Carrying Capacity Consideration in Integrated Watershed Management Approach to Landscape Planning: The Prek Thnot Watershed Project Experience Policy Brief

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Policy Brief

Key Messages

- ❑ Prek Thnot is one of the important watersheds providing ecological and environmental services that are in dire need of attention.
- ❑ The consultative process and optimization approach used by the APFNet–funded "Landscape Approach to Sustainable Management of Forests in Prek Thnot Watershed" demonstrate the possibility of developing a watershed management plan that consider the carrying capacity of the watershed and optimized benefits
- ❑ Policies are needed to improve the management of Prek Thnot watershed:
  - Creation of a governing body for Prek Thnot watershed under the office of the Provincial Governor.
  - Build the watershed management capability of the actors in Prek Thnot watershed.
  - Promote the investments in Prek Thnot watershed.
  - Promote the adoption of soil and water conservation among the land developers in Prek Thnot watershed.
  - Increase buy-ins of the IWMP among the policy makers to integrate the plan in various development programs.
  - Institutionalize the monitoring of the tracking indicators of the IWMP

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1.0 The Watershed Approach to Sustainable Landscape Management

Prek Thnot watershed provide important ecological and economic services. Prek Thnot watershed covers the provinces of Kampong Speu and Kandal and Phnom Penh, the Capital City of Cambodia covering a total land area 666,764 hectares, 77.8% of which are in Kampong Speu province. The surface runoffs of the watershed drain towards Phnom Penh (Figure 1).

The watershed provides a practical way of defining a landscape since it is easier to visualize the impacts of land management such as surface runoff, soil erosion, pesticide deposition, groundwater condition etc. The watershed approach involves consideration of landscape scale (The Nature Conservancy, 2014).

A watershed is an area of land (a catchment) that catches precipitation and drains towards a common outlet[1] (such as rivers, streams, lakes or sea). It is sometimes interchangeably used with river basin. Milwaukee Riverkeeper made a distinction between the two: while both drains towards a common outlet, the river basin are described to areas where the water drains to a larger river. The term watershed is used to describe an area, smaller than the basin that drains to a smaller stream, lake or wetland. Many smaller watersheds may therefore found within a river basin.

Prek Thnot watershed is a mosaic of various ecosystems and pockets of forest that mostly become geographically isolated with sporadic agricultural developments. The loss of the forest cover of Prek Thnot are caused by unabated cutting of the forest areas, fuelwood and charcoal production, expansion of farms and agro-industries, settlements and diminished its protective role.

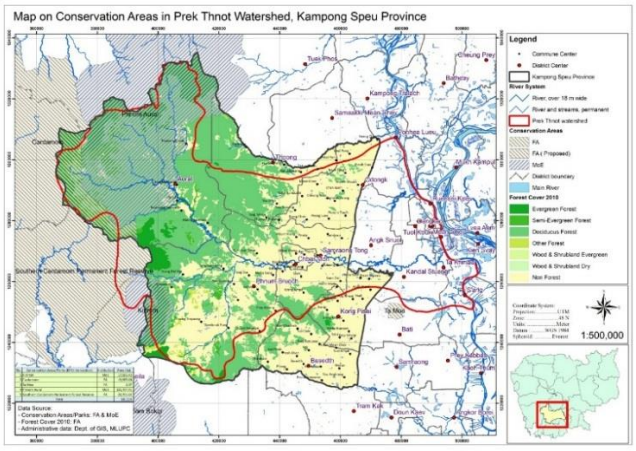

Figure 1. Map of Prek Thnot watershed

2.0 The APFNet-Funded "Landscape Approach to Sustainable Management of Forests in Prek Thnot Watershed"

The project supported the implementation of an integrated watershed management plan (IWMP) that strike a balance between the economic development and biophysical limits (carrying capacity) of Prek Thnot watershed. The project showcased a participatory process of bringing together different stakeholders to come up with a common vision amidst the diversity and conflicting interests. The plan aims to meet the economic development needs of the province without impairing the hydrological function of the watershed. The planning has the following features:

1. Considered the carrying capacity of the watershed
2. Use optimization and trade-off in land use planning
3. Adopted a consultation process

The development of the watershed planning followed the following phases: development of the optimum land allocation model, developing the land allocation map, and developing the watershed management plan based on land allocation (Figure 1). An optimal land allocation of the area amidst the competing goals was determined using mathematical models (Linear and Goal Programming). Consultations were conducted with the stakeholders as part of the legitimization process of the Integrated Watershed Management Plan (IWMP). The consultation is the cornerstone of legitimization of the IWMP.

