Understanding how people and the environment interact

The science of environmental and social systems – what it means for human wellbeing and a healthy environment in the long term

In some places, the natural environment has become so degraded that it fails to provide critical functions needed for human survival and wellbeing; in other places, it is entering a 'danger zone' in which there is a high risk of irreversible ecological changes occurring.

In 2005, the Millennium Ecosystem Assessment warned readers that "Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fibre, and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth. The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of the degradation of many ecosystem services, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people."[23] The Assessment also found that "some systems have eroded their capacity to provide services on a regional basis, such as inland waters, forests and drylands"[24] and "the increased efficiency of use of many ecosystem services has been offset by increases in the absolute amounts of consumption of services, giving rise to serious concerns about the sustainability of their supply."[25]

ESPA has not produced a comprehensive scientific assessment equal to the Millennium Ecosystem Assessment but, instead, has (during 2010–2018) supported a set of leading-edge scientific research projects to test and illuminate the dependencies of human wellbeing on environmental resources. ESPA studies look at the drivers of environmental loss and replenishment, the human consequences of these dynamics, and the institutions and governance that help to shape them.

The relationship between environmental degradation and human wellbeing is not a simple linear relationship.[26] Sudden and unpredictable changes in ecosystem services include the collapse of fisheries from overfishing, rapid soil salinisation caused by shrimp farming, and the switch between clear and turbid lake water caused by gradual increases in nutrient-rich run-off.[27] Scientific research has shown that when ecological limits such as these examples are transgressed, then the natural environment can reach unprecedented, irreversible and often undesirable states.[28] The concept of a 'safe operating space' describes the conditions within which a system should remain to avoid crossing these thresholds of irreversible change – or 'tipping points'.

Caribbean coral reefs are said to have passed such a threshold – and to have become rapidly and unexpectedly encrusted with algae. Here, nutrient loading (e.g. through agricultural run-off) provided the conditions for algae to grow on the reefs. At first, fish ate the algae and kept it in check. However, decades of over-fishing reduced fish numbers and meant that fish could no longer perform this function. