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USAID Mekong Adaptation and Resilience to Climate Change (USAID Mekong ARCC)

Valuing Ecosystem Services in the Lower Mekong Basin:

Country Report for Thailand


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1. INTRODUCTION

Ecosystem services are the benefits people receive from nature. They have immense economic value. Case in point is the ecosystem services provided by the Khao Yai National Park. The Park is one of Thailand's oldest and most popular national parks. It is situated in the western part of the Sankamphaeng Mountain Range, at the southwestern boundary of the Khorat Plateau. The Park is the third largest in Thailand, covering an area of 300 square kilometers, including evergreen forests and grasslands. Its altitude mostly ranges from 400 to 1,000 m above sea level. It is a haven for plants and wildlife. There are 3,000 species of plants, 320 species of birds like red junglefowl and Coral-billed Ground-cuckoo and 66 species of mammals, including Asiatic black bear, Asian elephant, gaur, gibbon, Indian sambar deer, pig-tailed macaque, Indian muntjac, dhole, and wild pig.

The Park is renowned for its recreation, tourism, and research opportunities, attracting between 500,000 and 1 million visitors every year. This translates into a significant economic impact. In one of the earliest studies of ecosystem service values in Thailand, Kaosa-ard et al. (1995) used what is known as the travel cost method to measure the direct use values of the Park, which include ecotourism, biodiversity prospecting, and scientific tourism. They also measured the value of the Park to those who may never visit it but nonetheless are willing to pay to protect its rich diversity of plants and wildlife. These values are measured through what are known as contingent valuation surveys. Taken together, the researchers found the total economic value of the Khao Yai Park to both visitors and non-visitors to be over 3 billion baht (US$ 120 million) per year. Use at the Park has increased over the past two decades, and so has the value of these activities, now totaling nearly US$ 186 million per year.

As the Khao Yai National Park case study suggests, ecosystem services can be categorized into those that arise in association with direct uses such as recreation, tourism, and research. They also include various "non-use" values, such as people's willingness to pay to protect species and habitats they may never see.

This report begins with a description of what ecosystem services are and how they can be categorized. The Millennium Ecosystem Assessment is the most ubiquitous and comprehensive categorization of ecosystem services, which fall into four broad categories: provisioning, regulating, supporting, and cultural (MEA 2005). However, more recently, the European Environmental Agency (EEA) has been sponsoring development of the Common International Classification of Ecosystem Services (CICES) to help negotiate the different perspectives that have evolved around the ecosystem service concept since that time and assist in the exchange of information about them (Haines-Young and Potschin 2012). The CICES classification system groups ecosystem services into three categories: provisioning, regulation and maintenance, and cultural. These are the categories adopted for this report.

The case study also touches on two valuation techniques—travel cost and contingent valuation. There are several more. After reviewing categories and examples, the report discusses each major valuation technique in detail.

The report then highlights several policy venues in Thailand where ecosystem service valuation can play a role. These include policies related to protected areas and conservation, agriculture and aquaculture, urban growth and development, and power development. In each of these policy venues, ecosystem service valuation can help improve decision-making. As an example, new aquaculture development decisions can be made more economically efficient if they take into account the protective flood control services that mangroves and wetlands provide for Thailand's coastal communities. A study following the catastrophic 2004 tsunami correlated loss of life and property to mangrove loss, and, conversely, the life-saving benefits of intact mangrove forests that were able to intercept and diffuse the tsunami's enormous energy (EJF 2006).

Next, the report turns to a seven-step process for ecosystem service valuation. Best practices are drawn from internationally recognized guidelines, such as those summarized by the World Wide Fund for Nature (Emerton 2013). The report then offers some concluding thoughts and underscores the important role ecosystem service valuation will play as Thailand makes the transition to a green economy.

2. ECOSYSTEM SERVICES TYPOLOGY AND EXAMPLES FROM THAILAND

Gretchen Daily is credited with having offered the first formal definition of ecosystem services in 1997: "[e]cosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily 1997). The most ubiquitous definition of ecosystem services used today is a more generalized one: "[e]cosystem services are the benefits people obtain from ecosystems" (MEA 2005). But the concept is rich, and one of its key dimensions is an economic one. It is intertwined with the concept of natural capital – one of the essential forms of capital required for a properly functioning economy (Goodwin 2003). Just like built capital (piped water systems), natural capital (forests) yields annual services (water purification) that have immense economic values because if they were lost, society would have to spend enormous sums of money to replace them. Framed as such, ecosystem services are the services provided by stocks of natural capital such as forests, wetlands, estuaries, marine ecosystems, grasslands and other ecological communities.

One of the earliest efforts to estimate the value of ecosystem services was the seminal study by Costanza et al. (1997), which put ecosystem services on the map in a big way by estimating their annual contribution to the global economy in the order of US$ 33 trillion/yr. In 2014, this study was updated with new unit ecosystem service values and land use change estimates between 1997 and 2011 (Costanza et al. 2014). The authors also addressed some of the critiques of the 1997 paper. Using the same methods as in the 1997 paper but with updated data, the estimate for the total global ecosystem services in 2011 was US$125-145 trillion/yr. in 2007 dollars. The magnitude of the economic values reported in these studies as well as those reported in the vast ecosystem service literature spawned by them has provided the impetus for an increasingly focused international effort to better define what ecosystem services are, how to measure them, and how to incorporate this information into policy decisions.

While the concept is still evolving, one of the leading efforts to synthesize the research and develop standard classifications schemes is the European Environmental Agency's (EEA) Common International Classification of Ecosystem Services (CICES), a process developed to help negotiate the different perspectives that have evolved around the ecosystem services concept over time and assist in the exchange of information about them (Haines-Young and Potschin 2012). The CICES classification system groups ecosystem services into three categories: provisioning, regulation and maintenance, and cultural, described as such:

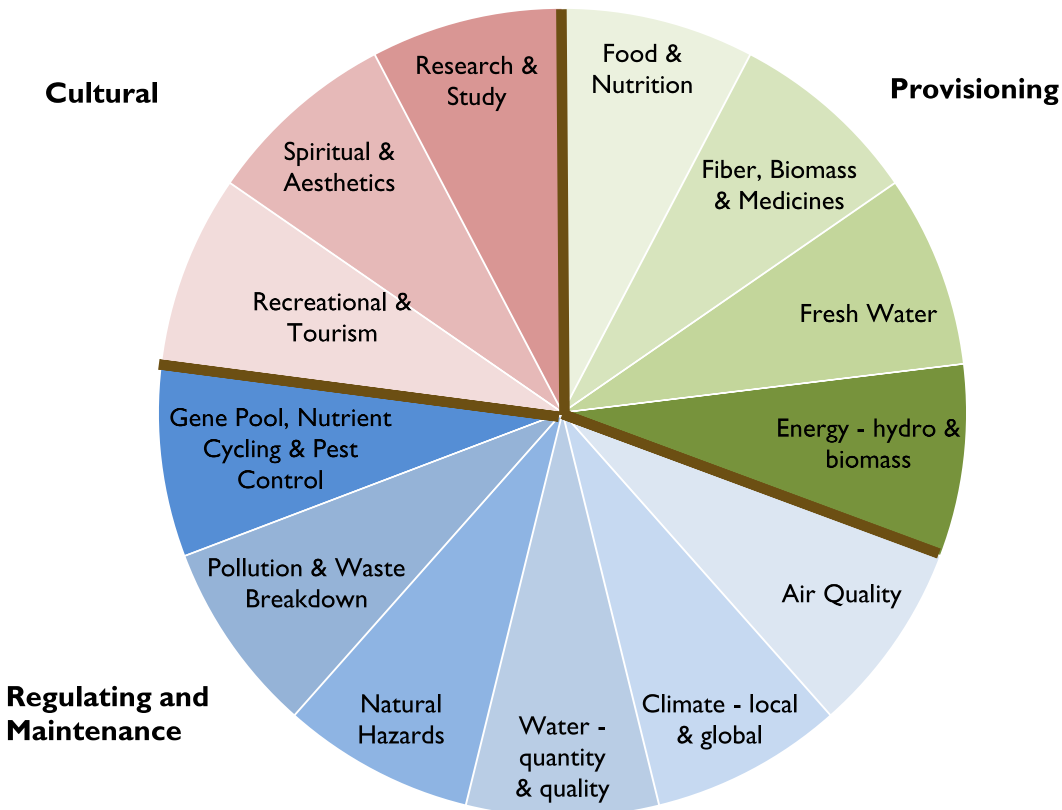
- ***Provisioning services*** -Defined as all nutritional, material, and energetic outputs from living systems. They are tangible things that can be exchanged or traded, as well as consumed or used directly by people in manufacturing. Foods and medicines are some of the most ubiquitous. In Thailand, there have been many studies placing values on provisioning services of natural ecosystems. As one example, Kallesoe et al. (2008) investigated the value of a wide range of mangrove products taken from Laemson National Park by local households. They found that mangrove products like fish, mollusks and crustaceans provide local households with annual benefits in the order of US$ 9,500–14,500. On a per hectare basis, the mangroves found in and around Laemson National Park generate products every year worth US$ 1,336–3,306 to local communities.