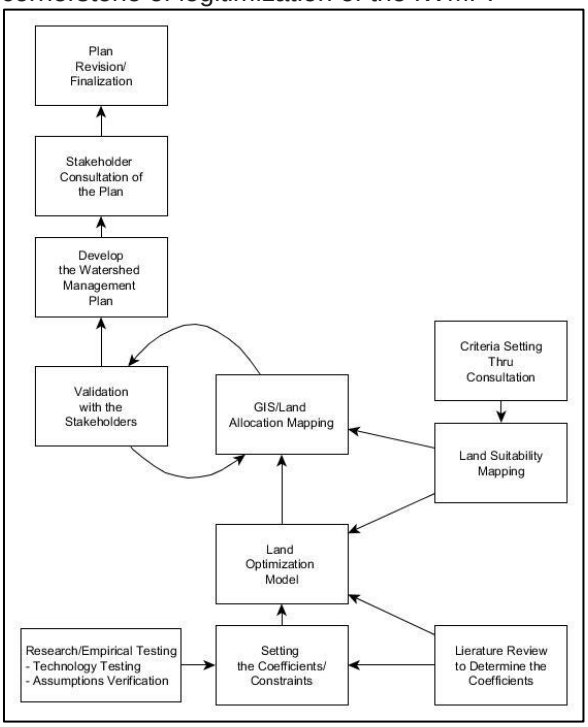

Figure 2. The process of developing and legitimization of the IWMP

[1] Milwaukee Riverkeeper. https://www.milwaukeeriverkeeper.org/whats-a-river-basin-whats-a-watershed/

Landscape Approach to Land Use Planning. Landscape approach to planning are becoming more relevant as an effective means for addressing natural resource degradation and enhancing ecosystem services and biodiversity benefits. The catchment is more practical in defining the boundaries of a landscape since the interactions among the different land uses can easily be identified and measured (e.g. erosion and hydrologic function as indicator of forest health upstream). An essential element of a landscape approach is the involvement of all relevant stakeholders in decision making through a transparent and accountable multistakeholder process (CARE Nederland and Wetlands International. 2017). Collaborative landscape planning and management can be challenging as it requires support from different stakeholders. Landscape plans must therefore meet the basic criteria of being technically, socially and political acceptable. Technical acceptability includes satisfying carrying capacity, economic viability and land suitability criteria.

Some of the main characteristics of the landscape approach[2]:

- It places communities at the center, especially the poor and vulnerable, whose lives and livelihoods are increasingly under threat from disasters, the impacts of degraded ecosystems and climate change.
- It takes into account all actors - either contributing to or impacted by disaster risk - and factors that influence this risk, such as the status of ecosystems, land and water use, infrastructure, and climate change.
- It examines the entire landscape in which risks originate and manifest themselves and the many interactions and interdependencies between ecosystems and human socioeconomic systems. This approach focuses on the catchment upstream of the target community as the defining geographic area of interest, but also recognizes the area downstream to avoid unintended consequences of planned interventions.
- It includes an analysis of the hydrology (groundwater and surface water) and how this affects the community.
- It considers the ecosystem provisioning services (which directly support livelihoods) and on sustaining their regulating and supporting services.
- • It manages trade-offs: There are often trade-offs between building resilient ecosystems, implementing broader development interventions and enhancing livelihoods. The landscape approach actively seeks synergies between different types of interventions and preventing unintended negative (downstream) impacts.
- It demands for a long-term perspective to ensure lasting impact. In most cases, a programmatic approach involving more than one project is needed to make a difference in a landscape

