Rapid Hydrological Appraisal in the Context of Environmental Service Rewards

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RHA Guidelines in the Context of Environmental Service Rewards

Acknowledgement:
This publication is produced under collaboration of RUPES Program and SII Netherlands.

The Program for Developing Mechanisms for Rewarding the Upland Poor in Asia for the Environmental Services They Provide (RUPES) is supported by the International Fund for Agricultural Development (IFAD).

SII Netherlands is the Programme of the Netherlands' Ministry of Foreign Affairs

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ISBN: 979-3198-29-X

March 2006

Photo Cover by: Kevin Jeanes
Design, Lay-out and Illustration by: Nungki NW (Opie)

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EXECUTIVE SUMMARY

Agriculture usually implies impacts on the broad complex of 'watershed functions', if we take a natural forest without any human presence as point of reference. Forest protection as part of watershed management is often (still) considered to provide downstream economic benefits that may well exceed the local benefits of agricultural use—but traditional land use rights of people in the upland mean that forms of rewards or compensation are needed to ensure that land use decisions in the uplands align with what may be optimal resource use at a larger scale of consideration. Especially where hydro-electricity schemes derive substantial economic benefits from the continued flow of water, the concept of payments for watershed protection services has become popular.

However, there is no shared opinion among scientists, farmers and policy makers about what these services really are, how they depend on the condition of the landscape (and the amount of forest that is part of it) and how payments or rewards can be made transparent (linking reward to delivery) and robust (surviving paradigm shifts). To judge how far apart the potential partners in a rewards mechanism are and what it would take to bridge the 'perception' and 'communication' gaps in the way the local 'forest and water' debate has developed, a form of 'rapid appraisal' is needed.

The experience of the 'Rewarding Upland Poor for the Environmental Services they provide' (RUPES) consortium has shown that the overall likelihood of achieving negotiated reward mechanisms depends on four aspects:

Value-shared perceptions of the way identifiable watershed functions are influenced by upland land use, and affect downstream interests;

Threat-the existence of trade-offs between the local utility of upland land use decisions and these identifiable watershed functions;

Opportunity-the presence of community scale institutions that effectively constrain individual land use decisions and that can secure compliance with agreements;

Trust-between local communities, governments and outside actors as a basic condition for negotiations and compliance by all partners to agreements.

The guidelines presented here allow for a 'rapid appraisal' (over a 6-month period) of the hydrological situation and the perceptions of key stakeholders (value, threat and opportunity) to enable an appraisal of the opportunities for negotiating land use agreements that include rewards for the protection or rehabilitation of watershed functions in the uplands.

The appraisal (with a focus on cost-effectiveness and a target budget below USD 10 000 when implemented in a country like Indonesia) is based on six components:

- Search of the literature and web-based resources on the area and initial 'scoping' meeting with key stakeholders;
- Spatial analysis of the landscape based on remotely-sensed imagery and available maps and digital data;
- Exploration of local ecological knowledge of the landscape, water movement and consequences of land-use options;
- Discussions with a wide range of stakeholders and policy makers on issues of land use and hydrological functions;
- Modelling of the water balance and water use in the landscape to explore scenarios of plausible land-cover change and their likely impacts on key performance indicators;
- Communication of results and appraisal of the opportunities for negotiated agreements.

Examples from a Rapid Hydrological Appraisal (RHA) in the Lake Singkarak area ,West Sumatra, Indonesia, illustrate the steps.

1. Background

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1. BACKGROUND

1.1. The end product of a Rapid Hydrological Appraisal

It may be best to start at the end (figure 1). At the end of a Rapid Hydrological Appraisal (RHA), an 'honest broker' or intermediary will have to advise the local and external stakeholders of a landscape with agricultural use as well as concerns over watershed functions, whether it is worth pursuing 'negotiations' on environmental-service rewards. If the answer is 'no', both sides can avoid disappointment by focussing on other activities or sites. If the answer is 'yes', further studies will be needed. If the broker isn't 'honest', all parties (including the 'broker') may lose by wasting time and effort.

Figure 1: The main conclusion of a Rapid Hydrological Appraisal is an advice to pursue more formal negotiations of environmental-service reward (ESR) mechanisms, or look for alternative arrangements as the chances of success are likely to be low.

1.2. Translating value into action

Rapid Rural Appraisal, Participatory Rural Appraisal, Diagnose and Design—there is a whole suite of methods to assess the relation between livelihood strategies of local communities and the landscape in which they live. Do we need a new name for a slightly different approach?

The relation between land use and the flows of water to downstream areas is important, because human demand on water for agricultural production, industries and domestic use are increasing globally, while supply is stable at best. Fears that the quality, quantity and regularity of flow of water from uplands is affected by 'deforestation' are at the base of much regulation of land use, restricting opportunities of upland people to make a living the way they want and see fit. Concerns over loss of tropical forest are based on the loss of 'intrinsic value' of forests, but also for the loss of environmental-service functions.

However, many countries cannot afford the luxury of having uplands without farmers, but neither can they afford lowlands without a clean and reliable water supply—so the trade-off between local livelihoods and external flows of water is an important one. Many upland communities live within the forest margin, or on previously forested landscapes. The land use mosaics they have created include forest areas, grassland areas, agriculture and agroforestry, and may still provide important environmental-service functions. Communities gain income or subsistence (direct benefits) from what they harvest, grow or extract from these upland landscapes. Yet, there is no income for maintaining the landscape in order to produce environmental-service functions for off-site and downstream beneficiaries. Maintaining or enhancing these functions thus remains an 'externality' to their decision making.

As purely regulatory approaches have not worked, there is a global interest in systems that combine regulation with positive incentives ('sticks and carrots'). In that context, however, we find that there are often substantial differences in perceptions among stakeholders as to what is at stake. On one hand downstream stakeholders may perceive that only 'full forest cover' can guarantee that their interests are secured and that any type of deforestation is a threat, on the other hand upland land users find that more open land cover types (agroforestry or even open-field agriculture or pasture lands) suit their livelihoods and can be made compatible with their local needs for watershed functions. To scope these perceptions and their degree of overlap and similarity, we started using the 'rapid hydrological appraisal' tool that we present here. It builds on the concepts and tools of participatory rural appraisal, but delves deeper into the perceptions of various stakeholders on:

- the severity of 'watershed problems' in relation to land use;
- the positive contributions made by specific land use practices that help reduce the problems;
- the potential basis for forms of 'environmental-service rewards' that provide incentives for supporting 'protective' activities as alternatives to more 'degrading' ones.

RHA takes the participatory appraisal process a step further via the use of computer-based landscape-hydrological simulation models:

- to compare the overlap between stakeholder perceptions of current and past patterns, processes and impacts of land and water use, and biophysical reality as assessed via independent analysis of the site landscape, hydrology and environmental characteristics;
- project forward the hydrologic and environmental implications of current trends or future changes in land- and water-use patterns by modelled 'scenarios'.

The overall 'objectives' are 'for all stakeholders' to better:

1. understand local land use patterns, the benefits they provide to actors in the landscape, the alternative land use options that exist and the current drivers of change;
2. understand the impacts of local land use change on environmental services, and thus on potential 'buyers' that are willing to provide incentives to maintain or enhance specific services;
3. evaluate whether or not it makes sense to invest further in a negotiation process that can lead to a reward mechanism that will deliver on stakeholder expectations.

1.3. Rewards for environmental services

Mechanisms that link lowland beneficiaries to upland land use decisions through appropriate reward mechanisms may provide a cost-effective way to enhance sustainable development. The RUPES ('Rewarding Upland Poor for the Environmental Services they provide') consortiumin which the World Agroforestry Centre (ICRAF), International Fund for Agricultural Development (IFAD), IUCN, Centre for International Forestry Research (CIFOR), International Institute for Environment and Development (IIED), Conservation International, the Ford Foundation, WWF and other international partners work together with national partners in (currently) Indonesia, the Philippines, Vietnam, China, Thailand, India and Nepal is supporting a network of 'action-research sites' and 'national policy review' activities to facilitate such mechanisms. Specific attention is given to 'pro-poor' forms of environmental-service reward (ESR) mechanisms. Benefits to poor people can come both through the way rewards are channelled and through the positive environmental impacts of the decisions they support.

The RUPES project has been developed in the expectation that mechanisms that link lowland beneficiaries to upland land use decisions, through appropriate reward mechanisms, may be a key 'action' required to address rural poverty in the uplands and provide a cost-effective way to enhance sustainable upland development, and to conserve the 'value' upland watersheds have for areas downstream (downstream usually refers to water flows, but is also used in the context of flows of greenhouse gasses influencing climate and flows of organisms affecting global biodiversity). The overall environmental value of upland areas for external stakeholders can be analysed in terms of biodiversity, landscape beauty, carbon stocks (and related greenhouse-gas emissions) or water flows. These four categories of services all derive from the make-up of the landscape (land-cover types and spatial organization) and they relate to broader human functions of provisioning of food and fibre, health, spiritual values and buffering against extreme events (figure 2). The main concept is to 'close the feedback loop' and ensure that the consequences for 'downstream' communities of the land use mosaics that evolve in the uplands are reflected in the rules and rewards that the upland communities receive and perceive. The scale at which these four types of environmental services are perceived varies (table 1).

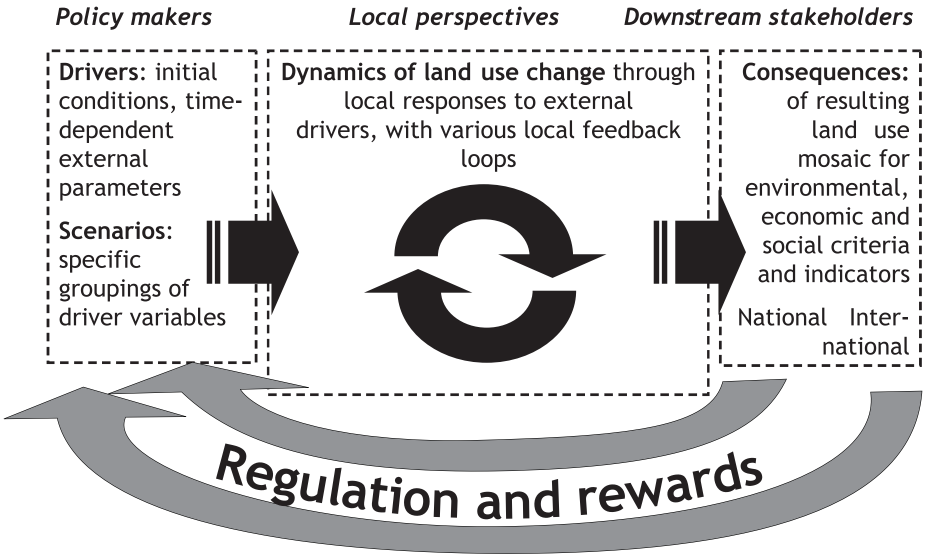


Figure 2: Drivers of land use change in the uplands, downstream consequences and the feedback loop via regulation and rewards that influence the real drivers of change.

Table 1: Generic rating of the scale of influence and concern among four categories of environmental services

Scale	Carbon stocks (global warming)	Biodiversity	Landscape beauty (ecotourism)	Water flows
Local rural community	0	++	++	+++
Provincial / district public & policy makers	+	+	++	+++
National public & policy makers	+	+	+	+++
Global public & policy makers	+++	+++	0	++

+++ very important; ++ important; + some significance; 0 not a direct concern.

Initial analysis suggests that carbon stocks and biodiversity are primarily global concerns, while concerns about water flows dominate at local to national scales.

The experience of RUPES (van Noordwijk et al. 2004b, van Noordwijk 2005) suggests that the overall likelihood of negotiated reward mechanisms depends on four aspects:

Value : shared perceptions of the way identifiable watershed functions are influenced by upland land use and affect downstream interests;
Threat : the existence of trade-offs between the local utility of upland land-use decisions and these identifiable watershed functions;
Opportunity : the presence of community scale institutions that effectively constrain individual land-use decisions and that can secure compliance with agreements;
Trust : between local communities, governments and outside actors as a basic condition for negotiations and compliance by all partners to agreements.

In the context of reward mechanisms for forest-derived environmental-service functions, 'watershed functions' in a broad sense are likely to be the most urgent, direct and marketable aspect of upland land use. Biodiversity protection may be eligible for higher rewards per person in specific areas and increasing terrestrial carbon stocks may have captured the imagination of many policy makers, but watershed functions are prominent in the public perception (van Noordwijk 2005). For any of these 'environmental services', the local, district and provincial levels are probably the most critical to project implementation success, as they are the level of operation where national and international plans and implementation concepts often tend to fall apart. It thus seems preferable to start with issues that are high on the agenda at this critical implementation level, and consider how other 'values' of land use can be 'bundled' in terms of overall rewards and incentives. The tentative conclusion is that watershed functions are the most urgent, direct and 'rewardable' aspect of upland land use that can form a basis for RUPES mechanisms. Poverty reduction mechanisms vary from reduction of blame to financial payments:

- Stop negative 'drivers' that enhance poverty and degrade environmental services (STOP 'PUPES')
- Enhance local environmental services and resources (e.g. regular supply of clean water, access to beneficial plant and animal resources)
- Enhanced security of tenure, reduced fear of eviction or 'take-over' by outsiders, allowing investment in land resources; increased asset value
- Enhanced trust with (local) government, increased 'say' in development decisions
- Increased access to public services (health, education, accessibility, security)
- Payment for labour at least equal to opportunity cost of labour
- Increased access to investment funds (micro credit or otherwise) for potentially profitable activities
- Entrepreneurism in 'selling' 'commoditized' environmental services.

In the public debate on watershed functions, all of these 'reward mechanisms' are likely to play a role.

1.4. Watershed services

The generic term 'watershed functions' means different things to different stakeholders and in different situations. General perceptions of these functions, although they may only have a weak relation with the biophysical reality, are the basis of policies and thus become the socioeconomic reality of the uplands, with conflict, evictions and resulting poverty as outcomes (figure 3).

After a century of attention to 'watershed management' there is still a remarkable lack of clear criteria and indicators of the hydrological functions that society expects to be met from water-catchment areas. Hydrological functions of watersheds, given the rainfall that the area receives and its underlying geology and land form, include the capacity to:

1. transmit water
2. buffer peak rain events
3. release water gradually
4. maintain water quality
5. reduce mass wasting (such as landslides).

The relation between full ('forest') and partial ('agroforestry') tree cover and hydrological functions in this sense involves changes at different time scales, and trade-offs between total water yield and the degree of buffering of peak river flows relative to peak rainfall events.

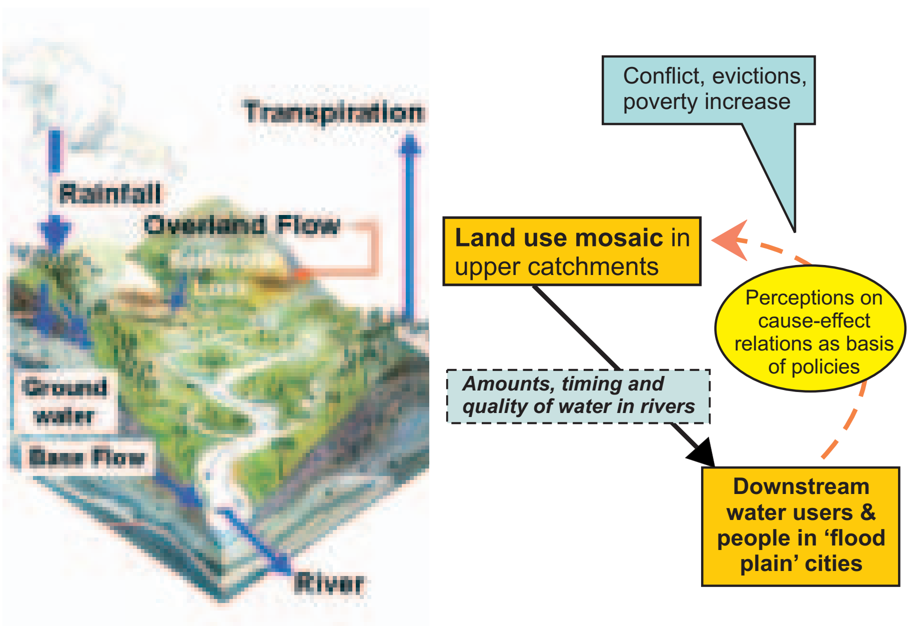
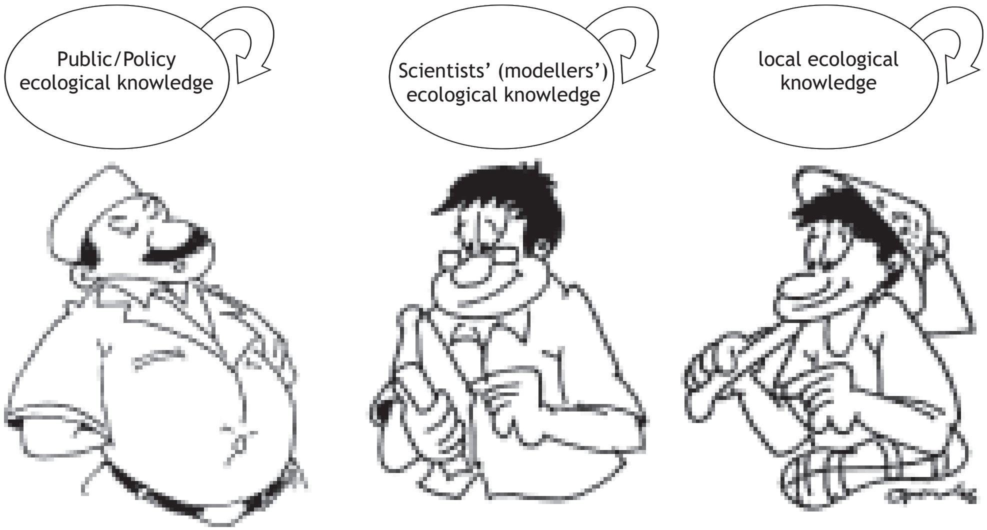


Figure 3:
Biophysical (ecological) perspectives on the flow of water through landscapes (left) are translated into human relations between downstream and upstream people — with perceptions that may have only a weak relation with the biophysical reality and policies based on these perceptions.

More realistic expectations of quantitative indicators for historical baseline, current situation and plausible future scenarios may help the negotiations (especially the differences between current situation and a range of plausible scenarios for change). The appreciation of the various quantitative indicators probably differs by stakeholder group and needs to be understood from the perspective of 'local-upland', 'local-lowland', 'public-policy' and 'ecology-hydrology' to facilitate the negotiation process.

The RHA approach has been further developed to address the hypothesis that communication may be constrained by gaps between three types of knowledge on watershed function (shown in figure 4). In discussions between upland and lowland land users, public policy, and science, the three types of 'knowledge' (local, public and scientific) are interacting, often expressed in languages that have little in common and using concepts that may be considered 'myths' by other stakeholder groups.



Where negotiations between multiple stakeholders are an essential part of any river-basin or catchment management programme or RUPES mechanism, clarity is needed on what environmental-service function is the focus, how it is provided, who can be (or claim to be) responsible for providing this service, how it is being impacted upon at present, and how rewards can be channelled effectively to enhance or at least maintain the function, address any negative impacts or enhance any positive impacts.

If scientists (hydrologists, modellers, environmental-impact assessors), local communities, the public and policy makers are to work together effectively to discuss water-resources issues, and jointly develop ESR schemes to address these issues, attempts must be made to close the gaps between the three groups' perceptions and achieve the situation shown in figure 5.

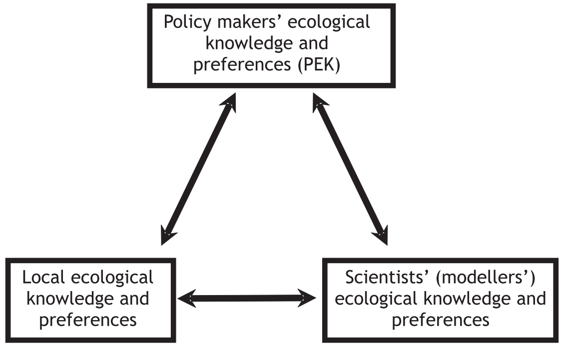


Figure 5: Desirable situation where the three knowledge domains are connected and interact.

Programmes or projects do not work without smooth communication, especially when multiple groups and layers of stakeholders are involved. Communication requires information so that all can work towards at least a common understanding of the alternative views, and (at best) consensus, regarding the issues for focus of follow-up work. The philosophy is that RHA should be the tool to supply the information that facilitates this smooth communication and the building of agreements to pave the way for follow-up ESR development.

1.5. RHA as an instrument for the 'scoping' stage of reward negotiations

From an initial idea that 'environmental-service rewards' (ESR) might be appropriate for a certain location to full implementation of an ESR mechanism, a number of steps are needed (figure 6). The RHA process has been developed for 'intermediaries' to facilitate communication between potential ESR buyers and sellers and assess whether further negotiations have a chance of success.

Figure 6:
Seven steps in the development of an environmental-service reward (ESR) mechanism and the role of RHA in the initial stages.

7 stages in development of RUPES reward mechanism

	Stage	Providers, sellers of ES	Intermediaries	Beneficiaries, buyers of ES
I	Scoping		R H A	
II	Awareness		R H A	
III	Identifying partners		R H A	
IV	Negotiations			
V	Action Plans			
VI	ES Reward support for action			
VII	Monitoring			

1.6. Need for a new approach

Need for something quick and cheap
The traditional 'solid science' approach to studying catchment function and environmental services is costly in terms of time input, trained 'expert' input and subsequent expense. A typical 'paired catchment' experiment will take at least 2 years for a calibration phase and 3 (or better 10) years for the response to treatment effects to be recorded across relatively dry, relatively wet and average conditions. The results cannot be directly extrapolated to other locations, as details of soil, vegetation and rainfall patterns will differ. The scientific knowledge so derived is thus of little practical value for local stakeholders in a different set of circumstances (even if those differences are small).

There is thus a need to develop an approach which is both quicker and cheap enough so that local or provincial government bodies could implement it independent of outside aid (i.e. so they can set up their own ESR schemes). The RHA approach has been developed to meet this need:

- to assist at the initial 'scoping stage' of the development of an ESR programme;
- to reduce implementation time (target of less than 6 months) so as to keep implementation costs low and give rapid feedback to initiate other follow-up ESR development activities;
- to make it affordable (target of USD 5000 - 10000), to reduce labour and input costs, and to reduce the 'transaction cost' for any rewards agreement.*

Need to integrate across disciplines
Efforts are underway around the globe to conduct 'action research' to find a way to more effectively and smoothly integrate the different disciplines of participatory social survey, ecological modelling (hydrological-climatological-landscape modelling) and landscape spatial analysis (combined landscape ecology and land use change analysis).

RHA is part of this integrationist movement aiming to achieve this cross-disciplinary integration task, combine the inputs into the one 'negotiation support system (NSS)', and do so cheaply and quickly.

Need for clarity concerning criteria and indicators of hydrological function
Improved stakeholder understanding of quantitative indicators of watershed function and their use to determine the (historical) baselines may help the negotiations, especially if they allow the current situation to be compared with plausible future scenarios of the catchment condition. The appreciation of the various quantitative indicators probably differs by stakeholder group, and these differences in understanding need to be explored and understood within the RHA approach to facilitate the negotiation process.

Need to address the complexity of landscape and water-resource interactions
Efforts are also underway around the globe to conduct 'research' to determine precisely which factors are driving the changes in catchment function, and to what relative extent. The RHA approach aims to expand this body of knowledge in relation to tropical catchments, most especially within warm humid Asia:

*This cost target was chosen to be affordable where the potential value of environmental services to downstream beneficiaries is of the order of at least $50 000 per year if so, a one-off investment of $5000 is not unreasonable to get a proper foundation for an ESR.

- to clarify 'what' water-related service, to 'whom', is caused by 'which combination' of: 'natural capital' (rainfall, geology, landform and natural vegetation) and 'social or human capital' (jointly responsible for modifying land cover and land-use practices);

- to assist in the development of specific criteria and indicators for the (rapid) assessment of hydrological function of tropical catchment areas and land-use mosaics, that can be used to evaluate options for sustainable management of such areas.

In addition, there is a complex of cascading and cumulative environmental influences upon water quantity and quality, which needs to be addressed as the analytical focus of any ESR scheme scales up and moves down the river basin. It is hoped that the RHA approach will increase the effectiveness of water-related ESR schemes in addressing this complexity by adopting a 'spatial framework' for scoping river-basin-related environmental impacts (figure 7).

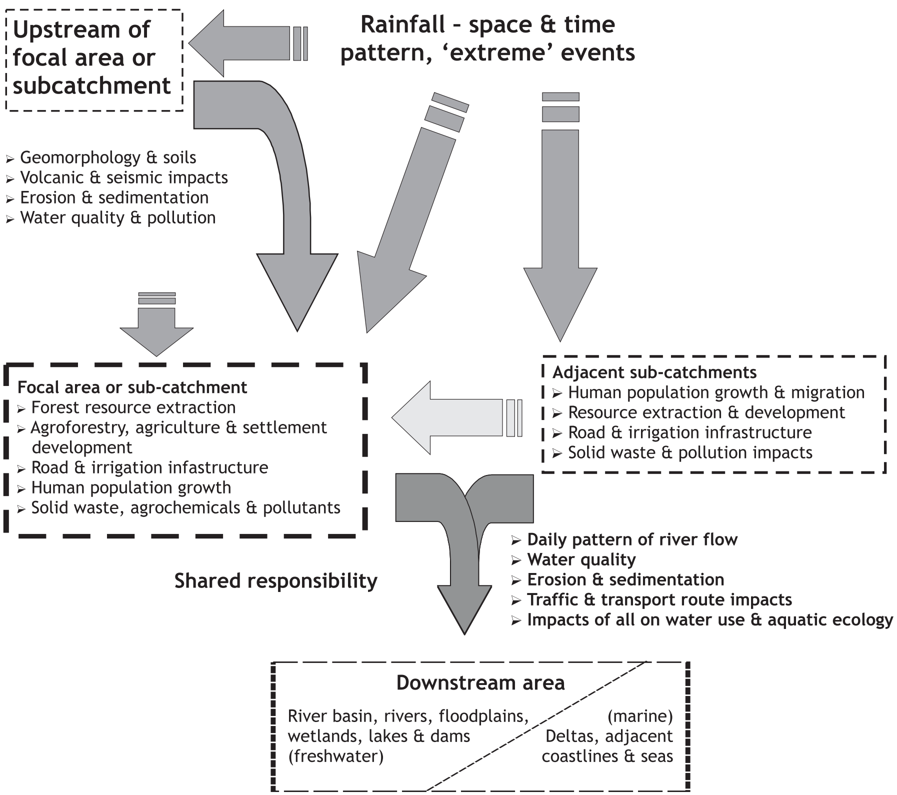


Figure 7:
The sub-catchments that are the focus of an RHA will generally be part of a wider river basin with areas upstream, adjacent sub-catchments and a shared responsibility of areas downstream usually with ultimate effects on coastal and marine systems.

The RHA analysis of environmental impacts, environmental values and ultimately ESR, when dealing with water resources, cannot realistically focus on the sub-catchment study site alone and in isolation. It must also consider upstream and adjacent area activities and influences upon the sub-catchment study site. It must also consider the cumulative influence of upstream, adjacent and study site landscape and water-resource related activities on the downstream environment.

Similarly, regarding communication on water-resource and environmental issues, the complexity of cascading and cumulative interaction often leads to stakeholders having differing perceptions regarding problem issues and causes, depending on their location within the river basin, or their ability to perceive and understand the cascading interactions within the basin. The RHA 'scoping environmental spatial framework' hopes to assist communication, by providing a framework to separate the different hydrology or water-quality impacts, and different causes of impacts, in relation to spatial location within the basin.

The current RHA approach was derived from a more comprehensive 10-step 'catchment analysis and management framework' (figure 8) developed by ICRAF-SEA as a 'negotiation support system' (NSS) (van Noordwijk et al. 2001, 2004a). 'The highlighted 'Domains' only in column 3, figure 8, are currently covered by RHA process.'

Step	Main questions	Domains
1	'Characterization' (rainfall, population density, migration status, main agricultural enterprises, etc.); and 'diagnosis' of main issues and problems related to watershed functions and livelihoods (including sources of drinking water)	L, S
2	'Landscape appraisal', slopes, land use and vegetation zones, toposequences of soil from ridge to river (lake)	L, W
3	Understanding the 'flows of water' and consequences for lateral flows of soil, nutrients, pollutants. 'Entrainment' of soil particles into the overland flow of water, potentially followed by filtering effects that separate water from soil particles	W, L
4	Characteristics of 'land-use systems' (cash and labour input requirements, yield, profitability) and impacts on water flows (evapotranspiration, impacts on soil compaction, surface cover)	A, W, S
5	Characterization of landscape mosaic on 'segregate-integrate' spectrum, and consequences for the way productive and environmental functions are being met	A, L, S

Step	Main questions	Domains
6	Understand 'trade-offs' between relative agronomic function (RAF) and relative environmental function (REF)— builds on step 4	A, W
7	The 'landscape mosaic' (building on step 5) in the context of lateral flows and 'externalities' for on-farm decision making; 'existing regulation and incentives' ('carrots and sticks') at community and government level; is the existing landscape mosaic a stable configuration meeting all needs?	S, L
8	Analysing the existing patterns and land use practices from a multistakeholder (including 'gender and equity') perspective	S, N
9	Understanding the existing problems and conflicts at the level of 'local, policy and scientific knowledge': is there a shared perspective (but possibly different appreciation of the various outcomes) or is there a need for 'levelling off' as first step in 'negotiations'	N, S
10	Follow up to 'negotiated agreements', monitoring compliance and impact on environmental services and people's livelihoods	N, S, W, A, L

Domains: L Landscape, S Socioeconomic relations (household level), W Watershed functions, A Improved land use / agroforestry technology, N Negotiation support systems.

Figure 8: Ten steps in a Negotiation Support System (NSS) process to assist stakeholders to improve land use mosaics from the perspective of critical watershed functions and healthy (profitable, sustainable) land use practices.

Need to test the limits of reliable science

Lastly, behind the development of the RHA approach is the experimental desire to run new action research on the ground to see if the 'cheap and rapid' concept actually works. The 10-step approach to an NSS (figure 8) was the inspiration for the 'simplified' RHA. Does this simplification still maintain the rigour required for a responsible, cost-effective appraisal process? Three key questions are:

- Does RHA deliver an answer with adequate precision for the purpose at hand?
- Can RHA be scaled-up to realistically deal with the river-basin scale of management?
- How far can we 'push' it (i.e. reduce the cost, reduce the time input and reduce the labour input) before it 'falls apart' (i.e. becomes no longer reliable or useful)?

1.7. Spatial scale and context in river-basin management

The first step in the RHA approach is to define the working area; primarily in terms of river-basin and sub-catchment boundaries, but also in terms of the government administrative boundaries that overlay these physical features. The primary determinant for the 'scale' of the assessment of an RHA is the administrative entity that may form the basis for 'environmental service rewards'. However, this may require adjustment of the boundaries of the appraisal to hydrological realities.

While a hydrologically correct 'sub-catchment' should include all the 'headwaters', the administrative entities that are the basis for a RHA might not. In figure 7 we assume that there may be 'headwaters' upstream of the area that is the focus for an RHA. Usually, the unit of assessment is only part of a larger 'basin' and shares the 'downstream' area with other sub-catchments (figure 7).

An RHA may become part of a broader 'environmental management strategy' for the water resources of the total river basin (figure 9), as it may help define the 'environmental baseline' and 'environmental assessment' which are also the first steps of a standard river-basin 'environmental management plan' (EMP). The RHA also overlaps directly with the 'institutional strengthening' and 'monitoring' sub-components of the standard river-basin EMP approach (figure 9).

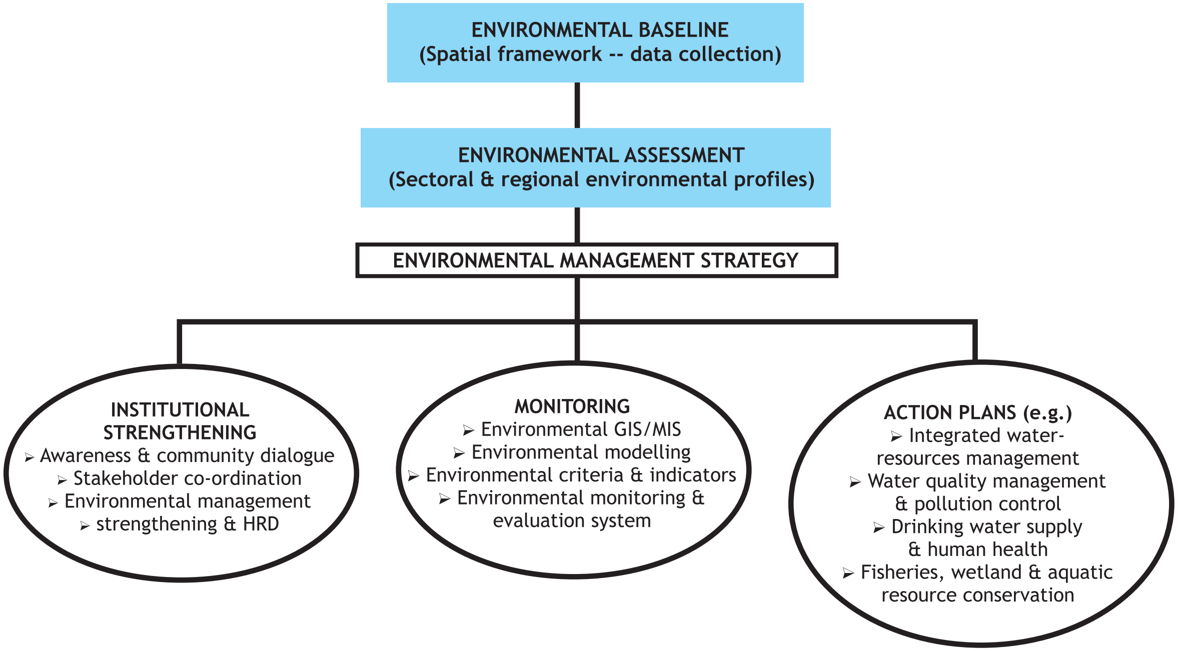


Figure 9: RHA within the context of a river-basin environmental management framework.

2. Rapid Hydrological Appraisal approach-in brief

2.1. Five phases of an RHA
2.2. Staying within budget and time frame

2. RAPID HYDROLOGICAL APPRAISAL APPROACH - IN BRIEF

2.1. Five phases of an RHA

A Rapid Hydrological Appraisal over a 6-months period consists of five recognizable:

I. 'Inception' and reconnaissance of stakeholders and 'issues' (month 1)

II. 'Baseline data collection- desktop survey' of (grey) literature and reports (months 2-4)

III. 'Baseline data collection fieldwork': ground truthing for spatial analysis, participatory landscape analysis, local ecological knowledge (LEK) and public and policy makers' environmental knowledge (PEK) surveys (months 3-4)

IV. 'Data processing' (modeller's ecological knowledge, MEK) and Scenario analysis (months 3-5)

V. 'Communication' and refinement of the findings (month 6).

An example of the timing of the phases of the RHA, taken from the RUPES Singkarak Lake Basin project, is shown in Box 1.

Box 1: Time allocation in the first RHA carried out for the RUPES project in the Singkarak Lake Basin, West Sumatra, Indonesia (see Box 2 for the summary of results obtained in this time frame)

- First month to scope the issues, stakeholders and site, in the office, with a reconnaissance field trip and stakeholder meetings (phase I);
- Second month to initiate within-office desktop and national-level data collection (carried through into months 3 and 4 by the remaining team members who do not go to the field to chase those 'hard to get' pieces of essential data) (phase II);
- Second month to tailor-design the RHA approach, field surveys and overall work plan to suit the phase I and II data outputs regarding study site, landscape, issues and perceived likelihood of data availability (phase IIIa);
- Third month to implement field-level detailed data collection and surveys (phase IIIb);
- Third month to initiate backup data-processing (by team which does not go into the field), which is continued in full force from months 4 to 6 when the field team returns (phase IV);
- Sixth month to wrap up the analysis, reporting and data presentation and get back to the stakeholders to present the 'first cut' results (phase V).

To show the reality of how the technical steps fit within the implementation phases, the full details of scheduling and time input of the technical sub-tasks in each phase, as designed and implemented for the RUPES Singkarak Lake Basin project (Box 2), are shown in figure 10.

Box 2: Executive summary of the first RHA carried out for the RUPES project in the Singkarak Lake Basin, West Sumatra, Indonesia

A 'rapid appraisal' was conducted, during a 6-month period, of the hydrological situation in the Singkarak Lake Basin in West Sumatra (Indonesia) in the context of the development of payments for environmental services that are aimed at rewarding the upland poor for protection and/or rehabilitation of watershed functions.

The main 'issue' that became the focus of the study is the relationship between the hydroelectricity project (HEPP, PLTA Singkarak), the fluctuations in the level of the lake, the water quality in the lake and the land cover of the catchment areas that contribute water to the lake. Payments made by the PLTA to the local government can, in part, be seen as rewards for maintaining or improving environmental services. The 'nagari' of Paninggahan (which coincides with one of the lakeside sub-catchments) has become an action-research site for the RUPES project to test the modalities of ESR schemes. In discussions, it became evident that there was no full and shared understanding of the relationships between land cover and the 'environmental services' provided.

The assessment (within a relatively short time frame, with a focus on cost-effectiveness) was based on five components:

- Search of the literature and web-based resources on the area and initial 'scoping' meeting with key stakeholders;
- Spatial analysis of the landscape based on remotely-sensed imagery and available maps and digital data;
- Exploration of local ecological knowledge of the landscape, water movement and consequences of land-use options;
- Discussions with a wide range of stakeholders and policy makers on issues of land use and hydrological functions;
- Modelling of the water balance and water use in the landscape to explore scenarios of plausible land-cover change and their likely impacts on key performance indicators with the GenRiver model.

The major land-cover types in the Singkarak Basin are rice fields (17%), agricultural crops (15%) and forest (15%). Rice fields occur in the lowland area, below 1000 m a.s.l. and with the slopes of less than 30%, commonly found in the southern part of the basin, around Solok, and to a lesser extent in the area north of the lake around Batipuh and Padang Panjang. The underlying substrates of these areas are alluvium for those in the south and breccia in the north, but both are originally from andesite volcanic material.

Besides rice, other types of agricultural crops are also found in the lowland plain around Solok to the south around Cupak / Mt. Talang around 1000 m .a.s.l. and above. In this higher-elevation area, the crops are mostly vegetables, having long been the main cultivation in the area. Other land-cover types like mixed gardens, coconut-based mixed garden, shrubs and grass are found in smaller patches all over the basin. At higher elevation (> 1000 m a.s.l.) and where slopes are steep (>30%) along the western range of the basin (parts of Bukit Barisan) and in the upslope of Mt. Merapi and Mt. Talang—forest is the dominant land-cover type. Patches of pine forest are found in the Bukit Barisan range above Paninggahan and Batipuh.

The main conclusions of the consultations are that there is broad agreement on 'objectives' such as the need to maintain a clean lake, productive landscapes on hills and irrigated plains that meet the expectations of the high population density as well as produce electricity for the provinces of West Sumatera and Riau.

There is a widely held perception that the current landscape is not meeting all these expectations: the PLTA is not able to provide as much electricity as was expected, the fluctuations in the level of the lake are a concern to the people surrounding the lake, the water quality of the lake is a concern, the population of the endemic fish (ikan bilih) is declining and previous efforts to rehabilitate the Imperata grassland (alang alang) in the area have not been very successful.

Much of the debate is focused on proposed solutions and especially on the relative merits of 'reforestation' and the various alternative ways to achieve 'land rehabilitation'. While for many policy makers reforestation (either using the local Pinus merkusii or other fast-growing tree species) is the main approach, villagers in Paninggahan are convinced that streams dry up in the dry season after reforestation with pine trees, while the natural forest is providing regular stream flows. The water-balance model with the default parameter values for pine tree confirmed a higher water use by canopy interception and transpiration compared to more open landscapes, but no substantial difference with natural forest. Impacts of land cover via soil properties may need to be tested further. Further hydrological distinctions between the limestone and granite parts of the landscape are needed as well

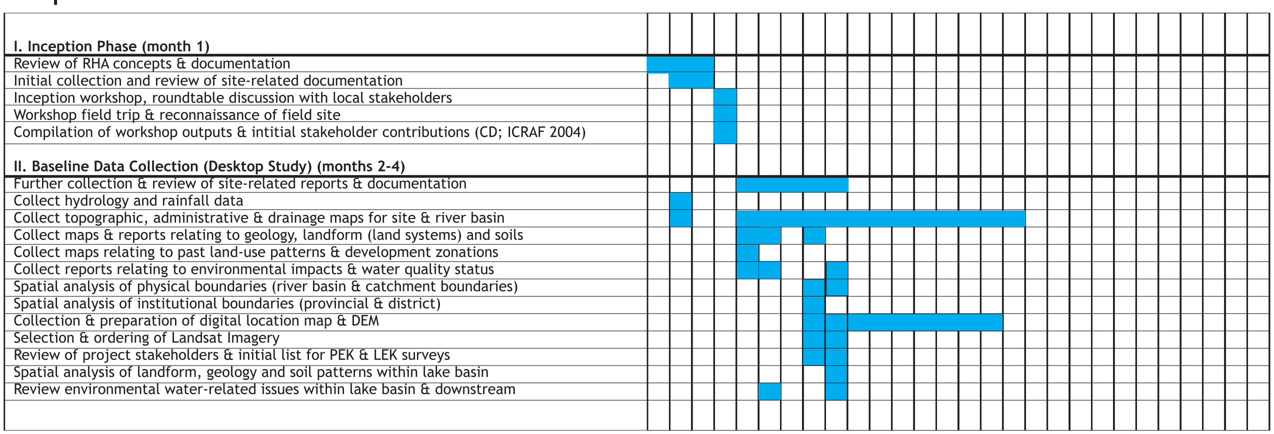
Overall, the water-balance model suggested that the possible performance of the PLTA is only mildly influenced by land cover within the range of scenarios tested. Compared to the current land-use mosaic, an increase of 5% or a decrease of 5% of the maximum electricity production can be expected, while the variation between 'wet' and 'dry' years in the period 1991- 2002 was much larger. Details of PLTA lake management matter a lot. A change in mean annual rainfall under the influence of global climate change will have a strong effect on PLTA performance. Declining water quality in the lake leading to weed infestation will offset any gains in water supply that could result from 'land degradation'. Reforestation with fast-growing evergreen trees will have a mildly negative effect on water usable by the PLTA.

A basic assumption for 'payments for environmental services' is that the supply of these services does depend on activities of those 'rewarded'. For the PLTA, this assumption is not supported by much evidence ... Payments made by the PLTA may have various types of rationale:

- Compensation for damage caused by the HEPP project, to the farmers along the Ombilin river whose waterwheel irrigation systems are disturbed and to farmers with rice fields surrounding the lake affected by increased flooding;
- Shared responsibility for maintaining the water quality in the lake as the HEPP project modified outflow rates and increases debris accumulation;
- Payments of tax to local government;
- Goodwill-enhancing payments to the local community;
- Payments for environmental services conditional to the delivery of these services.

At this stage, the evidence for the last component is relatively weak, and almost absent for the scale level of avoided degradation in a single 'nagari'. Efforts of all lakeside 'nagari's will be needed to deal with the issues of lake water quality, while rehabilitating the other inflows to the lake need at least equal attention.

Implementation Schedule



Implementation Schedule

III. RHA Methodology Development & Survey Planning (months 2-3)

- Preparation of detailed project workplan
- Initial preparation for GenRiver model simulation
- Consultation & review of RHA methodology & operational process
- Planning for spatial analysis (DEM, base map & land-use mapping)
- Consultation & planning for stakeholder survey & prioritization
- Consultation & planning for LEK & PEK social surveys
- Preparation of field work schedule & key stakeholder appointments
- RUPES project meeting & sub-project coordination discussions

III. Baseline Data Collection (Field Survey) (month 3)

- Collection of site-related project & research reports from field sources
- Collection of rainfall, hydrological & lake limnological data from field sources
- Collect information on hydropower scheme operational procedures
- Reconnaissance survey of lake basin landforms & farming systems
- Field confirmation of focus sub-catchment & river / lake basin boundaries
- Scoping review of stakeholders & preparation of LEK & PEK focus lists
- Field confirmation of village, sub-district and district administrative boundaries
- Collect updated planning, land & forestry agency development zonation maps
- Collect planning & forestry agency land-use maps, images or aerial photos
- Implement PEK surveys within lake basin & at provincial level
- Collect information on fishery, lake & related environmental issues
- Collect information on environmental impacts, pollution & water quality
- Collect information on the environmental history of lake-basin landscapes
- Collect information on water use upstream from & downstream of the lake
- Scoping profile of new projects & development within lake basin
- Environmental profile of lake basin (hydrology/water-quality issues)
- Review likely & desired future land-use/catchment management scenarios (PEK)
- Implement LEK surveys in focus sub-catchment
- Scoping assessment of land use & recent changes within lake-basin catchment
- Detailed assessment of landform, vegetation & land use of focus sub-catchment
- Review likely & desired future land-use/catchment management scenarios (LEK)

IV. Data Processing & Problem Analysis (months 3-7)

- Develop DEM & base-maps of river basin & focus sub-catchment
- Finalize image correction & spatial analysis of river-basin landscape
- Prepare map of administrative boundaries
- Prepare detailed current land-use / vegetation cover map for focus sub-catchment
- Prepare of coarse land-use / vegetation cover map for lake & river basin
- Analyse LEK survey & data sets
- Analyse PEK survey & data sets
- Environ. impact analysis of hydrology/water-quality issues within basin (EEK & MEK)
- Analyse LEK, PEK, EEK & MEK perception gaps
- GenRiver simulation of focus catchment & lake basin (current situation)
- GenRiver simulation of focus catchment & lake basin (future scenarios)
- Analyse land-use influence on lake basin / focus sub-catchment function
- Analyse landform/climate infuence on lake basin & focus sub-catchment function
- Analyse other environ. impacts on lake basin/focus sub-catchment function

V. Reporting Phase (month 7)

- Preparation of Final RHA Project Report
- Prepare study results & conclusions for presentation to project stakeholders
- Final field workshop - presentation & consultation with project stakeholders

Figure 10: Lake Singkarak Rapid Hydrological Appraisal Actual Work-Plan.

2.2. Staying within budget and time frame

Table 2 provides an outline of the summary details of RHA labour and cost inputs per implementation phase. This serves as an introductory view of project management and cost realities which lie behind the execution of the following expanded technical steps, as experienced within the current Indonesian financial environment.

Table 2: Estimate of time and budgetary requirement for a RHA as implemented in Indonesia in 2004

Phase		Time (person-days)			Personnel costs	Other costs	Total (US$)	Percentage of total budget
		Junior	Intermed	Senior	(US$)[1]	(US$)		
I. Inception (local workshop)	Liaison person	10	2	2	720	500[2]	1220	12
II. Baseline data collection (desktop)	EEK & MEK specialists	20			600	250[3]	850	9
IIIa. Methodology development & planning	EEK, MEK & LEK specialists	6	1	0.5	315		315	3
IIIb. Baseline data collection (field survey)	MEK, LEK, EEK / PEK & spatial analysis specialists	50	10		2100	1200[4]	3300	33
IV. Data processing & problem analysis	MEK, PEK, LEK & spatial analysis specialists	20	5	2	1200		1200	12
V. Communicating the findings (local workshop)	Liaison persons & MEK specialists	10	4	2	840	2200[5]	3040	21
Total		**116**	**22**	**6.5**	**5775**	**4150**	**9925**	**100**

Notes:
1. Staff costs per day are counted as $30, 60 and 150 day-1, respectively, for the junior (bachelors), intermediate (masters) and senior (PhD level) research staff categories.
2. Initial 1-day workshop with 25 participants and $20 per participant cost level.
3. $100 for photocopy costs and $150 for satellite image.
4. Field costs estimated at $20 per person-day.
5. Final 1-day workshop with 40 participants and $30 per participant costs plus $1000 for report printing.

3. Rapid Hydrological Appraisal- in detail

3.1. Programme management, liaison and monitoring
3.2. Spatial analysis and land use appraisal
3.3. Scoping environmental survey and stakeholder analysis
3.4. Public and policy maker ecological knowledge survey (PEK component)
3.5. Local ecological knowledge survey (LEK component)
3.6. Hydrologist or modeller's ecological knowledge analysis (MEK component)
3.7. Communication of findings
    3.7.1. Goal of communication
    3.7.2. Steps in the process
    3.7.3. Final assessment of the opportunities for environmental-service rewards

3. RAPID HYDROLOGICAL APPRAISAL - IN DETAIL

In sections 3.1 to 3.7 we will in turn describe and discuss:

- The details of the steps of the technical approach;
- The time, labour and budgetary input of each component;
- The lessons learned from the field (difficulties and positive points), in terms of:
  a. time input or delay per activity,
  b. budget over-run per activity,
  c. technical difficulties of implementation or precision,
  d. scaling issues (what works at small scale, what works at large scale),
  e. institutional scaling issues (what can be out-sourced easily; what is best done with in-house expertise),
  f. perception of external stakeholders from the study area and internal team members as to the feasibility and usefulness of the general approach.

3.1. Programme management, liaison and monitoring

Overall success of the appraisal depends on successful project management, public relations, and communication skills. These are the project inputs that: get the RHA process introduced and started on the ground; keeps the process together and heading in the right direction; keeps things to time; ensures the delivery on 'promises' and 'results' to preserve stakeholder relations, and sets a positive mood among stakeholders for follow-up stages of the RUPES programme.

Lessons learned

- **Time input:** Management, monitoring and liaison time input by staff was much more intensive during the periods spent out of office and in the field. These are periods when sub-contracted field staff, local project-management staff and local project stakeholders (government officials, agency staff and community members) all require close attention and time input to ensure that the RHA process is introduced and understood, and that stakeholders and team members cooperate and carry out their tasks as expected and in a timely manner. Management within the orderly confines of the office, in coordination with familiar colleagues who are well skilled in their disciplines, is much less time demanding.

- **Technical difficulties of implementation:** With minimal staff employed to implement the RHA, the majority of staff time must be focussed on field-level and within-office technical aspects. This has its drawback with respect to the liaison component of the project. First, at time of initiation of fieldwork (due to the RHA being the first step in a multiphase project), a considerable amount of field and data-collecting time was spent on 'liaison duties' reintroducing the project concept and logistic dimensions (cost sharing, tasks and obligations) upon 'first contact' with RUPES team members and field staff. This was apparently due to lack of time spent discussing these specifics during the project inception period, which in turn was due to low budgets and low staffing input from project outset. Similarly, upon 'first contact' with government and agency officials and community leaders, considerable liaison effort must be made by RHA staff on behalf of the total RUPES project and follow-up sub-projects. This liaison input is needed to introduce the concept and stimulate the local cooperation and interest needed to sustain the project through its later phases. This essential liaison time also needs to be deducted from time available for RHA-specific activities whilst in the field.

- **Perception of external stakeholders and internal team members:** With respect to the external stakeholders, West Sumatran Government officials and agency staff voiced concern that the RHA appeared to be just another study within the already intensively studied Singkarak lake basin. They wished to know what the linkage was to 'action follow-up', and how this project would be useful to the province. Considerable liaison effort was needed to convince these stakeholders that the RHA is not 'just another study'. There are risks in making such a 'promise', when the delivery of the 'action' is in the hands of other sub-component teams of the project, and when delivery on the 'promises' may not happen for a considerable time, if at all.

  With respect to RHA team members, there was concern that the 3-month absence of RUPES project staff from the field, whilst awaiting RHA data processing and output, may result in the initial interest of RUPES project field staff and local government and community stakeholders evaporating. The absence of a continual staff presence actively working on RUPES activities may result in the stakeholders' conclusion that this is in reality 'just another academic technical study', implemented by 'outside technical specialists', with little relevance to them in terms of 'action follow-up'.

- **Institutional scaling issues:** Lastly, from the experience of RUPES Bakun project*, there was a general consensus from ICRAF-SEA project staff, contracted project managers and collaborating project staff that the RHA process as outlined from the Singkarak, Indonesia experience probably could not be implemented in the Philippines within the $5000 - 10 000 budget limit and within the 6-month time limit initially targeted. The consensus was that the RHA approach as implemented under the RUPES Singkarak project in Indonesia by in-house ICRAF-SEA staff more familiar with the technical components and approach, would not be implemented as rapidly or cheaply in the RUPES Bakun, Philippines case, where the total RHA team would have to be out-sourced and trained from scratch in the technical aspects of the approach.

3.2. Spatial analysis and land-use appraisal

The sub-steps within the RHA spatial analysis and land use appraisal technical approach are outlined in figure 11. The detailed plan and scope of the spatial-data acquisition and processing component under the RHA approach, using the RUPES Singkarak example, followed three sub-component technical steps.

*The RUPES Bakun project is another RUPES project focusing on ESR related to water and catchments, based in the Bakun Baranguay of Benguet Province, northern Luzon, The Philippines.

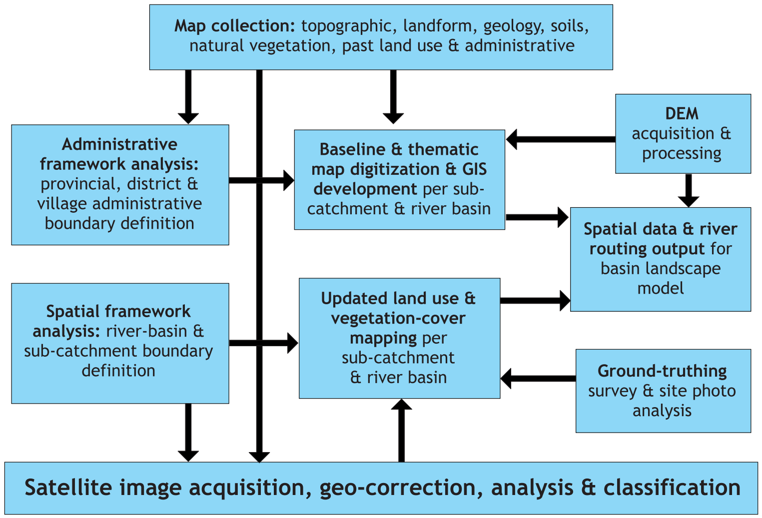
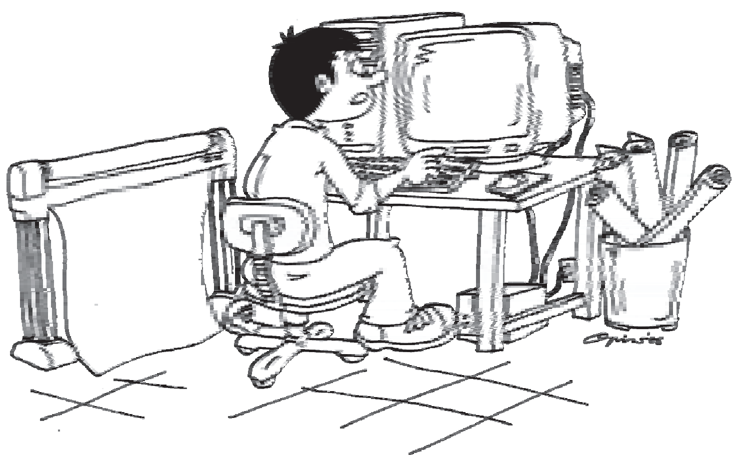


Figure 11: Steps in the RHA spatial analysis and land use appraisal component.



- **Step 1 - Geospatial extent and definition:** Using in-house topographic maps (photocopies and originals), the spatial framework analysis and administrative framework analysis of figure 11 are the first steps in the rapid scoping assessment of the work area. Spatial framework assessment analysis first targets the river-basin and lake-basin boundaries (at 1:250 000 scale) to define the level-2 RHA macro-study area, then analyses the specific target sub-catchment boundaries (at 1:50 000 scale), to define the level-1 sub-catchment detailed focus of the RHA study (see figure 12). This then allows the definition of the map scales and sheet coverage for follow-up base map and thematic map acquisition these are the best available topographic base maps for the sub-catchment (ideally 1:50 000) and the most practical scale available for field use for the river basin (ideally 1:250 000).

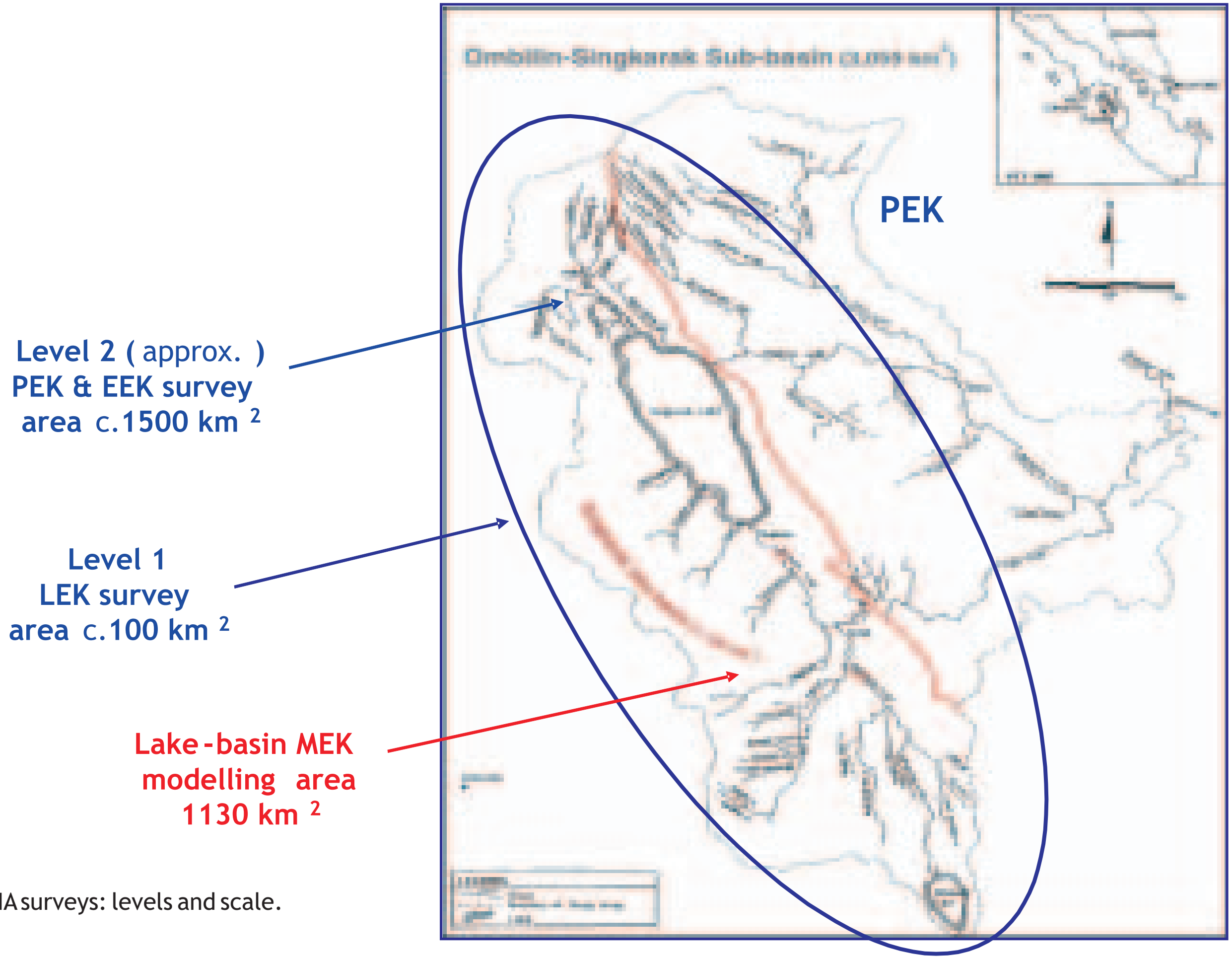


Figure 12: RHA surveys: levels and scale.

- **Step 2 - Geospatial data collection / map acquisition (conducted over a 14-week period):** Acquisition and purchase (from various agencies and institutions) of targeted spatial data (maps and digital), and analysis of these data is conducted concurrently with the survey work of other members of RHA team in the field:

  - topographic maps (for focus sub-catchment and total river basin);
  - relevant boundaries (primarily administrative, soils, geology; secondarily land systems, land-development zones);

- Digital elevation model and the features derived from it;
- land cover / land use (primarily current; secondarily past);
- satellite image coverage (2-year-old Landsat 7, preferred because they are cheaper than more recent images).

The details of target datasets, options for source, preferred scale, coverage and processing remarks for the major datasets, as derived from the RUPES Singkarak project, are outlined in table 3.

Table 3: Key target spatial datasets for RHA

Parameter group	Options of available datasets	Scale / resolution, coverage	Remarks
Landform & river network	National mapping agency (BAKOSURTANAL),topographic map series	1:250 000 scale, need 4 sheets to cover river basin. 1:50 000 scale, need 2 map sheets to cover focus sub-catchment & 9 map sheets to cover the total lake	Purchase
Geology	Department of Mining and Energy, national geological map series	1:250 000 scale, need sheets to cover lake basin	Purchase
Soils	Centre for Soil and Agro-climatic Research, Land Unit and Soil map series	1:250 000 scale, need 2 sheets to cover lake basin	Purchase
Geomorphology	National mapping agency (BAKOSURTANAL), topographic map series	1:250 000 scale, need 2 sheets to cover the lake basin, 4 sheets to cover the river basin	Purchase from national mapping agency
Land cover / land use	TREES / MODIS Global Land Cover 2000 of JRC (Joint Research Center) Global Land Cover Characterization from USGS EROS Data Center	Global coverage, resolution 1 km	Data acquisition website

Table 3: Key target spatial datasets for RHA

Parameter group	Options of available datasets	Scale / resolution, coverage	Remarks
	TREES / MODIS Global Land Cover 2000 of JRC (Joint Research Center) Global Land Cover Characterization from USGS EROS Data Center		
	Classified images done by other organizations	Province or district, probably at 1:100 000 or 1:250 000	Need to determine whether these actually exist
	Land cover maps of National Land Agency or other organization	Province or District, probably at 1:100 000 to 1:250 000	Are they sufficiently up to date (more than 5 years old no good)? Need digitizing and legend adjustment
	Landsat Image	Resolution 30 m, probably need 2 scenes	Acquire RS imagery, establish locally relevant 'legend', initial image interpretation, ground truthing, interpretation per sub-catchment. Takes more time, resources, etc., for obtaining final result among all possibilities

Table 3: Key target spatial datasets for RHA

Parameter group	Options of available datasets	Scale / resolution, coverage	Remarks
DEM, land form, river network	USGS Shuttle Radar Topographic Mission (SRTM)	Global coverage, 90-m resolution grid size. Free download from web: http://srtm.usgs.gov/	Data acquisition, and further processing of a mosaic of sheets. Extracting DEM to obtain relevant features (characterization of river network and delineation of sub-catchments)
	Contour lines (from digital copies of topographical maps if available)	1:50 000 scale, probably need 2 sheets to cover focus sub-catchment 1:250 000 scale to cover the river basin	Data purchase from national mapping agency (BAKOSURTANAL). Interpolation and extraction of relevant features (stream, sub-catchment)
Village ('nagari') administrative boundaries		Local provincial or district sources	Possible sources to be verified with local authority, organizations, etc. Most probably need digitizing, geo-referencing to the other datasets

Table 3: Key target spatial datasets for RHA

Parameter group	Options of available datasets	Scale / resolution, coverage	Remarks
Other administrative boundaries	Topographical maps	1:250 000 and 1:50 000 scale	(Already available in hard-copies.) Purchase (digital version) or digitizing

- **Step 3- Geospatial data processing and outputs:** focuses on four streams of data processing:
  - Map digitizing (administrative boundaries, soils and geology) (2 weeks planned; actual 8 weeks to complete).
  - Map finalization and GIS development (base map, catchment and river-basin boundaries, administrative boundaries, soils and geology) (3 weeks planned; actual 8 weeks to complete).
  - Digital Elevation Model processing (DEM-SRTM): Acquisition and processing (DEM editing and reliability check) (1 week); hydrological feature extraction (sub-catchment boundaries and drainage lines and features) (1 week); river routing distance extraction (measuring total length of rivers and tributaries) via GIS processing for GenRiver model data inputs (that is, sub-catchment derivation, distance to outlets, etc.) (1 week).
  - Land-use / land-cover mapping: Satellite-image acquisition (Landsat 7, two scenes); image pre-processing and geometric correction (2 weeks); land-cover map production (image classification), as necessary if up-to-date land-cover maps are unavailable and maps have to be produced from raw image (2 weeks); fieldwork preparation (1 week); ground-truthing field survey (1 week); accuracy assessment of image classification (1 week); land-cover information extraction for input to GenRiver water-balance model.

Lessons learned

- **Time input or delay:** Problems were encountered in procuring a suitable topographic base-map cover. No digital map coverage of any kind existed for the study area, necessitating that all thematic maps and some of the topographic features had to be digitized. Hard-copy topographic map sheets were generally out of print at the national mapping agency, so they had to be purchased from the army, which required a time-consuming national security agency clearance, resulting in the planned time period of 9 weeks allowed to obtain the maps extending to 14 weeks.

- **Fund input or budget over-run per activity:** Budget concerns existed from the outset owing to the high cost of having to purchase updated digital satellite images. With the expectation that satellite images and up-to-date land use maps may not be available at provincial or district level (as was proven in the field), the option of ordering considerably cheaper 2- to 3-year-old (2002 or 2001) Landsat 7 digital imagery was taken at the project outset (at the cost of $25 for image and delivery).

- **Technical difficulties of implementation or precision:** The search for suitable land use and land-cover mapping proved challenging, despite a recently completed (2 years ago) 10-year German-funded project on the lake basin having reportedly purchased images and carried out land use mapping and detailed GIS development. No agency in the province or district knew the whereabouts of any of the previous project data. There was also no up-to-date classified image coverage of the basin. Additionally, the existing land use maps of the provincial and district land and planning agencies were all completely out of date, and based upon 10-year-old data, or reinterpretations of even older topographic maps. The most up-to-date land use mapping of the basin had been conducted in 1995 by the Forest Department (catchment management authority) — this was considered too old to be currently reliable.

  The task of finding village administrative boundary maps proved similarly difficult. Unexpectedly, provincial and district governments, land agencies and planning agencies were all currently utilizing inaccurate sketch maps of village ('nagari') boundaries. Local village administrations were using more accurate larger-scale maps, yet these were only available as 'blueprints'. This presented the difficulty of interpreting accurate locations on the ground with respect to topographic features. Again, only the provincial Forest Department possessed accurate maps—seemingly the only agency with efficient document-archiving abilities, they still possessed the original 1:20 000 scale Dutch 1887-1890 series topographic maps outlining the originally surveyed, clearly defined, village administrative boundaries.

- **Team member perceptions:** Concern was expressed from the project outset by the RHA team that the process of satellite-image acquisition, processing, classification and ground truthing, to produce 'updated' land use mapping, would most likely be a critical 'bottleneck activity' that most slowed the progress of the overall RHA. These concerns proved justified (see figure 10—delays in phase IV due to delays in obtaining maps and Landsat imagery). The RHA fieldwork period had to be delayed to month 3, to allow sufficient RHA scoping and design to be achieved. The laborious work of image classification had to be delayed until fieldwork verified that no other options existed (around month 3.5). The spatial-analysis team had projected 8 weeks of work to complete the job (not including time delay in ordering and acquisition), thus bringing the RHA process up to month 5.5, in an originally projected 6-month project time period, before the GenRiver catchment modelling process could begin to finalize the modelling of the 'current catchment situation' (that is, it had to be delayed until updated land-cover estimates per sub-catchment were delivered). This left an impossible 2 weeks to complete all modelling (future and current scenarios), reporting and delivery. To avoid this 'bottleneck', the lessons from implementation experience were: expect the worst and order at least one of the needed images before departure on fieldwork (around month 2.5); verify promptly whether a second image is needed to cover the basin boundary as defined in the field (end month 3); begin image processing promptly upon return of field team and finalize the task in 7 weeks instead of the projected 8 weeks (to deliver at end of month 5);

begin GenRiver modelling earlier (by month 5.5) with best estimate figures for land use cover per sub-catchment. This to be updated and finalized later upon receipt of the more accurate figures.

3.3. Scoping environmental survey and stakeholder analysis

The sub-steps within the RHA scoping environmental survey and stakeholder analysis technical approach otherwise known as the scientists', or environmentalists', ecological knowledge (EEK) survey are presented here. This landscape-level social and environmental survey is structured as outlined in figure 13.

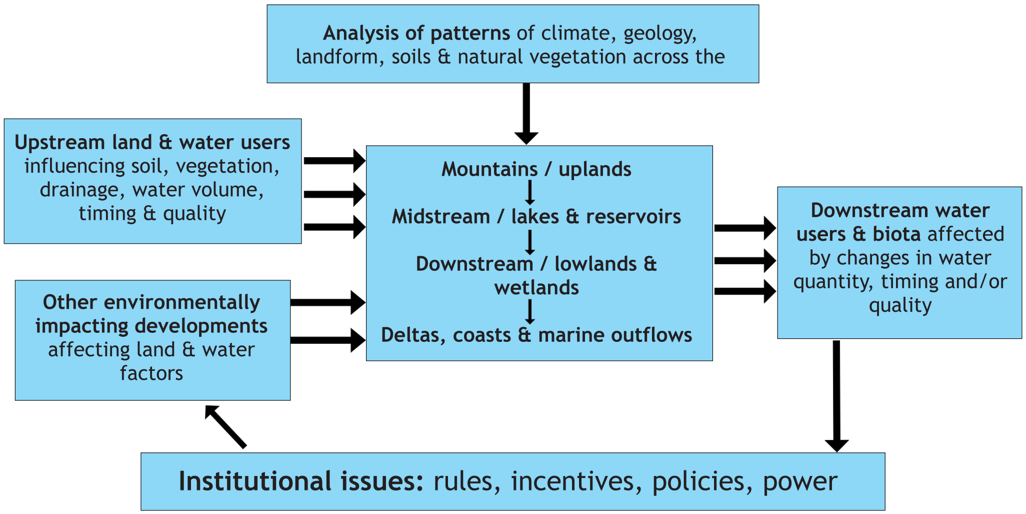


Figure 13: Steps in the RHA scoping environmental survey and stakeholder analysis.

The river-basin-wide environmental scoping component of RHA is implemented by the 'scientists' (environmental scientists and hydrologists) who conduct RHA work activities at the level-2 river-basin macro level of RHA study. It is implemented during the inception, baseline-data collection, field survey and data analysis implementation phases, as a six-step process as outlined below (with indicative labour input shown from the RUPES Singkarak case study):

- ***Desktop scoping review*** (2 person-days): Conduct desktop baseline review of existing environment-related reports, and basin-wide scoping analysis of the spatial data (maps) on the landform (land system and land unit), geology, soil, natural vegetation and climatic features and patterns within the river-basin macro-study area. Reveal where the existing environmental problems and likely areas of environmental impact lie within the river basin; and provide a spatial framework for the different types of landscape found in the basin (to be used later in planning the PEK survey in terms of locations, institutions and questions, and reconnaissance field trips).

- ***Environmental data collection*** (11 person-days): Conduct district-, province- and regional-level data and report collection in effort to locate and acquire updated environmental baseline data and reports specific to environmental-impact issues, and provide a more comprehensive set of written materials to form a modeller's environmental knowledge (MEK) view of environmental issues. This view should be formed independently from the PEK and LEK perceptions. Make visits to such organizations as the regional (hydro) electricity corporation, and provincial planning, forestry, water-resources management, environmental and land registration agencies.

- ***Specific reconnaissance field inventory and ground truthing*** (6 person-days): Conduct specifically targeted reconnaissance trips around the river and lake basin macro-study area to view and digitally photograph the landscape, land use, development and infrastructure (for example, visiting the hydro-power scheme). This is done as a familiarization and documentation exercise to visually confirm: the layout of the study area landscape; vegetation; land use patterns; trends in landscape, water quantity and water quality degradation; and development patterns. Also ground truth the existence of previously reported and unreported environmental impacts or issues.

- ***Field-level stakeholder and issue identification*** (1 person-day): Conduct interviews with selected provincial and regional agency officials (during data collection). Combine conclusions from interview outputs with independent conclusions drawn from visual observations made during reconnaissance tours of lake basin. Conduct interview and discussions with selected local leaders or district agency staff. This is done to develop the target checklist of community groups, government officials and agency staff, at provincial and district level, within the lake basin and downstream, and to form the focus of the PEK survey. Finalize development of a checklist of environmental-issue discussion points to guide the structure of PEK interviews.

- ***General reconnaissance field inventory and ground truthing*** (4 person-days): Conduct the same activities as during specific reconnaissance field inventory, whilst conducting the PEK survey interviews within, adjacent to and downstream of the lake-basin, and in river-basin areas not previously covered during the earlier exercises.

- **Modeller's ecological knowledge (MEK) initiation:** Conduct a separate and concurrent analysis of the data and comments from the PEK and LEK survey respondents to produce a separate 'Modeller's Ecological Knowledge' (MEK) conclusion on the environmental impact trends and cascading interconnected influences and causal factors which may be found throughout the basin if the total data of the LEK, PEK and MEK surveys are combined and analysed in a spatial manner as per the environmental spatial framework outlined in figure 7. This analysis (outlined in figure 13) explores the impact of upland land and water users, and other development activities, upon a cascade of water bodies and related landscape features running down through the river basin, and upon the downstream water users, via use of structured PEK interview discussion points (identified within the step above) relating to:

    - upper catchment condition, water supply issues (quantity and quality) and land-use impacts;
    - mid-catchment lake and fishery conditions, lake development, use and water issues;
    - the specific environmental impacts of the hydro-electric scheme upon the mid-catchment lake and downstream;
    - the existence of any other impacting developments in the lake basin;
    - the general trends in water use within the river basin, and existence of impact of any development trends (land use, water-supply changes, hydro-electric scheme and other developments) upon the quality or scarcity of water supply.

Examples of survey results as derived from the Singkarak RHA stakeholder analysis and environmental scoping exercise are presented in figures 14 and 15.

Upstream (catchment)	Mid-stream (lake basin)	Downstream (Ombilin river)
➤ Conservation agencies ➤ Forest agency ➤ Timber harvesters Livestock owners ➤ Upland farmers ➤ Town water supply ➤ Irrigation farmers ➤ Town & village residents ➤ Property & regional developers ➤ Mining industry	➤ Hydro-power corporation ➤ Lake fishermen ➤ Aquatic conservation lobby ➤ Lakeside farmers ➤ Tourism industry ➤ Lakeside developers	➤ River fishermen ➤ Riverside residents ➤ Irrigation farmers ➤ Town water supply

Figure 14: Stakeholders identified in the Singkarak RHA.

Lessons learned

- ***Time and funds input:*** The approach is cost and time efficient in that the exercise of 'scoping' is conducted jointly and simultaneously with numerous other aspects of the RHA (PEK and LEK surveys; during hydrological and spatial data collection). In addition, it is a welcome recreational exercise (driving and walking around the landscape observing and taking photos) to counter the intensity of the other RHA survey activities.

- ***Technical difficulties of implementation or precision:*** In terms of precision, the technique is both robust and precise in that: it reinforces and ground-truths data gathered from previous reports and from provincial and regional sources; it reinforces and supports the spatial analysis (with digital-photo landscape inventory and visual assessments); it provides an additional sampling observation of issues discussed and reviewed in the LEK and PEK perception surveys; and it ties together the observations recorded at small scale (e.g. LEK survey) and larger scale (e.g. PEK survey; provincial, national and international reporting efforts; and the overall spatial analysis).

What are the major issues?

Water supply and regulation
- Upstream horticulture, cropping expansion and forest loss in steep volcanic catchments → unstable river flows, flooding problems and decreased water supply
- Intact forests on steep limestone upper catchments → stable river flows and water supply
- HEPP water-level regulation:
  rises: flooding lakeside rice fields and housing
  reductions: impacting negatively on endemic fish populations

Water quality
- Horticulture, upland cropping and forest loss in upstream areas → sediment in rivers
- City and village → rubbish and waste
- Lake water quality degrading due to outflow obstruction by HEPP weir

Biodiversity and fisheries
- Local endemic fish, 'bilih', impacted by overfishing and degraded lake & rive habitats

Figure 15: Singkarak RHA preliminary MEK environmental-issue identification.

3.4. Public and policy makers' ecological knowledge survey (PEK component)

The perceptions of hydrological processes among local people, the government and local institutions take a central role in influencing the negotiation process for any environmental-payment scheme. The public and policy makers' ecological knowledge (PEK) survey goal is to explore and articulate the knowledge, experience and perceptions of the major groups of people who have direct influence upon the management of all sub-catchments of the RHA study area, with primary survey aims to:

- apply a 'rapid' method for exploring major issues, problems and associated knowledge and perceptions related to hydrology, water resources and environmental issues among major stakeholder groups (with sub-topics outlined in green box of figure 16);
- test this rapid approach, as a form of 'participatory river-basin analysis', at the level-2 RHA macro-scale across the province within, adjacent to and downstream of the focus Singkarak lake basin, yet outside of the focus level-1 sub-catchment area;
- test the approach as a rapid regional scoping tool, in an attempt to define local knowledge and perceptions, primarily regarding the significance of environmental impacts of upper-catchment usage, as compared with other water-resource-impacting developments within the lake basin.

The sub-steps within the RHA public and policy makers' ecological knowledge survey, or the PEK social and environmental perception survey, are outlined in figure 16.

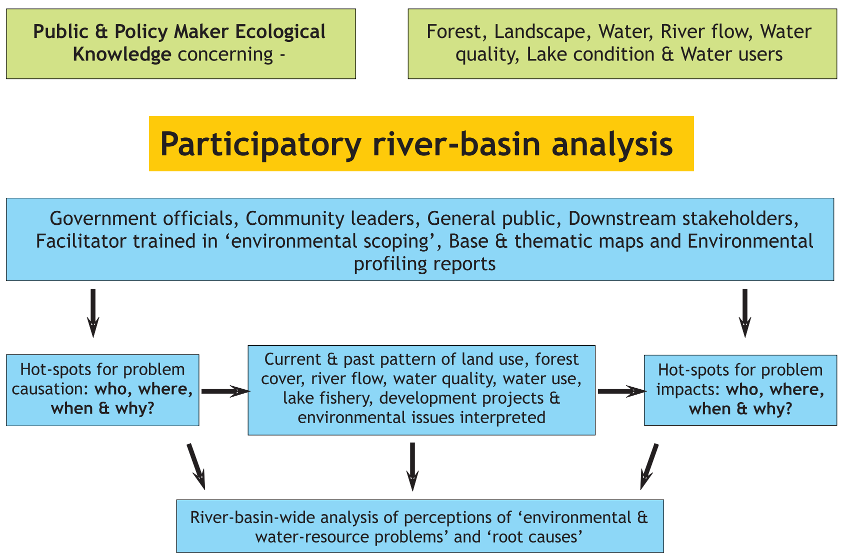


Figure 16: Steps in the RHA public & policy makers' ecological knowledge survey.

Based on the Local Ecological Knowledge (LEK) methodology used in various research activities of ICRAF-SEA (Dixon et. al., 2001), the 'Public and Policy Makers' Ecological Knowledge' (PEK) approach was developed by adjusting the LEK approach to cover a broader macro-level basin-wide survey.

As with the LEK survey approach (section 3.5 below), PEK methodology also adopts a 'semi-structured' interview approach as the basis for the detailed discussions. However, the list of discussion topics is expanded to support the broader 'scoping review' of land use-related and other possible water-resource-impacting activities within the Singkarak lake basin. Also, the list of stakeholder 'groups' interviewed requires expansion to cover the greater number of 'stakeholder groups' within the larger area of the lake-basin survey, including key community groups, different levels of government administration and key agencies with specific interest in water resources, landscape and environmental management.

The expanded number of interview topics, stakeholder groups and physical locations, combined with limited time access to those to be interviewed (see comment below under Lessons Learned), leads PEK methodology to focus primarily upon issue identification, location and probable causal factors. This results in many brief interviews*, with less attention given to exploring stakeholders' perceptions regarding the 'workings of the processes' as covered by the LEK survey. This is the primary difference between the PEK and LEK methodologies.

The details of the sub-steps in PEK survey methodology, including methods used, outputs and indicative time durations (from the RUPES Singkarak experience) are outlined in table 4.

* PEK survey of the Singkarak site was conducted as 44 separate interviews, covering 14 stakeholder groups, and a total of 66 persons, over a 17-day period. In comparison, the LEK survey was conducted as 13 interviews, covering 4 stakeholder groups and a total of 23 persons, over a 10-day period.

Table 4: Steps in the PEK survey methodology

Step	Methods	Expected outputs	Time
Step 1: Scoping the issues — Preliminary orientation and rapid characterizing of issues of concern within the lake basin (conducted at inception phase by the environmental scoping component	Reconnaissance field trips; introductory workshop with local stakeholders; desktop review of related reports, maps and development plans (e.g. PLTA scheme reports)	Gathering of site maps and reports; conducting workshop; review of water-related environmental issues; rough definition of impact locations and affected and affecting stakeholder groups	5 days
Step 2: Defining a spatial framework — defining the focus and boundaries of the detailed LEK survey; and limit of extent of surrounding PEK surveys (conducted under the Spatial data analysis component above, at Desktop baseline data collection phase — section 3.3)	Manual definition of related sub-catchment, lake-basin, river-basin & administrative boundaries from topographic maps	Decision on survey spatial focus for LEK and PEK surveys; definition of focus sub-catchment boundaries for LEK survey; definition of lake-basin boundary and logical extent of downstream focus for PEK survey	2 days
Step 3: Planning for PEK interviews — discussing the methodology differences from LEK, discussing tentative sites, likely issues and a tentative checklist of stakeholders	Discussion with supervising social scientist; review of different ICRAF survey methodologies applied under different projects	Decision on applicable methodology for PEK in view of stakeholder numbers, issues and time available for survey	1 day
Step 4: Stakeholder and issue identification (on the ground) — development of a checklist of key stakeholder groups with local informants and leaders, and definition of key issues for discussion	Interview with selected provincial and regional agency officials; reconnaissance tour of lake-basin landscape; interview with selected local leaders or agency staff	Checklist of target community groups, government officials and agency staff, at provincial and district level, within the lake basin & downstream; checklist of discussion points	5 days
Step 5: Knowledge articulation	Planning location and time schedule for stakeholder interviews; interview and discussions (groups if possible) during scoping survey of river basin (2-7 interviews a day)	Interview schedule; knowledge and perception of hydrology issues from each group on all reference sites or 'cases'	13 days
Step 6: Data compilation and preliminary evaluation	Summarize general output and methodology; summarize interview data (write up interview notes into database); analyse key issues, problem areas and perceptions as to causal factors; field-report preparation	Report of public and policy makers' knowledge and perception of different stakeholder groups	9 days

An indicative checklist of PEK discussion topics guiding the 'semi-structured' interview process, and relevant to water-resource, landscape and environmental management (as defined under PEK Step 4 and the 'Field-level stakeholder and issue identification' step of the MEK environmental scoping survey) is outlined in box 3.

An indicative checklist of PEK discussion topics guiding the 'semi-structured' interview process, and relevant to water-resource, landscape and environmental management (as defined under PEK Step 4 and the 'Field-level stakeholder and issue identification' step of the MEK environmental scoping survey) is outlined in box 3.

Box 3: Original RHA methodology LEK and PEK target questions

1. Is there a real and important problem?
2. What is the problem and since when has it been manifest?
3. What is causing the problem?
4. Who is causing the problem?
5. Who is affected?
6. How bad is it for those affected?
7. What can be done to stop or reduce the problem?
8. How do we know that this will work?
9. What effort and cost does this solution require from whom?
10. Why hasn't this solution been implemented yet?
11. Why do we think it will work this time?
12. Who will have to contribute to the cost?

Lessons learned

- **Time input:** Most respondents were government officials and had limited time available to meet with interview teams, or were just about to leave on, or delayed in coming back from, field trips, meetings or official ceremonies. This necessitated very rapid interviews. Additionally, government-agency respondents were on occasion unavailable for interview appointments, requiring a return visit, resulting in further loss of effective survey time. This reduced time available to be spent for subsequent follow-up interviews with other respondents.

- **Technical difficulties of implementation or precision:** The original RHA project-proposal methodology provided a guideline that LEK and PEK surveys should adopt a 'semi-structured' interview approach exploring a sequence of 12 'digging questions', concerning stakeholder problem perception and possible solutions (listed in box 3). In view of the PEK survey having to cover a larger numbers of respondents, i.e. a longer list of stakeholder categories to be replicated over 2 to 3 districts, an early conclusion was reached that PEK interviews most probably would have to be limited to a rapid coverage of questions 1 to 8 (box 3), due to shortage of time per interview.

- **Team member perceptions:** The original RHA project guidelines also prescribed a framework for 'exploration of eco-hydrological terms and explanatory knowledge', which revolved around analysis of 'who benefits from what' and 'land-use logic and choice'. It was concluded that this framework was more appropriate for the more detailed and spatially confined LEK survey, and for a primary focus upon land-use impacts on catchment function—the interview framework for the PEK survey would have to change. It would need to include a broader scoping analysis of the relative impact of land use, PLTA hydro-electric scheme and other catchment developments upon upper-catchment function, and the lake and downstream environments. It would also need to analyse 'who was impacting' (who benefits) and 'who was impacted' (who loses) for each impacting development identified. The PEK survey final design could only be defined in the field after scoping assessment of 'which environmental issues' are of 'what significance' in 'which part' of the river basin.

  A major weakness of the PEK approach as a vehicle to explore knowledge and perceptions was that in covering a broad survey area and multiple categories and levels of stakeholders it must be applied as a series of rapid-scoping 'snap-shot' interviews. This has the advantage of sampling the broad range of PEK perceptions across the geographical locations, but the weakness of necessitating short interview time with policy-making and public stakeholders. Agency staff and government officials are additionally problematic because of their busy schedules and limited time availability for in-depth and comprehensive interviews.

  The short interview time made it difficult to pursue the full range of 'digging questions' in the semi-structured approach. Consequently, most of the PEK interviews pursued just three questions, namely 'Is there a problem?' 'What, where and who is causing it?' and 'What are the secondary affects?' The questions of 'Who is affected?' 'How bad is it for them?' 'What can be done to stop or reduce the problem?' and 'How do we know this will work?' were covered less often.

  The short time also meant that the respondents' perceptions of the 'processes behind the problems' could not be explored as exhaustively as could be done within the LEK survey. Additionally, there was the problem (or the interviewer's embarrassment) to pursue more fundamental questions to probe the respondent's understanding of the processes on the ground, when respondents were technically qualified, educated and the questions may have seemed inappropriately simplistic.

The end result of the above weaknesses is that the PEK survey may be considered more 'scoping' in its nature, and less 'in-depth' than the concurrent LEK survey.

3.5. Local ecological knowledge survey (LEK component)

The sub-steps within the RHA local ecological knowledge survey, or the LEK social and environmental perception survey, are outlined in figure 17.

The LEK survey goal is to explore and articulate the knowledge, experience and perceptions of selected local communities which have a direct influence upon the management of one focus sub-catchment adjacent to the lake and within the river-basin RHA macro-study area. The primary LEK survey aims are to:

- apply a 'rapid' method for exploring major issues, problems and associated knowledge and perceptions related to hydrology among local community stakeholder groups;
- test this rapid approach in one focus sub-catchment, or the level-1 RHA study area.

The RHA LEK survey methodology is based upon the Local Ecological Knowledge (LEK) methodology of Dixon et. al. (2001), see Joshi et. al. (2004) used in various research activities of ICRAF-SEA. The 'traditional' LEK approach used detailed and rigorous iterations of individual interviews, supported by the data-processing software package known as the Agro-ecological Knowledge Toolkit (AKT). The 'rapid' RHA LEK methodology, however, has adopted the approach of replacing individual interviews with detailed discussion with small homogeneous groups of people, and avoided the use of the AKT. These steps were taken to reduce the logistical effort (time and expense) of the field-data collection and analysis stages of the survey, in the hope of delivering a 'scoping review' of local perceptions more rapidly and cheaply.

The details of the sub-steps of LEK survey methodology, including methods used, outputs and indicative time durations (from the RUPES Singkarak experience), are outlined in table 5.

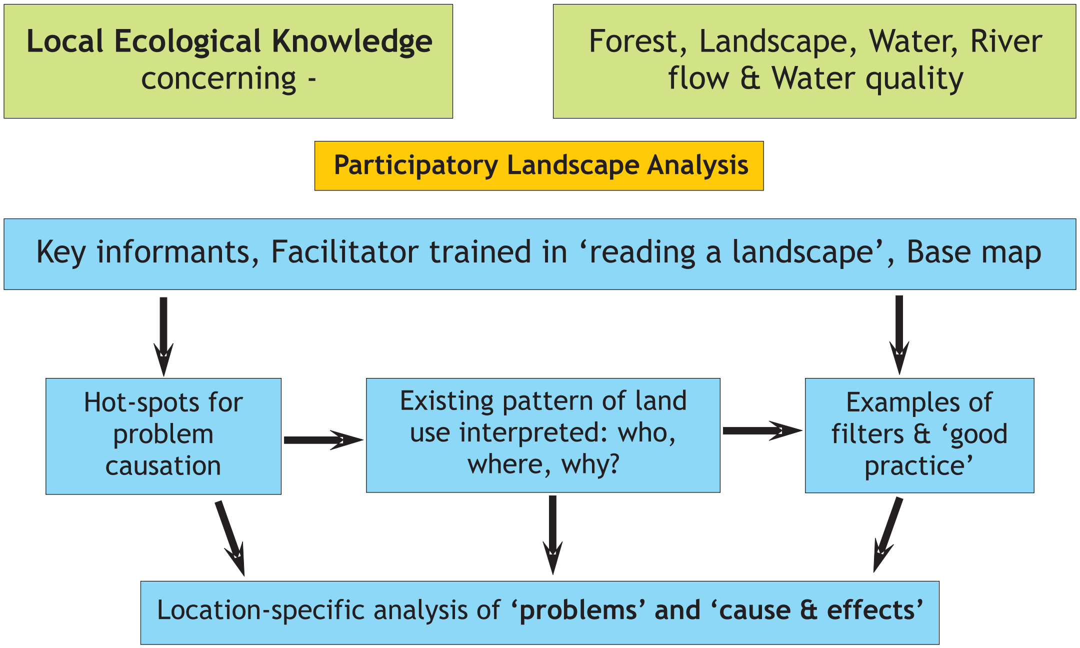


Figure 17: Steps in the RHA local ecological knowledge survey.

Table 5: Steps in the LEK survey methodology

Step	Methods	Expected outputs	Time
Step 1: Scoping — Preliminary orientation and rapid characterizing of the domain and issues of concern	Observation, expert consultation, sketch mapping	Sketch map; domain description; stakeholder-group selection	3 days
Step 2: Planning for group interviews — Choosing sites representing identified issues; checklist preparation and pre-testing	Site visits and discussion	Sites or 'cases' selected for group interviews; checklist finalized	2 days
Step 3: Knowledge articulation	Group interview and discussion during transect walk (one group a day)	Knowledge and perception of hydrology issues from each group on all reference sites or 'cases'	5 days
Step 4: Data compilation and preliminary evaluation	Summarize interview data (play back recordings) and reconfirm where necessary; field-report preparation	Report of knowledge and perception of different stakeholder groups	4 days

- **Step 1 - Scoping:** Includes initial field visits during inception phase, consultation with local and external experts to understand the area in general, the hydrological issues of concern and to identify the major stakeholder groups. A sketch map of the village and sub-catchment areas should be prepared with major land use systems and other necessary details. Areas with issues of concern (e.g. flooding, landslides, drought) should be marked on the map. Stakeholder groups are selected for interview and discussion. These include male farmers, female farmers, government officials and non-government officials in the focus sub-catchment.

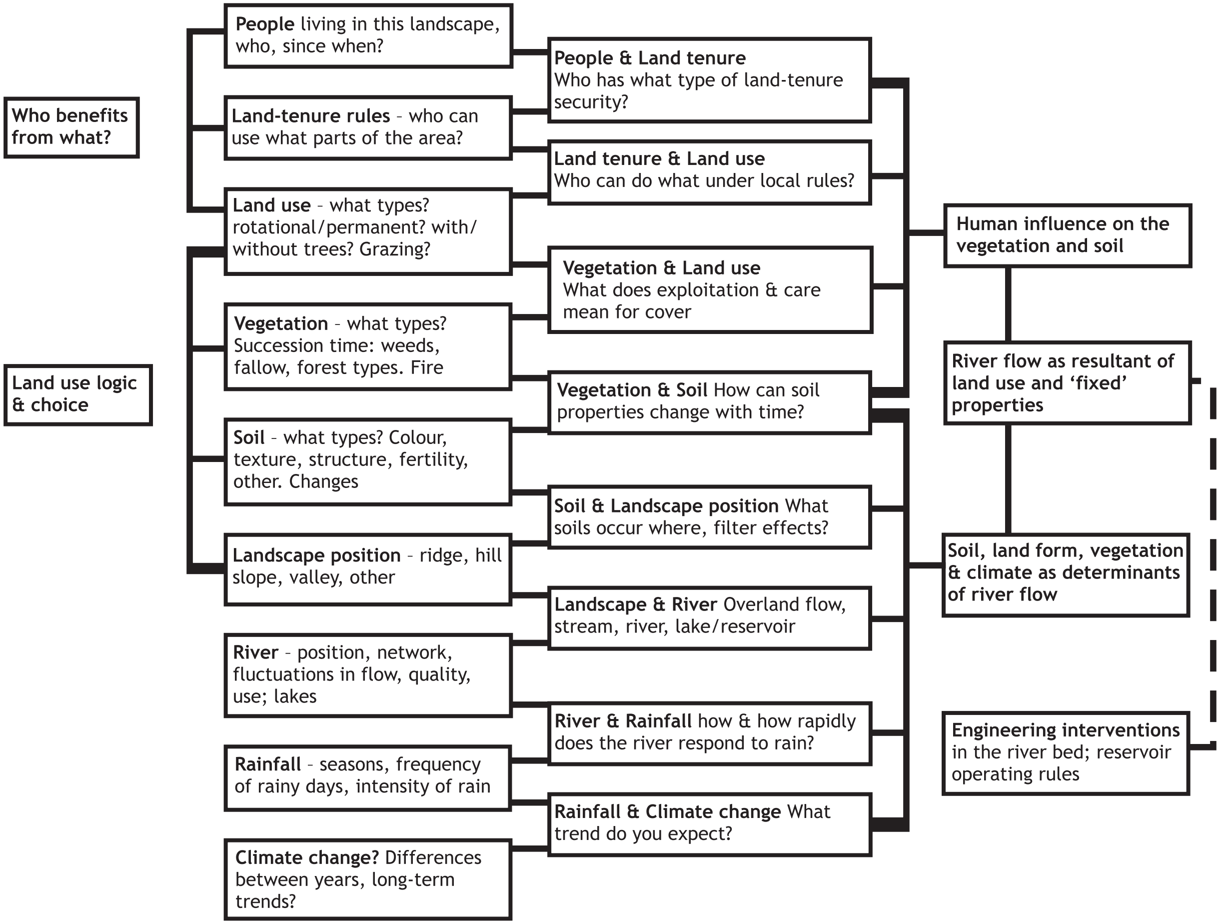


Figure 18: Domains of local ecological knowledge explored in the Singkarak RHA.

- **Step 2 - Planning group interviews:** Pre-survey planning input, guidance and training input is provided by a senior social scientist and a senior LEK survey specialist (anthropologist) of ICRAF-SEA to a junior social scientist and the LEK field-survey leader. Plans are made to adopt a Participatory Rural Appraisal (PRA) 'transect walk' methodology as the basic LEK technique in the field. In the field, a transect route with sites representing issues of concern (e.g. erosion, flood, land use, sedimentation, water contamination) should be identified and these sites used as 'reference cases' for group interviews and discussion. The range of areas (domains) of ecological knowledge that might be considered in the PRA is illustrated in figure 18, while the checklist of questions used for interviewing different groups in the Singkarak RHA is given in box 4.

Box 4: LEK interview semi-structured interview topics

Landscape
- Where does the transect run?

Soil
- What type of soil is in this area?
- How do you classify the soil?
- What species of tree or crop are planted in each type of soil? In the past? Now? Why?

Forest
- What is forest used for?
- What happens if forest is replaced with the other land use? (agroforestry or crop)

Agriculture
- How is the farming carried out here? (Slash and burn? Crop?)
- What species of tree or crop are favoured in this area?
- Are tree crops used more than seasonal crops? Why?
- How is water partitioned between trees and crops?

Pond fishery (aquaculture)
- What system of fish culture do you use here? Where do you implement this fish culture (i.e. where are your fish ponds) and why?
- What is the connection between water supply and type, and production of the aquaculture system?

River
- Where is the river?
- What is the function the river to people? Why?
- What species of tree or crop are in the riparian zone? Why? Are they planted or wild? Why?
- How do you cope with flooding from the river?
- How can you prevent flooding from the river?

Water source
- What is the water source used for-agriculture, household, livestock, fishery?
- How do you get water supply? (for agriculture, household, livestock, fishery?)
- What is the water supply for dryland cropping, agroforestry and forestry-rainfall, river or well?
- What is the condition of the water source in the rainy season? Why?
- What is the condition of the water source in the dry season? Why?
- Have you ever experienced an extended dry season? When?
- How do you manage the water supply when the dry season is long? How do you divide supply between household, agriculture, livestock and fish ponds?
- Are your rice fields irrigated? Since when? What is the system of irrigation?
- What is the condition of the water source now? In the past?
- How can we protect/take care of the water sources? Why? Who has implemented any wat

Flooding

- Where has a lot of flooding happened? When?
- Why did the flooding happen?
- What is the disadvantage of flooding? Why?
- What is the impact of flooding on water source, soil, and crop, people?
- How do you prevent flooding in the river? Why? When?
- What is the people's concept about the cause of flooding? Why?

Erosion

- Why does erosion happened?
- What is the impact of erosion?
- How do you prevent the erosion? Why?
- When did erosion happen?
- What are the disadvantages of erosion? Why?

PLTA

- What is the impact of the hydro-power scheme upon the community around the lake?
- What was the condition of the lake, irrigation, fishery before and after the PLTA was built?

- **Step 3 - Knowledge articulation:** Transect walks are conducted with stakeholder groups (start from top of the slope of the catchment area). General local issues and issues of concern are discussed at the highest point with a clear view of the whole catchment. At each reference site thereafter, further discussions about the stakeholder group's knowledge, perceptions and views are conducted. The checklists were used and interview discussion was recorded on a tape (to avoid taking notes and other distractions). The total transect may be completed in 12 hours. The tape recordings are later played back to prepare notes and appropriate cause - effect diagrams.

  LEK field survey was conducted by two people, a junior social scientist (LEK survey specialist) and an out-sourced local field assistant (soil-science graduate). In the RUPES Singkarak case, individual and group interviews were conducted with community leaders, farmers and fishermen from within the sub-catchment and 'nagari'. Twenty-two people were interviewed, representing four community stakeholder sub-groups: female farmers, male farmers and fishermen, community leaders (non-formal government) and 'nagari' staff (formal government)*. Interviews were conducted to explore the ecological knowledge and perceptions of community leaders, farmers and fishermen regarding hydrological, land use, soil type and vegetation cover interactions, and historical and current trends regarding water supply, stability of flow and quality from springs, river and within the lake.

*Comprising 4 female farmers (from 3 'Jorongs') and 10 male farmers (2 of whom were also fishermen) (from 3 'Jorongs'). Community leaders comprising: a female leader (Bundo Kanduang), a religious leader (member of Majelis Ulama Nagari), and a traditional clan leader ('Datuk', member of Kerapatan Adat Nagari). Nagari government leaders comprising: 3 Wali Jorongs and 2 members of the Nagari Planning Group (Badan Perencanaan Nagari).

The technique was applied as a two-step process involving:

(1) group or individual interviews to obtain a scoping analysis of the current landscape, land use, hydrological and environmental issues;
(2) follow-up field excursions in the form of 'PRA transects' to explore the landscape location and spatial extent of land-use practices and the environmental and hydrological issues, and community perception of the influencing interactions and processes.

Additional individual and group interviews were conducted with traditional community leaders and village government ('nagari') staff members (five people in total) to obtain a rapid assessment of the patterns of land tenure and ownership within the village. Interviews were conducted with the Wali Nagari and one middle-income household to obtain general detail of the level and spread of community household incomes within the 'nagari'. Interview and survey techniques were applied as designed and implemented by the ICRAF-SEA Socioeconomic survey team within the RUPES project.

- **Step 4- Data compilation and preliminary analysis:** Data from all LEK stakeholder interviews and discussions were analysed along the lines of the framework outlined in figure 18. The interview results were thus grouped and written up according to topic with an attempt to compare the differences in perception between different stakeholder groups. Cause - effect diagrams and other information were then prepared.

Lessons learned

- **Technical difficulties of implementation or precision:** The rigorous approach of Local Ecological Knowledge (Dixon et. al., 2001) was adapted for a more rapid appraisal of local people's knowledge about hydrology. The method took nearly 2 weeks to explore, plan and implement, and was reasonably successful in clarifying the general understanding and perception of the local people. The time limitation was self-imposed to see if such local knowledge can be articulated from key stakeholder groups over a short period, as a part of Rapid Hydrology Appraisal.

- **Landscape coverage:** The reference sites in the landscape (e.g. landslides, road construction, flood areas, forests and agro-forests) were not visited by all groups (despite original plans to do so). Had this been done, a clearer comparison between the different groups' knowledge and perceptions would have been possible.

- **Team member perceptions:** Finally, the study, which was planned and conducted over a short period, has revealed some results that have implications on future research and development programmes. Examples include the use of pines in tree-planting programmes, the need to better understand the role of pine in hydrology issues, and the role of dams in local people's livelihood options. However, it also confirms the existing understanding among local people of trees in forests, along rivers and on farms in relation to hydrology - although this may have been explored at

3.6. Hydrologist's or modeller's ecological knowledge analysis (MEK component)

A general framework of approach to the RHA hydrologist's (scientist's) ecological knowledge analysis the MEK hydrological, climatic and landscape modelling component is outlined in figure 19.

The broad aim of the MEK analysis is to utilize past river-flow and rainfall conditions, and current data on the river-basin landscape (i.e. as shown in the middle right-hand box of figure 19) in the ICRAF-SEA modelling package GenRiver to explore how current and future land use change may influence modelled values of river flow, buffering of river flow versus rain (i.e. pattern of flood peaks), water quality and landslide risk.

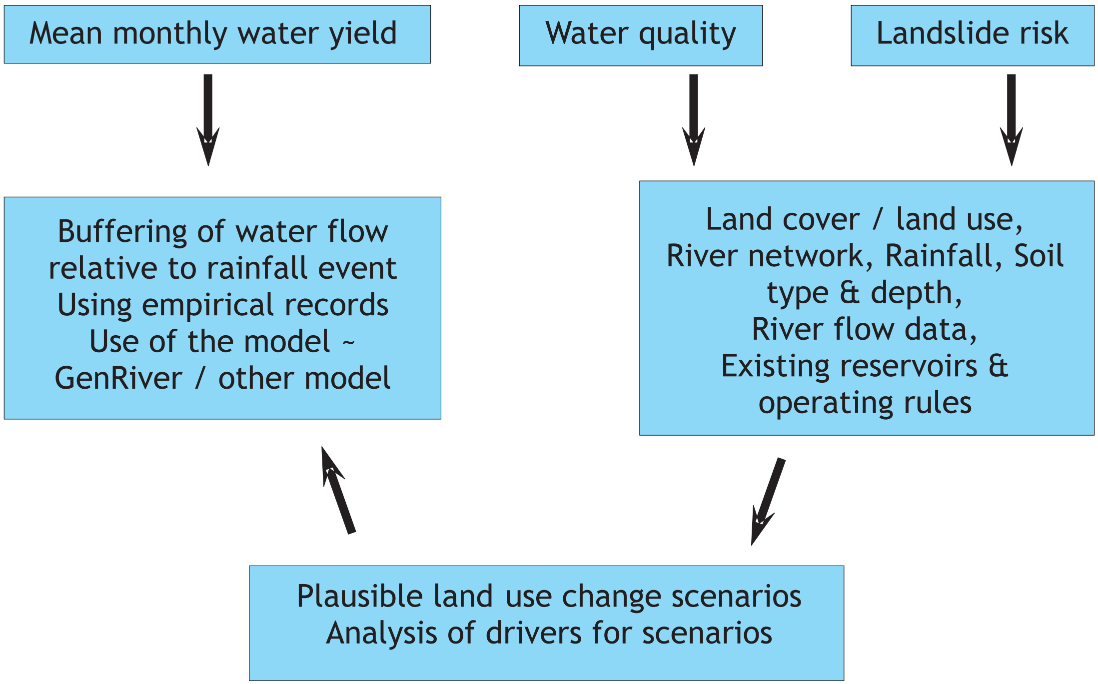


Figure 19: Steps in the RHA hydrologist/modeller's ecological knowledge analysis.

The GenRiver model and MEK analysis require:

- the spatial data,
- specific land use and land-cover estimates, and digital elevation model (DEM) river-network characterization and sub-catchment delineation inputs (outlined in table 3),
- the target datasets (outlined in table 6),
- specific data-processing 'activities' (as defined in table 6).

Table 6: Target water, climate and landscape datasets for RHA MEK analysis

Parameter group	Web-based and published datasets	Location-specific datasets	Activities needed for location-specific GenRiver parametrization
Rainfall	Global and local datasets??†	Search for location-specific rainfall records. Downscaling from monthly means to daily frequency. Spatial interpolation based on elevation, rain shadows	Collect basic datasets, analyse for consistency, apply downscaling routines, apply SpatRain module to generate space/time models of local rainfall
Other climate data	Global datasets??†	Search for data	Calculate monthly potential evapotranspiration
Soil depth and type	Existing soil maps	Local interpretations of soil maps and their legends. Use pedo-transfer functions for various soil structures	Interpret available data (from various sources). Apply ICRAF-SEA soil pedo-transfer functions
River-flow data for model calibration	SEA river basins??†	Consult archive of 'public works' for historical data	Analyse datasets and use for model calibration (especially recession curves in dry season)
Existing reservoirs and operating rules		Local exploration of reservoirs, discussions with dam operators	Definition of storage volume, and likely monthly pattern of filling and release of water

† If these data sets exist.

The GenRiver modelling application as used for the RHA-Singkarak MEK analysis was adapted from a model initially developed to analyse the river flow in the Way Besai watershed in Sumberjaya, north Lampung, Sumatra, Indonesia. Many default input parameters were adopted directly as used for the Sumberjaya catchment. However, to adapt the model to suit Singkarak lake basin conditions, the following specific data inputs were used.

- Climate: 10 years (1992-2002) of daily rainfall records for a station representative of the river-basin areas (Sumani). Potential evaporation (average values per month) derived from open-pan evaporation measurements taken from Singkarak PLTA (hydro-power scheme) completion report.

- Landform: A coarse DEM that allows derivation of overall difference in elevation within each sub-catchment, and a delineation of each sub-catchment boundary (the Lake Singkarak basin consisting of 10 sub-catchments).

- Soils: Mean soil depth (until major restriction to plant root development); average soil texture (or interpret soil types in a way that allows texture to be estimated) as input to 'pedo-transfer' functions to estimate soil water-retention curve (saturation, field capacity and wilting point); estimated bulk density relative to the reference value for soils under agricultural use, to estimate saturated hydraulic conductivity and potential infiltration.

- Geology: The estimation of the 'differential storage' in the 'active groundwater' as well as a 'groundwater release' fraction. These parameters were 'tuned' to the recession phase of the actual river flow during periods without rainfall. In the absence of such data, there is a need to 'guesstimate' these parameters. If data on the seasonal variation in depth of the groundwater table are available, this information can alternatively be used to calculate these parameters.

- Vegetation and land cover: The land-cover fractions per sub-catchment for forest, agricultural field, mixed garden, pine forest, rice field, settlements, shrublands and grasslands were taken from the spatial analysis as inputs for the model.