- ***Regulating and maintenance services*** - Includes all the ways in which living organisms can mediate or moderate the ambient environment that affects human performance. It includes such services as the breakdown of wastes and toxic substances, flood control, maintenance of biological diversity, carbon sequestration and purification of wastewater. As an example, the International Union for Conservation of Nature (IUCN) (2006) used a cost function approach to placing a value on the storm surge protection benefits of coral reefs in the wake of the 2004 tsunami. They found that the replacement value of coral reefs strategically located to reduce coastal flooding to be nearly US$ 2,100 per hectare—an indication of the value of the reefs that remained unscathed during the event.

- ***Cultural services*** - Includes all the non-material, and normally non-consumptive, outputs of ecosystems that affect physical and mental states of people. They include recreation, scenic and spiritual uses of the land and waters as well as the existence and bequest values people assign to places and species even from afar. The tourism industry is one of the prime beneficiaries of such services, and is increasingly being called on to pay its fair share of the costs of protecting lands and waters it showcases. As an example, Asafu-Adjaye and Tapsuwan (2008) used a contingent valuation survey to investigate the economic benefits of scuba diving in the coral reefs of Mu Ko Similan Marine National Park. Individual benefits were found to be US$ 27.07–62.64 per person per year. Aggregate benefits were between US$ 932,940 and US$ 2.1 million per year for all divers.

Within these major categories (called "Sections"), the CICES system further refines them into additional subcategories. Figure 1 below offers an illustrative example of the types of services within each category. The CICES system is more formally organized into divisions, groups, classes, and class types (see **Annex A**). The increasingly granular classification system, while complex, is designed to provide a uniform, standardized and comprehensive system for the valuation of ecosystem services.

Figure 1: Types and Classification of Ecosystem Services



3. ECOSYSTEM SERVICE VALUATION METHODS

Over the past three decades economists have developed a wide range of methods for assigning monetary values to ecosystem services. The choice of method depends upon the general type of ecosystem service (provisioning, regulating, cultural) whether the service provides direct or indirect benefits to those affected and whether the economic value is associated with use of the ecosystem or associated with its non-use values. The distinction between direct and indirect use and non-use values is illustrated in Table 1, adapted from the US National Research Council (2005).

Direct use benefits of ecosystem services are those that involve some kind of physical interaction, such as the extraction of fish or fresh drinking water from a river or most forms of recreation. Indirect use benefits are those that do not necessarily involve physical interaction but nonetheless represent a beneficial use; for example, the flood control benefits of wetlands that protect certain properties downstream even though the property owners who may benefit may not actually visit the wetlands providing this service.

Non-use values (also referred to as 'passive use values') on the other hand, are intrinsic values people may hold for preservation of a resource even though they may not receive any direct or indirect benefits from it (Kaval 2010; Boardman et al. 2001), but they are willing to pay for such protection, as shown in the example of Khao Yai National Park. Non-use values include those associated with protecting biodiversity or natural landmarks for their own sake (existence values), preserving indigenous cultures (cultural heritage values) or the desire to pass on resources for future generations (bequest values).

Table 1: Major Classification of Ecosystem Service Values and Some Examples

Use values		**Non-use values**
Direct	*Indirect*	
Commercial and recreational fishing	Flood control	Existence value for imperiled species
Aquaculture	Water purification	Existence value for outstanding scenic areas
Hunting	Storm protection	Cultural heritage values for spiritual sites
Fuelwood and timber	Wildlife and fish habitat	Cultural heritage values for national landmarks
Recreation	Pollination of crops	Bequest values for aquifer protection
Genetic material	Carbon sequestration	Bequest values for farmland protection

The concept of total economic value (TEV) is used to describe the sum of all of these values—use, non-use, direct and indirect. TEV provides the most comprehensive measure of ecosystem service benefits and thus represents the "gold standard" when conducting valuation studies. For example, the TEV framework is now widely used to identify the costs and benefits associated with protected areas (ICEM 2003). However, it is also widely understood that certain values—especially non-use values—may be too difficult to obtain and too subjective in many situations. As a result, some researchers have argued for an exclusive focus on use values.

When original valuation studies are undertaken methods for quantifying these values are generally grouped into three major categories: revealed preference approaches, stated preference approaches, and cost-based approaches (Liu et al. 2010; De Groot et al. 2002; Freeman 1993). When budgets do not allow for original valuation studies, researchers use what is known as benefits transfer method. Below is a brief description of these groupings and methods within them.

3.1 REVEALED PREFERENCE APPROACHES

Revealed preference methods of measuring ecosystem service values are based upon actual behavior in organized markets. In other words, value is revealed through direct market purchases of ecosystem goods or services or purchases of other goods or services whose prices are influenced by environmental quality. Specific techniques include:

- ***Market prices***: Valuations are directly obtained from what people actually pay for the ecosystem good or service in formal markets. Examples include the prices paid for fish, game, non-timber forest products, or recreational access.

- ***Travel cost***: Valuations of site-based amenities are implied by the travel costs people incur to enjoy them. For example, average purchases of fuel, food, and airline tickets to visit a particular natural area can be used to derive the value of a recreational visit.

- ***Hedonic pricing***: The value of a service is implied by what people will be willing to pay for the service through purchases in related markets, such as housing markets. A typical example of a situation amenable to use of hedonic pricing is the premium people are willing to pay for houses that are adjacent to parks and open space or which have scenic vistas. This price premium can be translated into a corresponding ecosystem service benefit per hectare.

- ***Factor income***: Ecosystem service values are derived from their impact on yields and income from marketed products. For example, agricultural yields have been shown to be greater in fields that retain more biodiversity (e.g. Shelley et al. 2014). The increase in farmers' income is thus a signal of the underlying value of biodiversity.

3.2 STATED PREFERENCE APPROACHES

Stated preference methods of measuring non-market values use surveys or interviews to ask people directly about their willingness to pay for some good or service or to rank alternative management scenarios and ecological attributes. The surveys typically involve a choice about a hypothetical or proposed situation. A distinct advantage of stated preference methods is that they allow researchers and policy makers to target preferences for specific components of environmental changes, such as existence value (Raheem et al. 2006). A disadvantage is that survey results can be affected by strategic responses, or responses that are designed to influence the outcome of the research, rather than by honest responses. Researchers have also found that some people are not willing to trade money for a loss in environmental quality. Specific techniques include:

- ***Contingent valuation***: People are directly asked their willingness to pay or accept compensation for some change in an ecosystem service or environmental quality. For example, the survey would ask respondents to state their maximum willingness to pay each year into a fund to acquire and protect habitat for an endangered species.

- ***Choice experiments***: Asking a series of questions about a respondent's relative preferences for various management strategies and associated ecological conditions. For example, respondents choose between various levels of water quality with different management strategies and associated costs of achieving those levels. There will typically be three or four alternative strategies with similar attributes (per question) presented.