2.1 **Carrying Capacity in Land Use Planning, Optimization and Trade-offs.** In this project, the heart of the land use allocation is a mathematical model (Linear and Goal Programming models). Although this approach has been widely used in many resource management problems, this is relatively new in Cambodia. The models seek to minimize the deviations between the desired goals and the actual results (Ostadhashemi et al., 2014) while Linear Programming (LP) technique is relevant in optimization of resource allocation and achieving efficiency. The plan give consideration on the carrying capacity of the watershed. The absorptive capacity of the ecosystem (or its resistance to change and resilience) in response to anthropogenic impacts (UNEP, undated) is the main consideration to achieving sustainable water resource management. The different societal goal considers maximization of benefits and minimization of the externalities or negative impacts. The goals of the land allocation of the plan include:

- Maximize Income from Land Use (Honey, Mushroom, Sugar, Rattan, Resin, Rice, Fruits, Ecotourism, etc.) (Products and Employment Income)
- Maximize Rice Production
- Maximize Food Production
- Maximize Supply of Construction/High Value Timbers
- Maximize Supply of Fuelwood
- Maximize Total Biomass Produced
- Maximize Forage Production
- Maximize Water Infiltration
- Minimize Soil Erosion
- Minimize Total Pesticide Loads
- Minimize Social Cost for Protection Management

In ecology, carrying capacity means the maximum number of individuals that can be supported in an environment without experiencing decreases in the ability to support future generations within the area (Kormondy 1996). The concept is used to point out that there is a limit to the growth of biological populations, and an analogy can be made for human societies (Schroll et al., 2012). The Watershed Management Plan provide a land use allocation that maximize the societal benefits without breaching the carrying capacity of the watershed.

[2] *Source: CARE Nederland and Wetlands International. 2017. A Landscape Approach in 7 steps for Disaster Risk Reduction. July 2017. https://reliefweb.int/sites/reliefweb.int/files/resources/CARE_WI-A-Landscape-Approach-for-DRR-in-7-Steps-1.pdf*

The allocation was reflected spatially in the watershed using GIS. The siting was guided by the land suitability maps based on the criteria set by the stakeholders in the consultation workshop. There are eight land use options considered in the model:

1. Rice Production
2. Production of Industrial Crops (cassava, sugar cane, potato, etc.)
3. Industrial Tree Plantations (Eucalyptus, *Acacia mangium* and other Fast Growing Species)
4. Fruit Orchards
5. High Value Crops (Cabbage, Tomato, Spices, etc.)
6. Conservation/Protection Forest
7. Sustainable Forest Management (CF, Partnership Forestry, Low Impact Logging)
8. Forage Production

3.4 **Consultation Process (Social and Political Acceptability).** The project conducted series of information dissemination workshops with different stakeholders to explain landscape planning concepts and land use siting criteria (Figure 3). The consultations also set the watershed vision and expected watershed services, which are key elements in shaping the watershed management plan. and the proposed measures to mitigate incompatible land uses.

Figure 3. Consultative workshop conducted

3.5 **Testing the Soil and Water Conservation technology.** Farming has been identified as a major causes of erosion in Prek Thnot watershed. The pilot agroforestry demonstrated the effectiveness of a soil and water control techniques in controlling soil erosion.

3.0 The Integrated Watershed Management Planning/Landscape Planning

An integrated approach to natural resource management at the watershed level ideally address the complex system dynamics in watersheds, and achieve global environmental benefits (Mena *et al.*, 2017). The coordinated efforts of different stakeholders, production of food and energy, mitigation of droughts, proper land use, reducing sedimentation, and improving the environment of the watersheds can be achieved. Integrated Watershed Management (IWM) implies the judicious use of natural resources such as land, water, biodiversity and overall ecosystem to obtain optimum production with minimum disturbance to the environment (Mena et al., 2017). The aim of IWM is to achieve sustainable development of the communities living in the watershed and improve productivity of available natural resources. This requires balancing their economic needs and expectations with environmental concerns. IWM approach, which takes into account the social, political, economic, and institutional factors, is generally recognized as the most practical and efficient way to improve water quality and other environmental components (Mena *et al.*, 2017) and the integrated watershed management plan of Prek Thnot watershed revolves around these principles.

4.0 Outcomes of the Project

4.1 **Land Allocation.** The consultation and land allocation model based on the criteria set by the participants resulted to optimum land allocation of Prek Thnot watershed [Table 1].

Table 1. Result of the land allocation in Prek Thnot watershed

Land Use	Total
Rice Production	103.900
Industrial Crops	92.500
Industrial Tree Plantations	12.900
Fruit Orchard	135.000
High Value Crops	7.400
Conservation/ Protection	104.500
Sustainable Forest Management (SFM)	50.300
Forage Production	-
Total	506.500

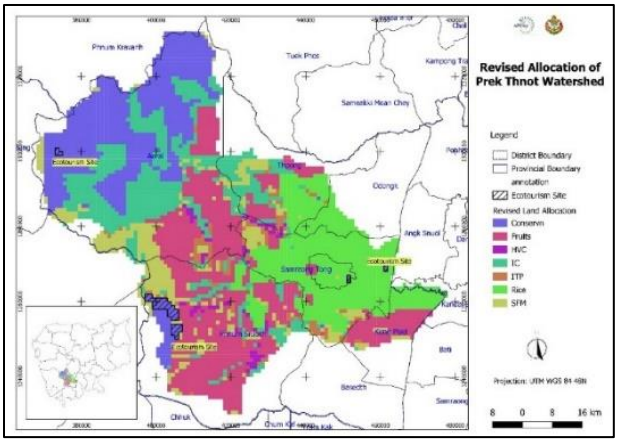

Figure 4. Optimum land allocation ***of Prek Thnot watershed***

Conservn = Conservation Area; Fruits = Fruit Orchard; HVC = High Value Crops; IC = Industrial Crops; ITP = Industrial Tree Plantations; Rice = Rice Production; SFM = Sustainable Forest Management

4.2 **Soil and water Conservation**. The demonstration plot shows the effectiveness of controlling soil erosion. After its establishment and after only a few rain occurrences, considerable amount of nutrient-rich topsoil was trapped in the soil and water control structures. The estimated soil erosion is 14.82 ton/ha/year in Krang Dei Vay Commune and 32.97 ton/ha/year in Tropeang Chor Commune.

Table 2. Result of soil analysis

Soil Properties	Location		Difference	Remarks
	Outside contour canal	In the contour canal		
Soil acidity (pH)	7.65	6.57	-1.08	lower
Organic matter %	2.92	313.00	310.08	significantly higher
Carbon %	1.70	1.82	0.12	increased
Nitrogen %	0.16	0.17	0.01	increased
Phosphorus %	0.044	0.045	0.001	improved
Potassium %	0.96	1.44	0.48	improved

Figure 5. Farmer collecting topsoil deposited in the contour canal

4.3 **Expected Impacts.** The total potential income of the watershed is estimated to reach to US$585 million if the area will be totally developed. The rate of return (IRR) is estimated at 10.2% with NPV of US$ 74 million. It is anticipated that the watershed will increase its capability to recharge the aquifers through increased infiltration, reduction of soil erosion and minimized chemical loads to the watershed (Table 3). The hydrological model (SWAT) indicates that the proposed land allocation will improve the hydrology of Prek Thnot watershed in terms of reducing surface runoff and soil erosion due to improved land use (Figure 6).

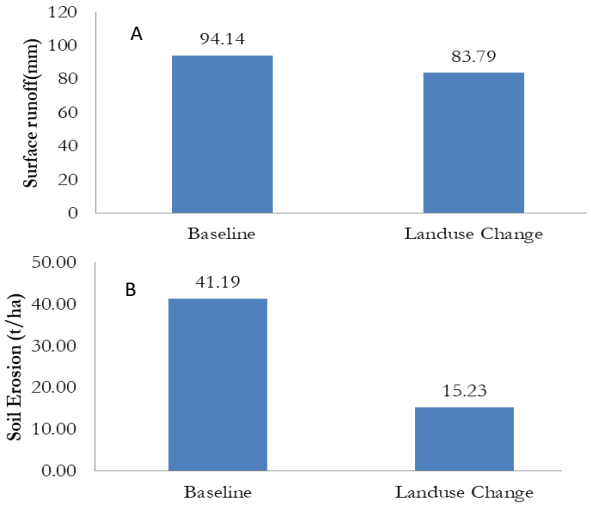

Figure 6. Hydrology of Prek Thnot watershed. (A) Comparative current and project surface runoff; and (B) Comparative current and projected soil erosion.

