blog.worldagroforestry.org

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