- ***Conjoint analysis***: A variant of choice experiments where people are asked to rank (rather than choose one) ecological conditions created by various management strategies. For example, respondents would assign ranks to various scenarios for wetlands management that involve tradeoffs between flood control benefits and fishery yields.

3.3 COST-BASED APPROACHES

Cost-based methods use historical cost data or projections to quantify the costs society would incur if an ecosystem were lost or what it would take to replace an ecosystem service with a technological solution. There are three primary methods:

- ***Avoided cost:*** This method assigns values to ecosystem services based on costs that would be incurred in their absence. For example, forests, wetlands, and mangroves provide many flood control benefits. If they were lost, loss of life, property, and damage to infrastructure would increase.

- ***Replacement cost*:** Valuing ecosystem services by calculating the cost of replacing them with technological solutions. For example, replacing natural fisheries with a system of hatcheries or wild pollinators with industrial bee hives.

- ***Restoration cost*:** Restoration cost is a method used to calculate the cost of restoring an ecosystem to its natural state after it has experienced some environmental damage, such as an oil spill (Kaval 2010). Or it involves calculating the cost of restoring ecosystems on damaged landscapes—such as promoting the natural regeneration of woodlands on areas that have been overgrazed by livestock. The cost of restoration is then used as a proxy for its ecosystem service values.

3.4 BENEFITS TRANSFER

All of the methods discussed above are appropriate when analysts have the resources and time to complete original valuation studies. However, in many situations budgets for these studies or the requisite amount of time to complete them do not exist. In these situations, economists use a technique known as benefits transfer to use values obtained from original studies in other, similar settings.

For example, the annual value of fisheries provided by a particular river segment can be approximated by the value calculated for another nearby segment of similar length in the same watershed. Or the per hectare value of non-timber forest products in one area can be applied to the same forest type elsewhere in the region. In using the benefits transfer technique, great care must be given to ensure that (1) both sites are as identical as possible, ecologically speaking; (2) there are no major differences in use patterns—i.e. one in an urban area, one in a rural area; (3) the same service is valued in both situations, and (4) values that are transferred in are calibrated to account for inflation, changes in exchange rates, purchasing power parity, and other economic and demographic factors that may influence the relevancy of the original valuation estimate to the new analysis area (Johnston and Rosenberger 2010; Eftec 2009).

4. POLICY APPLICATIONS

In Thailand, as in all other countries in the Lower Mekong River Basin (LMB), there are a variety of policy settings that can be informed by ecosystem service valuation. In general, valuation can play a role in any policy change that has a demonstrable effect on environmental quality – beneficial or adverse. Without valuation, economically important impacts may be overlooked, such as the loss or contamination of food and medicinal plant supplies for populations that directly obtain these from native ecosystems. Excluding ecosystem service valuation in these situations can distort economic analyses that otherwise seem to support new infrastructure or development decisions.

For example, in a recent re-analysis of several dam-building scenarios for the Mekong that incorporated ecosystem service values associated with lost fisheries and wetlands, Costanza et al. (2011) found that the net economic benefit of each scenario was substantially reduced. At a one percent discount rate (discounting puts future impacts in terms of today's dollars) for example, the benefits from dam building were reduced from positive US$ 33 billion to a negative US$ 274 billion because of the loss of critical ecosystem services (Costanza et al. 2011). The magnitude of this change underscores the importance of accounting for ecosystem services in economic impact assessments of public policy decisions. Below are examples of ongoing policy settings in Thailand where ecosystem service valuation can play an important role.

4.1 PROTECTED AREAS AND CONSERVATION

One of the most obvious policy venues for ecosystem service valuation is in the context of decisions to protect lands and waters by designating them as off limits to most forms of intensive uses. In Thailand, there is an elaborate system of protected areas that includes national parks, national conservation areas, wildlife sanctuaries, non-hunting areas, biosphere reserves, watershed reserves, conserved mangroves, forest parks and a few smaller designations such as botanical gardens and arboreta (ICEM 2003). There are at least 243 protected terrestrial and marine areas encompassing 108,827 square kilometers in Thailand.[1]

Decisions over the extent to which new protected areas should be established, if at all, often involve an economic analysis of "opportunity costs," which are simply the economic value of uses forgone – i.e. without protection, can the land be used productively for agriculture, urban expansion, minerals, or energy? Ecosystem service valuation asks the reverse – i.e. what is the economic value of existing uses that would be displaced if no protection were put in place and do these benefits exceed those from new development? In this way, ecosystem service valuation helps balance an economic analysis that may otherwise fail to capture the benefit stream associated with ecosystems in their natural state.

Valuing the ecosystem services of protected areas also sets the stage for economic development opportunities based on conservation rather than extraction of resources. For example, in 2012, Thailand's Department of National Parks, Wildlife and Plant Conservation announced plans to launch a trial payment for ecosystem services (PES) scheme at five national parks and one wildlife sanctuary in

[1] According to the Protected Planet project at: http://www.protectedplanet.net/countries/217.

cooperation with the United Nations Development Program. A key objective is to evaluate ways to increase revenue through sustainable tourism services and products and/or special user fees (diving, trekking) in order to benefit local communities. Valuation studies for ecosystem services of each protected area will be done to determine direct value of conservation efforts and assist with the design and success of new financing mechanisms.[2]

4.2 AGRICULTURE AND AQUACULTURE

The clearing of forests, grasslands, wetlands mangroves and other natural ecosystems to make room for growing crops, industrial tree plantations and fish farms has historically been the primary driver of ecosystem loss and degradation. For example, 80 percent of tropical deforestation has been caused by conversion to either commercial or subsistence agricultural systems.[3] Ecosystem services are not only lost as a result of direct conversion. Ecosystem services on residual patches of native habitats are often lost or degraded as a result of fragmentation, invasive species, pollution from fertilizers and pesticides and other stresses caused by adjacent land uses.

Agriculture and forest policies can help halt or slow further expansion of agricultural systems into native ecosystems by enhancing the productivity of lands and waters already used for intensive crops and by prohibiting expansion into new areas. Ecosystem service valuation can be used to examine the tradeoffs. For example, aquaculture development decisions tend to be driven by revenue generation, failing to account for interactions with the environment and the full value of the benefits derived from services provided by local ecosystems (Schmitt and Brugere 2013). In Thailand, the consequences of unsustainable aquaculture development decisions were graphically illustrated in the wake of the catastrophic 2004 tsunami.

Research completed by the Environmental Justice Foundation concluded that "the conversion of mangrove habitat into shrimp farms, tourist resorts, agriculture and urban land over the past decades, as well as the destruction of coral reefs, contributed significantly to the catastrophic loss of human lives and settlements" during the tsunami (EJF 2006). In the future, ecosystem service valuation can help decision makers understand the trade-offs between the benefits of aquaculture revenue and the existing ecosystem service values of mangroves and wetlands – including their ability to reduce the impacts of storm surges and tsunamis.

4.3 URBAN GROWTH AND GREEN INFRASTRUCTURE

Thailand is rapidly urbanizing. By 2060, it is projected that 56 percent of its population—or over 34 million people—will live in urban areas.[4] Like many urban areas throughout the developing world, Thailand's urban areas are facing the challenges of low quality housing, high densities, poorly maintained

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[2] More details of the pilot PES project can be found at: http://www.th.undp.org/content/thailand/en/home/operations/projects/environment_and_energy/CATSPA/.

[3] See, e.g. Mongabay Bay "Agriculture causes 80% of tropical deforestation." Available online at: http://news.mongabay.com/2012/0927-drivers-of-deforestation.html.

[4] According to the International Futures forecasting system and the Pardee Center for International Futures at the University of Denver. Available online at: www.ifs.du.edu.

infrastructure, health and environmental hazards, frequent flooding due to poor drainage, and inadequate social services (e.g., Phuttharak and Dhiravisit 2014). To this end, the country is cooperating with international agencies on sustainable urbanization projects such as the Asia Low Emission Development Strategies (LEDs) Partnership.

Within the context of these projects and programs, there is increasing interest in exploring "green infrastructure" solutions such as green alleys, urban forestry, and green open spaces such as parks and wetlands to better cope with floods and coastal storm surges than conventional or "gray" infrastructure technologies such as conveyance channels or sea walls (Emrich and Gegner 2013). Ecosystem service valuation can play a vital role in these contexts by helping to establish whether or not green infrastructure approaches are more cost effective than gray infrastructure especially in light of ecosystem service benefits they provide such as enhance property values, carbon sequestration, water filtration, and recreation (Talberth et al. 2013).

An example is the pressing need to guard Bangkok against the increasingly dramatic toll anticipated from flooding as climate change becomes more problematic. One key strategy that is gaining traction is to invest more heavily in green infrastructure solutions such as ponds, pools, streams, small woodlands, and pocket parks rather than conventional gray infrastructure solutions like large stormwater tunnels and drains (Vanno 2012). Ecosystem service valuation can help quantify the many direct (i.e. flood control) and indirect (i.e. recreational) benefits of green infrastructure so it can be weighed against the cost of gray infrastructure to determine which approach is optimal from an economic standpoint.

4.4 HYDROPOWER DEVELOPMENT

A central component of Thailand's power development plan is to import hydropower from new dams being planned in neighboring Lao PDR, China's Yunnan Province, and Myanmar. Thai investments will back these projects. Hydropower development is an area where ecosystem service valuation can play an important role in the decision making process over whether or not to invest. For example, prospective financing for hydropower projects in Lao that will supply hydropower to Thailand require economic, environmental and social impact studies (Phomsoupha 2012). As previously noted, failure to incorporate ecosystem service values into these studies can tip the balance in favor of a project that would otherwise be shown to create more costs than benefits (Costanza et al. 2011).

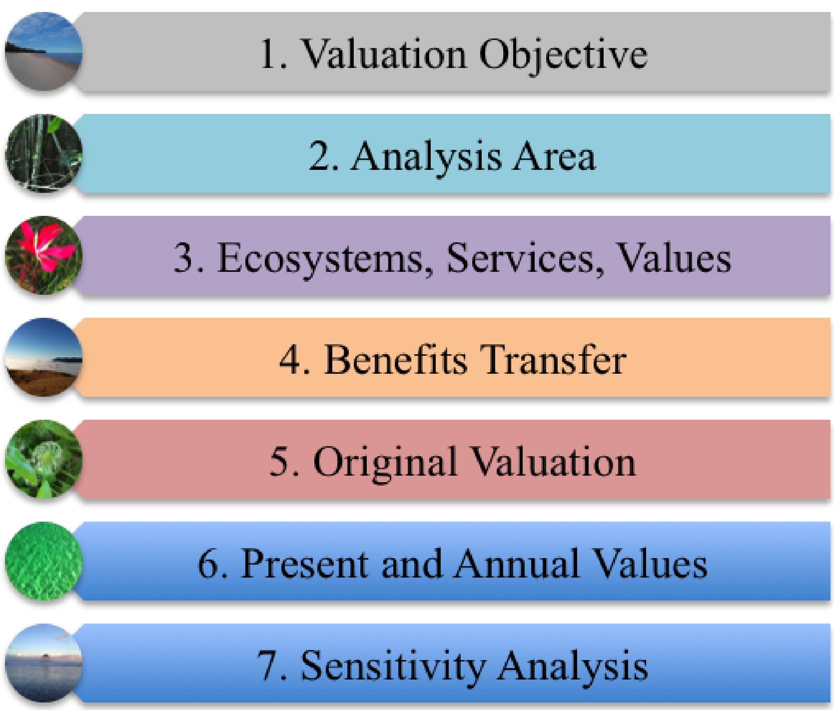
For example, Ziv at al. (2011) modeled the loss of fish biomass and biodiversity that would occur under a number of dam-building scenarios in the Mekong Basin. They found that if all 11 main-stem Mekong dams and 78 tributary dams were built as planned between 2015 and 2030 fish biomass would decrease by over 51 percent and that 100 new species of fish would be placed on the critically endangered status. They conclude that a cost-benefit analysis that puts value both on the hydropower generated and the value of fish biomass to both commercial and subsistence fishing would help identify which tributary dams should be built and which should be avoided.

In this context then, ecosystem service valuation studies that capture the provisioning (fish) and cultural (societal willingness to pay to avoid species loss) services of undammed river and tributary segments would make a critical contribution to a cost-benefit analysis needed to fulfill Thailand's financing guidelines and help ensure that hydropower development decisions are more firmly grounded in the public interest.

5. BEST PRACTICE GUIDELINES FOR CONDUCTING ECOSYSTEM SERVICE VALUATION

Now that the importance of ecosystem service valuation has been recognized, there is a rapidly proliferating body of literature that provides guidance on the step-by-step process and principles for best practice. The World Wide Fund for Nature has published a useful compendium of 49 separate best practice guidelines for valuing ecosystem services in general as well as particular services associated with biodiversity, forests, marine and coastal ecosystems, protected areas and wetlands (Emerton 2013). The compendium also provides links to analytical tools and data sources, and was designed to help guide valuation research in the LMB. Because the valuation guideline literature is relatively new, the processes outlined vary considerably from source to source. Nonetheless, there are several key steps that are common. Seven of these are highlighted below, in sequential order (Figure 2).

Figure 2: Key Steps in Ecosystem Service Valuation



5.1 CHOOSE THE APPROPRIATE VALUATION OBJECTIVE

The first important step in the ecosystem service valuation process is to be clear about the valuation objective (NRC 2005). As discussed in further detail below, this is because the scope of any valuation exercise is largely defined by its objective. There are three common objectives discussed in the valuation literature.

5.1.1 Measuring sustainable economic wellbeing taking nature's benefits into account

Economic wellbeing depends not only on the consumption of goods and services provided by formal markets but on the quality and quantity of goods and services provided by natural ecosystems. As previously noted, ecosystem services are especially important for economic wellbeing in the LMB. It has been reported that roughly 80 percent of the Greater Mekong's 300 million people depend directly on the goods and services its ecosystems provide (WWF 2013). As such, one useful objective of valuation is to measure the contribution of ecosystem services to economic wellbeing in a given country, province, or city and to provide a basis of comparison with the economic wellbeing derived from formal market systems (Liu et al. 2010; NRC 2005).

Relatedly, valuation can also be used to measure *sustainable* economic wellbeing – in other words, how much of the economic wellbeing measured by a valuation exercise is likely to persist over time? This depends on how well the underlying stocks of natural capital are managed. Goodwin (2003) described five types of capital on which a healthy economy depends: built capital, financial capital, human capital, social capital, and natural capital. An economy that maintains or builds its capital stocks on a per capita basis over time meets at least one important criterion for sustainability. Natural capital consists of the stocks of forests, wetlands, grasslands, mangroves and other natural ecosystems. Ecosystem services are the annual benefits of this natural capital stock. If natural capital is being depleted, it will be reflected in declining levels of ecosystem service provision over time either in terms of the quantity of provision or its value. Thus, ecosystem service valuations can be used in conjunction with data on the trends and management status of natural capital to help determine whether or not an economy is on a sustainable growth path.[5]

5.1.2 Informing policy decisions

One of the most ubiquitous and important objectives for ecosystem service valuation is to help evaluate the benefits and costs of public agency programs, policies, and projects that have the potential to either degrade or enhance natural capital and ecosystem services. In this context, "ascribing values to ecosystem goods and services is not an end in itself, but rather one small step in the much larger and dynamic arena of political decision making" (Daily et al. 2009). To the extent that benefit-cost analysis (BCA) or cost effectiveness analysis (CEA) is required by laws, regulations, or operating procedures as part of that political decision making process, failure to include ecosystem service benefits and costs will distort the results (Liu et al. 2010).

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[5] For an overview of natural capital accounting projects worldwide and their importance to sustainable development, please visit the World Bank's Wealth Accounting and the Valuation of Ecosystem Services (WAVES) project website at: http://www.wavespartnership.org/en/natural-capital-accounting-0.