*Table 3. Expected outcome (**Societal Goals) after the land allocation***

Maximize Income from Land Use (Honey, Mushroom, Sugar, Rattan, Resin, Rice, Fruits, Ecotourism, etc.) (Products and Employment Income)	585,419	US$ '000 /year
Maximize Rice Production (Limited by Site Carrying Capacity)	417,200	t/year
Maximize Meat Production - Bushmeat and Livestock (Limited by Site Carrying Capacity)	794,106	kg /year
Maximize Supply of Construction/High Value Timbers	157,281	m^3/year
Maximize Supply of Fuelwood	129,061	m^3/year
Maximize Biomass Production	7.7	Million ton
Maximize Forage Production	273,935	t/year
Maximize Water Infiltration for 3-Hr. Rain (m^3/ha.)	4,906	Million m^3
Minimize Soil Erosion	16,810	t/year
Minimize Total Chemical Loads	26,106	t/year
Minimize Social Cost for Protection and Management	1,776	US$ '000 /year

5.0 Challenges of Integrated Watershed Management

The implementation of the IWM is expected to face the following challenges : (1) limited awareness of the stakeholders and the communities; (2) resistance of target farmers to technological changes that will be introduced due to poverty and education; (3) uncertainty of sustainable funding to support the development programs; (4) limited skills of the farmers and key actors especially in controlling soil erosion, organic farming and agroforestry; (5) and speculation that put constant pressure to the forest and causing land conversion; and (6) weak institutional support.

6.0 Policy Recommendations

6.1 **Watershed Governance: Creation of a governing body for Prek Thnot watershed.** The management of the watershed should be under a single governing body. It is proposed that the office of the Provincial Governor will undertake the coordinating role of various agencies in developing Prek Thnot watershed. The governing body will also coordinate the different stakeholders, agencies and ministries who are major stakeholders of the watershed like the Forestry Administration, the Ministry of Environment, the Department of Agriculture, the Fishery Administration, MLMUPC and MoWRAM and the development NGOs and CBOs who are working in the area.

6.2 **Capacity Building: Build the watershed management capability of the actors in Prek Thnot watershed.** There is a need to enhance the skills of the different line agencies managing the watershed due to limited availability of professional hydrologists who can conduct the monitoring of the hydrological functions of the watershed.

6.3 **Investment: Promote the investments in Prek Thnot watershed.** Encourage economic investments and restoration of Prek Thnot watershed. Currently there is very limited budget for restoration of Prek Thnot watershed. The communes should support the reforestation, conservation and agroforestry in Prek Thnot through their CIP/CDP.

6.4 **Sustainable Land Management: Promote the adoption of soil and water conservation among the developers in Prek Thnot watershed.** A soil and water conservation policy needs to be promoted to land developers, particularly the Economic Land Concessionaires so that they adhere to the sustainable land management in their land developments. The ELCs must comply the provisions in their EIAs.

6.5 **Land Use and Development: Adopt the IWM as the framework in Commune Land Use Planning**. The IWM Plan will serve as a framework in formulating the CLUPs. The IWMP can coordinate the land use planning among the different communes.

6.6 **Policy Integration and Support of the IWM Plan: Increase buy-ins of the IWMP among the policy makers to integrate the plan in various development programs.** The provisions of the IWMP should be integrated to government programs and targets. The provincial government of Kampong Speu should lobby to the policy makers to support the implementation of the IWMP. Also, the plan should be integrated and harmonized to the five-year development plan of Kampong Speu.

6.7 **Monitoring: Institutionalize the monitoring of the tracking indicators of the IWMP.** Monitoring should be conducted in Prek Thnot watershed on the hydrological changes and the tracking indicators set in the IWMP. Satellite images or drone photos should be part of the monitoring modality. The office of the provincial governor should

take the lead in consolidating and disseminating information to the public on status of Prek Thnot watershed.

6.8 **Institutionalization of the Code of Conduct in Prek Thnot Watershed.** A code of conduct should be developed for Prek Thnot watershed that will serve as a guide among the developments (including NGOs). The Code of Conduct will be implemented in tandem with the IWMP and may be part of the EIA compliance.

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