The structure and approach of the GenRiver modelling application to processing these datasets is as generally outlined at 'plant level' in figure 20. Feeding further from 'plot-level' water balance to 'landscape-level' river flow is outlined in figure 21.

To meet the specific requirements of the Singkarak lake basin, the standard GenRiver model as described was further modified by:

- allowing land use cover estimates to be entered on a sub-catchment by sub-catchment basis;
- adding a lake sub-model to simulate lake water-level and storage-volume changes as affected by the hydro-electricity corporation's 'lake operation rules';
- developing an input for land use change scenarios, via development of a buffering indicator for each land use change scenario.

The GenRiver MEK analysis progresses through a five-step process as outlined in figure 20.

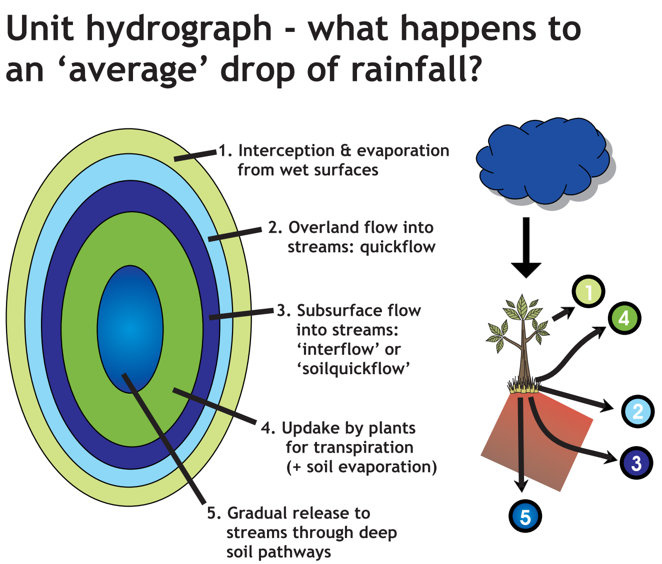


Figure 20:
Plant-level components of the GenRiver modelling approach.

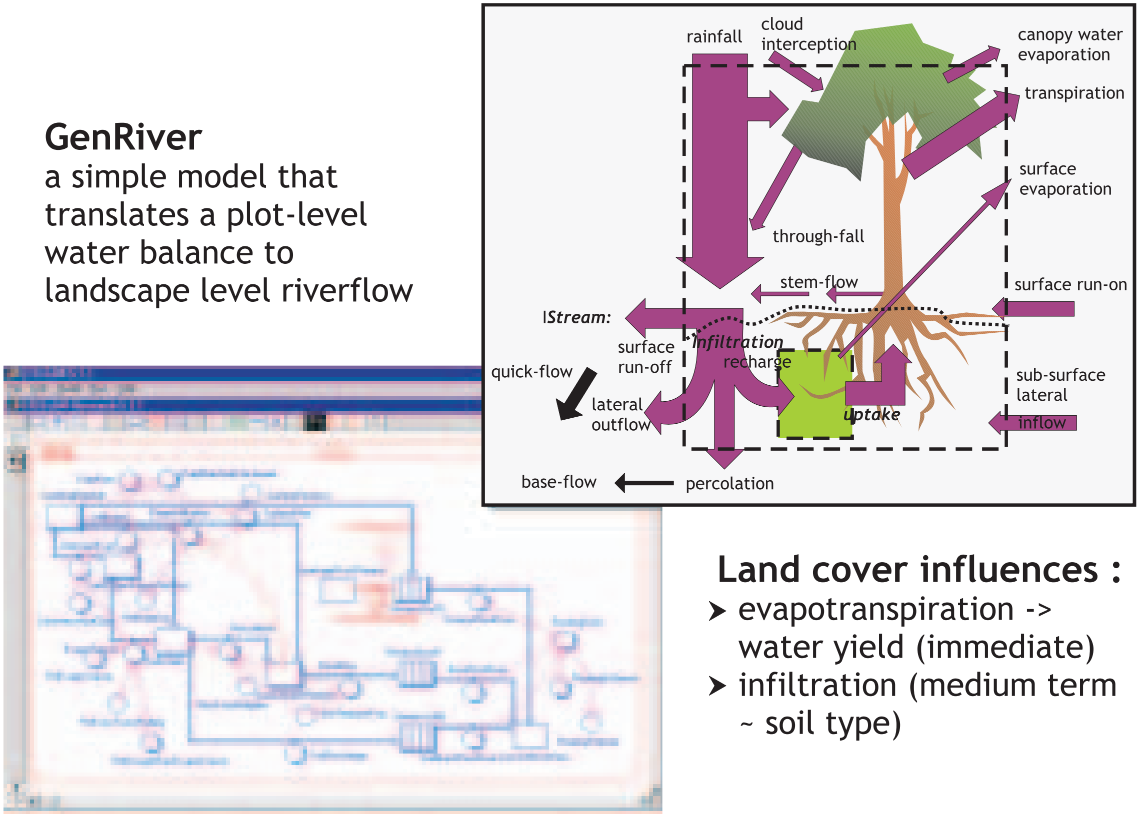


Figure 21: Plot-level and landscape-level components of the GenRiver modelling approach.

Lessons learned

- **Time input:** The time needed to compile the past studies for the site was nearly 3 months. This included an online search through the Internet, collection of available maps, physical data (hard-copy files from the hydro-electric company and the original technical design document) and literature from different government agencies. Field survey for setting up the model, in conjunction with the LEK and PEK studies, took a month. The field activity was very much dependent on the availability of local stakeholders. Spatial analysis and model implementation took most of the time, since an additional module had to be added to the model to describe the dynamics of the lake before and after the technical interventions for the hydro-electric scheme. Delay occurred because of the lack of information available for the site and because of some administrative requirements to run the field work and PEK survey.

- **Budget:** Spatial analysis and fieldwork were the most costly part of the overall RHA implementation.

- **Technical difficulties of implementation:** Scaling issues for rainfall data for model input were a challenge since data from only a few climate stations in or surrounding the watershed could be tracked.

- **Institutional scaling issues**: The Lake Singkarak RHA was carried out with ICRAF in-house spatial analysis and modelling expertise, with additional staff hired for the LEK component.

3.7. Communication of findings

3.7.1. Goal of communication

As outlined in chapter 1, RHA is meant to improve the effectiveness of communication among stakeholders by clarifying the various perceptions that exist and analysing their degree of overlap. The RHA will also lead to a decision point whether or not it is worthwhile to pursue negotiations for an environmental-service reward mechanism.

In technical terms, the RHA may thus be described as a 'Negotiation Support System' for bridging the gaps between the 'knowledge systems' of the various local communities involved, the public and the government policy makers (administrators and related technical-agency managers).

3.7.2. Steps in the process

To communicate the findings, the various perspectives on what is happening in the landscape should be presented and clarified for all stakeholders via the following seven 'communication' steps.

- **Gaps in perception:** The analysis and comparison of the differences in views so that all can see what is generally agreed upon and on which topics the views are far apart.

- **Source of the views:** The analysis of the 'conceptual basis' of each of the four knowledge domains (spatial, public/policy, local and hydrological ecological knowledge), supported by the facts from the field, perception studies, plus location specifics, so that all can understand the basis and explanation of each other's knowledge and logic.

- **Past land use reality:** With the above information on the table, the results of the GenRiver model simulations of landscape, climate and land use impacts upon each sub-catchment function, and the combined impact of all sub-catchments on the lake and downstream environments can be presented. First, as a study of what the original historical baseline situation would have been like, i.e. the historically well-forested catchments minus all the recent environment-impacting developments.

- **Present land use reality:** Second, moving on to a simulation of the current land use pattern, with quantitative study of its impact on river flows and the lake (as derived from MEK analysis and GenRiver), and qualitative assessment of the associated water-quality issues. With discussion of the differing levels of environmental impact resulting from the differing patterns and extents of land use change in the various sub-catchments of the river basin.

- **Land use plus other development reality:** Third, overlaying the modelled understanding of the impact of the hydro-power scheme and other river-basin developments upon water quantity and quality, to enable stakeholders to see the 'simulated' relative impact of each these additional developments upon the total catchment-lake-down river environment as compared to the 'land use only' impact.

- **Future likelihoods:** Fourth, moving on to the study of a set of possible future land use change scenarios. Developing one or several LEK scenarios. Taking care to develop scenarios as drawn from the LEK survey data, to show what the local communities are hoping or expecting to happen. Somehow piecing together each separate local community's view for each part of the basin, lake or river. Developing one or several PEK scenarios, representing in turn the range of differing views and development plans, as derived from the PEK survey of various government agencies and administration levels. Stakeholders then using this information as a starting point for understanding the expected impacts of future land use change scenarios.

- **Future options:** This to be a further starting point for negotiation as to which of the scenarios each stakeholder group wishes to be avoided or promoted. Whether the various stakeholder groups can develop a consensus, or negotiate a trade-off, to agree on jointly supporting or working together towards any one of the likely scenarios. Whether they can see some possibility of pairing up in 'buyer and seller' partnerships, and agreeing on some form of reward or compensation, to be passed from buyer to seller to pave the way for the jointly agreed scenario to actually happen on the ground.

(a) three people scratching their heads

(b) three people in agreement

3.7.3. Final assessment of the opportunities for environmental-service rewards

As final step towards the conclusion of the RHA, the feedback from the various stakeholders on the 'communication gaps' is used to assess the options for negotiations. To do this four aspects need to be considered:

- **Value -** is there a shared perception of the way in which identifiable watershed functions are currently influenced by upland land use and of the way that this affects downstream interests? If there is no clarity of what the broad concept of 'watershed functions' means in the local context, there is little chance that transparent mechanisms will emerge from further discussions. Firstly, there needs to be some agreement on which of the watershed functions (i.e. out of the list of five functions listed in section 1.4) appears to be 'most profitable' and realistic to focus upon. Then there needs to be a basis for agreement on how the 'service' can be monitored. There needs to be a way to judge 'intermediate' solutions (in between 'the whole landscape is covered by natural forest' and 'all the land surface is covered by concrete and drainage channels') to their functionality. If not, efforts may have to be geared towards bridging this communication gap.

- **Threat -** are there elements in the local land use that are beneficial to the local land user yet are a real threat to the environmental services provided to the lowland stakeholders? If 'land degradation' is perceived to be negative for all stakeholders and yet it occurs, there may be misunderstandings on the 'rationality' of decisions. Often the 'threats' are caused by lack of access to long-term benefit flows by the beneficiaries of short-term gains that lead to 'degradation'. In any society there are 'threats' that are regulated by law (e.g. preventing the dumping of pesticides into drinking water). Reward mechanisms cannot, in principle, be called upon to induce 'adherence to the law' (just as one doesn't generally pay non-criminals for not committing crimes today). So, the threats that can be addressed by 'environmental-service rewards' must be based upon activities that are allowable within existing regulatory frameworks, but that have negative effects that are not currently considered in the decision-making process.

Only for such type of threats can we expect 'rewards' to modify the decision making. If the current 'threats' are in fact caused by activities in breach of law, the solution will have to come from more effective enforcement, not from 'rewards'. If there are no 'threats', there is no clear need for external stakeholders to engage — as they can expect to enjoy the environmental service as a 'public good'.

- **Opportunity -** usually community scale institutions constrain individual land use decisions. Local regulation and the various sanctions that exist to encourage adherence, are a balance to the 'individual threats'. Where the local regulation is very strong and local stakeholders' perceptions of site environmental services and values coincide with those downstream, the 'threat' may in fact be reduced below what is 'rewardable'. If, however, there is hardly any effective local regulation, it will be difficult for any outside agent to modify the behaviour of individual agents. A judgment call is thus needed on the combination of 'individual threat' and 'collective action' as a basis for reward mechanisms.

- **Trust -** in many upland communities, past experience with 'outsiders' and 'government officials' has been far from positive and it is unlikely that a freely negotiated agreement can be reached. Where power relations are strongly asymmetrical, the 'agreement' may become an euphemism for something that is effectively imposed. In such a case, there are likely to be attempts to ignore and undermine the new set of rules. Where there is a reasonable basis of mutual trust, however, the development of additional 'environmental-service rewards' based on transparent mechanisms can further enhance the relationship. A judgment call is needed to assess whether or not there is a basis for further negotiations.

At this stage there are no quantitative guidelines on how to assess each of these four dimensions, and the RHA implementer will have to interpret the responses of the various stakeholders to the initial round of communications.

An issue may arise when the technical expertise that is called on for the spatial analysis and hydrological interpretation of land use scenarios does not match with the perceptions of 'LEK' and 'PEK' stakeholders. If the two have full agreement (for example, they agree that planting trees, regardless of type, will undoubtedly increase the annual water yield from a catchment), while the technical 'experts' disagree, there are two views on how to proceed:

- keep quiet about the 'scientific' perspective, as it may tend to dominate the discussions as soon as it is 'revealed', and let the stakeholders work on the basis of their shared perceptions;
- discuss the differences in perception, acknowledging that the 'science' is likely to be incomplete and may be wrong, but that it at least provides 'food for thought' for the other stakeholders.

If the technical perspective remains hidden for now, it is likely that it will be exposed in the (near) future and it may at that time cause undue concern; so it is better to be transparent from the outset.

The team involved in the RHA needs to discuss these possible outcomes and design their communication strategy in accordance with their responsibility as 'honest brokers' who acknowledge that they may not have any direct access to the full and only truth themselves.

Abbreviations and Acronyms

References

ABBREVIATIONS AND ACRONYMS

AKT	Agro-ecological Knowledge Toolkit
BAKOSURTANAL	Badan Koordinasi Survey dan Pemetaan Nasional (Agency for Coordination of Survey and national Mapping, Cibinong)
CIFOR	Center for International Forestry Research
DEM	Digital Elevation Model
DSS	decision support system
EEK	environmentalist's ecological knowledge
EMP	environmental management planning
EROS	National Center for Earth Resources Observation & Science
ES	environmental service(s)
ESR	environmental-service reward
GIS	geographical information system
HEPP	hydro-electric power plant
ICRAF	International Centre for Research in Agroforestry (synonymous with World Agroforestry Centre)
ICRAF-SEA	ICRAF Southeast Asia
IFAD	International Fund for Agricultural Development
IIED	International Institute for Environment and Development
IUCN	International Union for the Conservation of Nature
JRC	Joint Research Center
LEK	local ecological knowledge
m.a.s.l.	metres above (mean) sea level
MEK	modellers' ecological knowledge
MIS	management information system
MODIS	Moderate Resolution Imaging Spectroradiometer
NRI	Natural Resources Institute (UK)
NSS	Negotiation Support System
ODA	Overseas Development Administration (now DFID, UK)
ODNRI	Overseas Development Natural Resources Institute (now NRI, UK)
PEK	public and policy maker ecological knowledge
PhD	Doctor of Philosophy (doctoral degree)
PLTA	Proyek Listrik Turbin Air (electricity generation project with hydro-power turbines)
RAF	relative agronomic function
REF	relative environmental function
RePPProt	Regional Planning Programme for Transmigration (project of ODNRI, ODA)
RHA	Rapid Hydrological Appraisal
RS	remote sensing; remotely sensed
RUPES	Rewarding Upland Poor for the Environmental Services they provide (ICRAF project)
SEA	Southeast Asia
SRTM	Shuttle Radar Topographic Mission
TREES	Tropical Ecosystem Environmental Observation by Satellite
UK	United Kingdom
US	United States (of America)
USD	US dollars
USGS	US Geological Survey
WWF	World Wide Fund for Nature

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NOTE

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RUPES
Rewarding Upland Poor for Environmental Services

SII Netherlands
Programme for Co-operation with International Institutes