The overall framework for incorporating ecosystem service valuation into BCA or CEA is the "with and without" framework that answers the following question: what will be the value of ecosystem services over time in a particular nation, province, or city with and without the policy change? Typically, this is calculated as the present value of the stream of ecosystem service benefits over a specified time period. As one concrete example of this in the LMB, Emerton (2013) forecasted the ecosystem service values of four types of natural capital and five specific ecosystem services over a 25-year time frame with and without a suite of green economic growth policies. The green economic growth scenario depicts what will happen if the region's protected area system is expanded and re-categorized to include a more representative range of critical ecosystems and management systems, and also if renewed efforts are made to better fund and conserve ecosystems and biodiversity outside these protected areas. Results are provided for Cambodia, Lao PDR, Thailand and Vietnam in **Annex B**.

While the study is based on very coarse-level estimates of ecosystem service values per hectare for each ecosystem type, the results strongly suggest that green economic growth is a tool for enhancing ecosystem service values and associated economic wellbeing. In Thailand, green economic growth policies have the potential to enhance the net present value of ecosystem services from natural forests, freshwater wetlands, mangroves and coral reefs by US$ 2.06 billion, an increase of 7.8 percent over a business as usual economic growth scenario. In terms of specific services, the biggest gains would be associated with regulation of water quality and flow. Green economic growth may boost the value of this ecosystem service in Thailand by over 8.4 percent.

5.1.3 Establishing the basis for market-based solutions

As discussed previously, ecosystem service valuation is playing a role in the emergence of payments for ecosystem services (PES) markets in Thailand. Ecosystem service valuation is critical in helping determine beneficiaries' willingness to pay (WTP) for the services provided by those who influence the provision of ecosystem services from any particular ecosystem type. Conversely, ecosystem service valuation can be used to determine providers' willingness to accept (WTA) payments to forgo a particular land use or practice (i.e. overfishing or overgrazing) that may be degrading ecosystem services. Ecosystem service valuation studies in support of PES can also be used to estimate the overall size of the market—demand and supply quantities—to help determine whether or not PES schemes are likely to be big enough to have an impact on environmental quality.

5.1.4 Place-based ecosystem service valuation

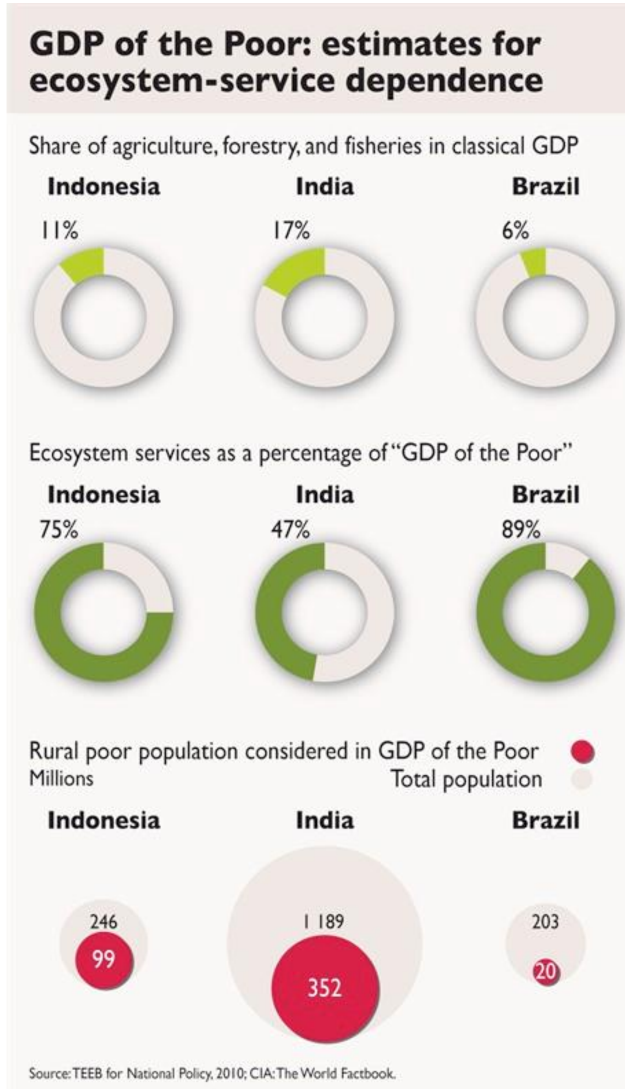
One of the most common objectives is to hone in on a particular ecosystem in a specific area—such as the Khao Yai National Park—and use ecosystem service valuation to develop estimates for the total economic value (TEV) of both market-based and non-market goods and services these ecosystems offer.

5.2 SELECT BOUNDARIES FOR THE ANALYSIS AREA

The spatial boundaries of an ecosystem service valuation exercise depend upon the valuation objective. For the most part, valuation studies carried out for purposes of economic performance evaluation should be set at the appropriate political boundary—a nation, state, province, or city or regional aggregations of these jurisdictions. Within these boundaries, the goal is to measure the contribution of ecosystem services to the resident population. While this may seem inconsistent with the notion of capturing the economic value of a particular ecosystem that confers benefits to people who may reside in multiple jurisdictions, it is consistent with how national accounts and other economic performance metrics are reported. And so setting the boundaries of an ecosystem service valuation exercise to these political boundaries is essential for making comparisons with these metrics.

As an example, work conducted under the auspices of *The Economics of Ecosystems and Biodiversity* (TEEB) project found that ecosystem services and other non-marketed goods make up between 50 and 90 percent of the total source of livelihoods among poor rural and forest-dwelling households—the so-called 'GDP of the poor' (TEEB 2010a). This contrasts with various national GDP figures where, for the most part, agriculture, forestry and fisheries account for between 6 and 17 percent of overall GDP (Figure 3).

Figure 3: Share of Ecosystem Services in the National Economy



When ecosystem service valuation is used for policy analysis, boundaries need not conform to political boundaries or project boundaries. This is because the impacts of a policy change may extend well beyond these boundaries. As an example, changes in agricultural policies that result in the expansion of intensive agriculture into natural forests or other native ecosystem can adversely affect the productivity of downstream freshwater and marine ecosystems. The conversion of natural ecosystems to cropland, pastureland and aquaculture has immediate and local ecosystem service impacts, but improvement of yields through increased fertilizer and pesticide applications can lead to the growth of hypoxic "dead zones" in freshwater and marine ecosystems far away. Globally, the extent of these dead zones has increased more than nine-fold since 1969 and now encompasses more than 245,000 km^2 (Diaz and Rosenberg 2008).

Recent global modeling by FAO suggests that fertilizer consumption could increase from 166 million tonnes in 2005/2007 to 263 million tonnes by 2050 (Alexandratos and Bruinsma 2012). This could be accompanied by a 2.4- to 2.7-fold increase in nitrogen and phosphorus driven eutrophication of terrestrial, freshwater, and near shore marine ecosystems along with "unprecedented ecosystem simplification, loss of ecosystem services, and species extinctions" (Tilman et al. 2001). Thus, an important part of any ecosystem service valuation exercise used to evaluate the impacts of agricultural policies should also consider the downstream impacts on aquatic ecosystem productivity and biodiversity.

Ecosystem service valuation studies that are designed for use in emerging PES schemes should not be constrained by political boundaries either. Rather, the spatial configuration of the study should be defined by the linkages between the beneficiaries of ecosystem services and those who have rights to use and manage the ecosystems that provide them. The two groups may be far removed. For example, PES schemes associated with tourism in national parks are often informed by studies that take into account international visitors' WTP for protection of biological diversity and scenery (Brander and Eppink 2012). As another example, hydroelectric facilities may be willing to participate in a PES scheme to protect water quality and flow that involves landowners and governments located well upstream (Scheufele et al. 2014). So in the context of PES, the geography of ecosystem service valuation studies should be more aligned with beneficiaries and providers rather than ecosystem boundaries or the boundaries of the relevant political jurisdiction.

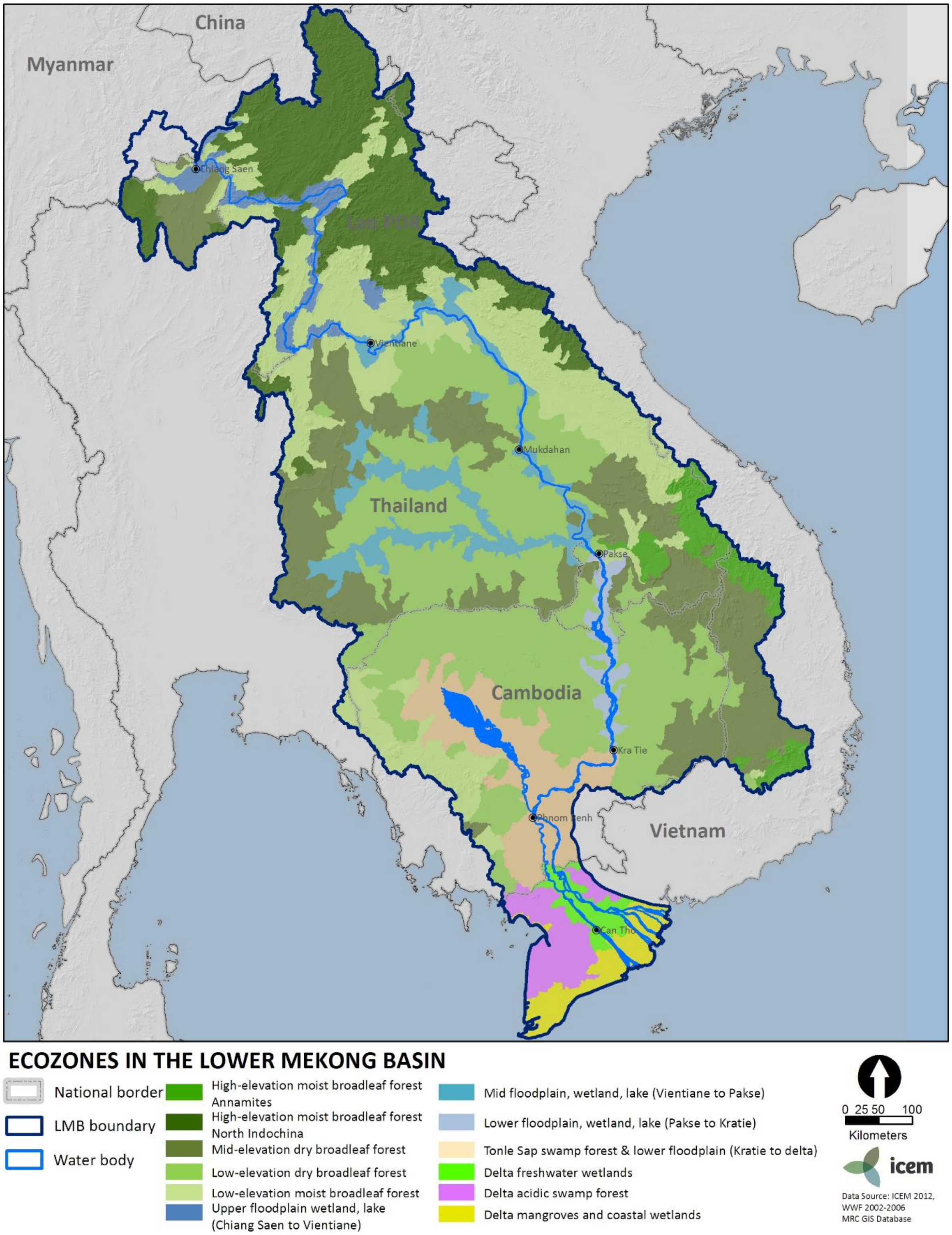
Valuation studies that are designed to fulfil the last objective—valuing particular ecosystems in a particular place—should, of course, be bounded by the extent of those ecosystems unless there is a good reason to further constrain the boundaries. For example, a study's objective may be to generate ecosystem service values for a particular forest type in a particular watershed, but data on use patterns by local villages may be limited to a few places. Rather than extend the results broadly throughout the watershed, the analyst may wish to constrain the boundaries of the study to just those portions of the forest where ecosystem use data is reliable.

5.3 IDENTIFY IMPORTANT ECOSYSTEM TYPES, SERVICES, AND VALUES FOR MEASUREMENT

The next major stage in ecosystem service valuation is to identify the ecosystem types relevant to the study. For purposes of economic performance monitoring, best practice is to consider the services from all major ecosystems in a nation, state, province or city. Aggregating a large number of ecosystem types into a few broad categories may help make the valuation exercise more tractable. Emerton (2013) followed this approach for the four LMB countries by consolidating ecosystems into four categories: natural forests, freshwater wetlands, mangroves and coral reefs.

However, to be more precise, analysts should select a fine-grained classification scheme that is as consistent across province or country boundaries as possible. Fortunately, in recent years, there has been excellent progress on this front. In the late 1990s, the World Wildlife Fund (WWF) developed a useful classification scheme based on ecozones—areas of similar climate, ecosystems and agricultural characteristics and potential. More recently, ICEM refined the ecozone classification system for use in the USAID Mekong ARCC project (Carew-Reid 2013). ICEM's classification includes twelve ecozones that are organized along the Lower Mekong Basin's elevation gradient (Figure 4). Still others are developing additional refinements. For example, in 2014, researchers from several German institutes produced Mekong LC2010—the first specific land cover product covering both the lower and the upper Mekong Basin (Leinenkugel et al. 2014).

Figure 4: ICEM Ecozone Classification Scheme for the Lower Mekong River Basin



Once ecological communities have been identified and classified in a study area, analysts should identify which of the many ecosystem services will be included in the valuation exercise. As previously discussed, CICES is emerging as one of the most ubiquitous classification schemes for these services and thus to maximize consistency with other valuation projects, this system can be used. Obviously, without considerable resources, the analyst should be selective in choosing which of these ecosystem services to address. Often, the research goal is to quantify a particular service that may have been overlooked in previous studies. Or the analyst may want to focus on a particular service or set of services—like carbon sequestration—that may be adversely affected by a project or policy or which may serve as the basis for a future PES program.

5.4 INCORPORATE EXISTING HIGH QUALITY INFORMATION THROUGH BENEFITS TRANSFER

As noted in Section 3.4, one of the most commonly used ecosystem service valuation methods employed when resources for original valuation work are limited is benefits transfer. With benefits transfer, all existing sources of information on ecosystem service values are reviewed, and those that can be reliably transferred to the study site are then calibrated. If existing studies are reliable, there is no need to replicate them and so using benefits transfer early on in a valuation exercise is always a good idea. Regardless of whether or not benefit transfer methods are ultimately used, they should at least be reported in a valuation exercise as a basis of comparison with values from new, original studies.

When benefits transfer is used, there are several sources that provide guidance on best practices. One of the most useful for valuation studies that are conducted to inform policy is the detailed guidance published by Eftec (2009). These guidelines walk analysts through an eight-step process that includes establishing the policy context, defining the appropriate good or service and the affected population, defining and quantifying change in ecosystem service provision, selecting relevant monetary valuation evidence, transferring that evidence, aggregating values for all services addressed and conducting sensitivity analysis.

For Southeast Asia, an extremely useful database of valuation studies was recently compiled by Brander and Eppink (2012). They compiled 787 separate value estimates drawn from 182 studies, many of which can be reliably transferred into ecosystem service valuation studies in the LMB. Of particular importance are studies related to mangroves, wetlands, and swamp forests in the coastal zones and studies that address ecosystem service values of upland tropical forests.

5.5 CONDUCT ORIGINAL VALUATION STUDIES WHERE GAPS EXIST

Once benefits transfer has been completed, gaps should be filled with original valuation studies when time and resources allow. The natural question at this stage is what valuation methods to use. This all depends on the particular ecosystem service being addressed. As discussed in Section 3.0, the choice of method depends upon the general type of ecosystem service (provisioning, regulating, cultural), whether the service provides direct or indirect benefits to those affected and whether or not economic value is associated with use of the ecosystem or associated with its non-use values. The distinction between use and non-use values is illustrated in Table 1. Another important distinction is between ecosystem goods and services that leave either a direct or indirect signal in organized markets (i.e. property values, agricultural yield, non-timber forest products market value) and those that are primarily non-market in nature (i.e. flood control, existence value).

As a general rule, methods for quantifying use values employ one or more of the revealed preference methods reviewed in Section 3.1 since a population's pattern of use of a particular ecosystem forms the basis for assigning values. In contrast, all non-use values are generally quantified through either stated preference or cost-based approaches reviewed in Sections 3.2 and 3.3. De Groot et al. (2002), later updated by Kaval (2010) published a useful table identifying relevant ecosystem service valuation techniques for 22 ecosystem services. The information is reprinted in slightly modified form (excluding some services) in **Annex C**.

5.6 QUANTIFY THE ANNUAL BENEFITS STREAM OVER TIME AND REPORT PRESENT VALUES

There are two general ways to report the results of ecosystem service valuation studies. The first is to report what annual ecosystem service benefits are now and, if the valuation study is policy driven, what they will be as a result of policy changes for the ecosystem types studied. The latter approach is simply the "with and without" approach discussed in Section 5.1.2. The second is to report the present value of this benefit stream over a specified time period. Best practice is to report both figures.

5.6.1 Annual ecosystem service benefit values

With respect to annual values, an important issue is to be able to aggregate values that are reported per person, per household, or per hectare from either benefits transfer or original valuation into a total value for the entire ecosystem or population affected. While this may seem straightforward, the complication is that values may vary spatially and over time, so care must be taken to avoid over- or under-representing the benefit stream.

As one example, coastal storm protection benefits of a particular mangrove ecosystem may be much higher near shorelines with expensive infrastructure in place, but much less so in sparsely populated areas. This is a problem generally labeled as "distance decay." Aggregation of values across sites without accounting for distance decay may result in serious over-estimation of total values (TEEB 2010b). As another example, existence values (measured as household willingness to pay) for establishing a new protected area for endangered species will inevitably rise or fall as a given population's willingness to pay adjusts to changing economic conditions and changes in preferences (Ervin et al. 2014). Accounting for changes over time is most relevant to benefits transfer, where the analyst may be using values developed ten or more years in the past

5.6.2 Present value of the stream of ecosystem service benefits over time

Calculating the "present value" of a stream of benefits is a standard technique involving the use of a discount rate to account for the fact that future benefits may be weighted differently than benefits accruing to the present generation. Two issues involve the selection of a time period and selection of an appropriate discount rate.

In policy impact settings, time periods selected for analysis are typically pegged to the analysis period associated with a proposed project – i.e. a new dam, whose expected useful life is 50 years. However, impacts on ecosystems and their services could extend well beyond a standard time period taken for the policy appraisal. Effects on ecosystems can take considerable time to develop, and this fact should be taken into account in valuation studies. This also requires incorporation of scientific data and models that provide a basis for estimating how these changes will develop over time (DEFRA 2007).

Although in general positive discount rates are used in ecosystem service valuation studies, arguments have been made for either a zero discount rate, signaling that the benefits of ecosystem services to future generations should be given just as much weight as the benefits enjoyed by today's generation, or negative, signaling that the benefits that accrue to future generations are even more important (NRC 2005). But when the idea is to calculate the present value of consumption benefits within just one generation the general approach is to assume a social time preference for consumption benefits now, which justifies a positive discount rate. The rate itself is typically set at the prevailing consumption discount rate.[6]

5.7 SENSITIVITY ANALYSIS

As with most economic analyses, an important final step is to test the sensitivity of results to changes in key assumptions (DEFRA 2007; NRC 2005). Sensitivity analysis is a technique for doing this. In sensitivity analysis, the focus is on values and assumptions used in the studies that are uncertain. TEEB (2010b) provides an in depth discussion on sources of uncertainty, and highlights three main sources: supply of ecosystem services, preference uncertainty (an issue with survey-based methods) and technical uncertainty (i.e. inaccuracies in the methods). Analysts should be aware of these general sources of uncertainty and be able to identify specific values and assumptions that should be incorporated into sensitivity analysis.

In the context of ecosystem service valuation studies, the most common parameters to vary in sensitivity analysis are the underlying assumptions over the physical quantities of the good or service provided, the efficiency of an ecosystem's regulation function and how it may change in response to policy, prices and/or willingness to pay values and how they change over time and in response to changing economic conditions, discount rates and analysis periods.

For example, with respect to the quantity of ecosystem goods and services provided, a given ecosystem type – say upland tropical forests – will typically have a range of yields for non-timber forest products much like agricultural yields vary from region to region based on soil types, elevation, slope, precipitation, and other factors. Therefore, sensitivity analysis can use upper and lower bound values to provide a likely range of ecosystem service benefits rather than relying on just one average figure.

[6] Also known, conversely, as the consumption rate of interest. It represents the interest one would have to receive in order to defer consumption of a given basket of goods and services to a later date.

With respect to the efficiency of ecosystem service provision and how that may change in response to policy, consider the example of wetlands and storm surge damages in coastal areas. One key piece of information that needs to be estimated by underlying scientific models is the centimeters of flooding reduced as a result of a marginal increase in wetland extent and the resulting impact on the probability and severity of economically damaging flood events (TEEB 2010b). The key here is to express the storm surge reduction benefits as a probability, not as a certainty, and in sensitivity analysis the assumed probability can be varied.

Another common approach in sensitivity analysis is to vary the discount rate. As discussed previously, a case can be made for a wide range of rates including zero, a negative rate, or a positive rate. Arguments have also been made for reducing discount rates over time rather than leaving them static to account for changes in economic growth and changes in the certainty of ecosystem service benefit streams over time (Costanza et al. 2011).

6. CONCLUSIONS AND RECOMMENDATIONS

In this document, WRI has provided guidance on standard typologies for classifying ecosystem services, methods for valuation, policy venues where valuation can play an important role, and a generalized seven-step process for best practice. As decision makers in Thailand consider use of ecosystem service valuation studies in the years ahead, there are three key points to keep in mind:

- First, the importance of ecosystem services cannot be underemphasized. As previously noted, it has been reported that roughly 80 percent of the Greater Mekong's 300 million people depend directly on the goods and services its ecosystems provide (WWF 2013). Therefore, if decision makers want good information about economic wellbeing in the LMB, inevitably they must employ the tools of ecosystem service valuation.

- Secondly, there are many policies and investments that have the potential to affect the quantity and quality of ecosystem service provision. Here, we reviewed several examples, but in reality, any policy and/or investment that affects the extent or functioning of intact native ecosystems will also affect the services they provide. And in considering the benefits and costs of such policies, impacts on the flow of ecosystem services must be considered for the analysis to be credible.

- Third, while the field of ecosystem service valuation is relatively new, it has now matured to the point where there is a wealth of detailed technical guidance manuals from which to draw on as well as a rich portfolio of ecosystem service valuation studies in the region that can be helpful. Many of them have been cited or reviewed here. Thus, when the need for valuation arises, lack of information should not be a significant barrier.

As Thailand further embraces a green economic growth pathway, ecosystem service valuation can play a role in ensuring that the flow of goods and services that nature provides will be protected, restored and managed to enhance livelihoods especially for those who are most vulnerable and lacking in resources.

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ANNEX A

Table 1: Common International Classification of Ecosystem Services (CICES) – Major Ecosystem Service Classifications

Type of service	General type of output or process	Specific type of output or process
Provisioning	Nutrition	Biomass
		Water
	Materials	Biomass
		Water
	Energy	Biomass-based
		Mechanical energy
Regulating	Mediation of wastes	Mediation by biota
		Mediation by ecosystems
	Mediation of flows	Mass flows
		Liquid flows
		Gaseous/air flows
	Maintenance of conditions	Habitat and gene pool
		Pest and disease control
		Soil formation and structure
		Water quality
	Atmosphere and climate	Greenhouse gases
		Micro and regional climate
Cultural	Physical interactions	Experiential
		Intellectual
	Spiritual and symbolic	Spiritual and emblematic
		Other cultural outputs

Table 2: Common International Classification of Ecosystem Services (CICES) – 4-digit Classification System for Provisioning Services

Section	Division	Group	Class	Class type
This column lists the three main categories of ecosystem services	***This column divides section categories into main types of output or process.***	***The group level splits division categories by biological, physical or cultural type or process.***	***The class level provides a further sub-division of group categories into biological or material outputs and bio-physical and cultural processes that can be linked back to concrete identifiable service sources.***	***Class types break the class categories into further individual entities and suggest ways of measuring the associated ecosystem service output.***
Provisioning	Nutrition	Biomass	Cultivated crops	*Crops by amount, type*
			Reared animals and their outputs	*Animals, products by amount, type*
			Wild plants, algae and their outputs	*Plants, algae by amount, type*
			Wild animals and their outputs	*Animals by amount, type*
			Plants and algae from in-situ aquaculture	*Plants, algae by amount, type*
			Animals from in-situ aquaculture	*Animals by amount, type*
		Water	Surface water for drinking	*By amount, type*
			Ground water for drinking	
	Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing	*Material by amount, type, use, media (land, soil, freshwater, marine)*
			Materials from plants, algae and animals for agricultural use	
			Genetic materials from all biota	
		Water	Surface water for non-drinking purposes	*By amount, type and use*
			Ground water for non-drinking purposes	
	Energy	Biomass-based energy sources	Plant-based resources	*By amount, type, source*
			Animal-based resources	
		Mechanical energy	Animal-based energy	*By amount, type, source*

Table 3: Common International Classification of Ecosystem Services (CICES) – 4-digit classification system for regulation and maintenance services

Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	*By amount, type, use, media (land, soil, freshwater, marine)*
			Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	*By amount, type, use, media (land, soil, freshwater, marine)*
		Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	*By amount, type, use, media (land, soil, freshwater, marine)*
			Dilution by atmosphere, freshwater and marine ecosystems	
			Mediation of smell/noise/visual impacts	
	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	*By reduction in risk, area protected*
			Buffering and attenuation of mass flows	
		Liquid flows	Hydrological cycle and water flow maintenance	*By depth/volumes*
			Flood protection	*By reduction in risk, area protected*
		Gaseous / air flows	Storm protection	*By reduction in risk, area protected*
			Ventilation and transpiration	*By change in temperature/humidity*
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	*By amount and source*
			Maintaining nursery populations and habitats	*By amount and source*
		Pest and disease control	Pest control	*By reduction in incidence, risk, area protected*
			Disease control	
		Soil formation and composition	Weathering processes	*By amount/concentration and source*
			Decomposition and fixing processes	
		Water conditions	Chemical condition of freshwaters	*By amount/concentration and source*
			Chemical condition of salt waters	
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	*By amount, concentration or climatic parameter*
			Micro and regional climate regulation	

Table 4: Common International Classification of Ecosystem Services (CICES) – 4-digit classification system for cultural services

Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	*By visits/use data, plants, animals, ecosystem type*
			Physical use of land-/seascapes in different environmental settings	
		Intellectual and representative interactions	Scientific	*By use/citation, plants, animals, ecosystem type*
			Educational	
			Heritage, cultural	
			Entertainment	
			Aesthetic	
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic	*By use, plants, animals, ecosystem type*
			Sacred and/or religious	
		Other cultural outputs	Existence	*By plants, animals, feature/ecosystem type or component*
			Bequest	

ANNEX B

Table 5: Ecosystem Service Values in the Lower Mekong Basin With and Without Green Economic Growth Policies

(All values reported in 2013, net present value, US$ billions)

Source: Emerton (2013)

	Cambodia		Lao PDR		Thailand		Vietnam	
	ESV w/o	ESV with	ESV w/o	ESV with	ESV w/o	ESV with	ESV w/o	ESV with
Natural forests	$6.78	$8.18	$26.34	$28.23	$12.81	$13.66	$18.26	$19.80
Freshwater wetlands	$9.92	$11.13	$12.54	$13.96	$13.34	$14.46	$10.03	$10.87
Mangroves	$0.16	$0.18	-	-	$0.58	$0.64	$0.35	$0.38
Coral reefs	$0.01	$0.01	-	-	$0.39	$0.44	$0.23	$0.26
Total:	**$16.87**	**$19.50**	**$38.88**	**$42.19**	**$27.13**	**$29.19**	**$28.87**	**$31.31**
Harvested products	$4.36	$5.16	$6.98	$7.54	$6.03	$6.44	$9.02	$9.77
Watershed protection	$0.61	$0.73	$14.68	$15.73	$2.14	$2.28	$7.92	$8.59
Carbon sequestration	$2.99	$3.61	$6.18	$6.63	$6.00	$6.40	$3.97	$4.30
Water quality & flow	$8.76	$9.84	$11.05	$12.29	$12.11	$13.13	$7.46	$8.09
Coastal protection	$0.13	$0.15	-	-	$0.74	$0.83	$0.44	$0.50
Coastal tourism	$0.02	$0.02	-	-	$0.10	$0.11	$0.06	$0.06
Total:	**$16.87**	**$19.50**	**$38.88**	**$42.19**	**$27.13**	**$29.19**	**$28.87**	**$31.31**

ANNEX C

Table 6: Ecosystem Services and Commonly Used Methods for Assigning Dollar Values

Ecosystem Service	Market or Non-market	Use or Non-use	Valuation Methods
Science and education	Market	Use-direct	Market valuation, benefit transfer
Recreation	Market Non-market	Use-direct	Market valuation, contingent valuation, travel cost, choice experiments, factor income, hedonic pricing, avoided costs, restoration costs, benefits transfer
Genetic and medicinal resources	Market Non-market	Use-direct Use-indirect	Market valuation, factor income, benefits transfer
Raw materials	Market Non-market	Use-direct Use-indirect	Market valuation, factor income, contingent valuation, choice experiments, benefits transfer
Food production	Market Non-market	Use-direct Use-indirect	Market valuation, factor income, contingent valuation, choice experiments, benefits transfer
Nursery function	Market Non-market	Use-direct Use-indirect	Market valuation, contingent valuation, avoided cost, replacement cost, factor income, choice experiments, restoration costs, benefits transfer
Plant and animal refugia	Market Non-market	Use-direct Use-indirect Non-use	Market valuation, contingent valuation, choice experiments, restoration costs, benefit transfer
Soil formation	Market Non-market	Use-direct Use-indirect Non-use	Market valuation, avoided cost, benefits transfer
Air and water quality	Market Non-market	Use-indirect	Market valuation, avoided cost, replacement cost, factor income, contingent valuation, choice experiments, benefits transfer
Pest control	Market Non-market	Use-indirect	Market valuation, replacement cost, factor income restoration cost, benefits transfer
Recycling of wastes	Non-market	Use-indirect	Contingent valuation, replacement cost, choice experiments, benefits transfer
Stabilizing climate	Non-market	Use-indirect	Avoided cost, benefits transfer
Erosion control	Non-market	Use-indirect	Avoided cost, replacement cost, restoration cost, benefits transfer
Plant pollination	Non-market	Use-indirect Non-use	Avoided cost, replacement cost, factor income, benefits transfer
Aesthetic beauty	Non-market	Non-use	Contingent valuation, choice experiments, benefits transfer
Human culture	Non-market	Non-use	Contingent valuation, choice experiments, benefits transfer
Preservation	Non-market	Non-use	Contingent valuation, choice experiments, benefits transfer
Biodiversity maintenance	Non-market	Non-use	Contingent valuation, choice experiments, restoration costs, avoided costs, benefits transfer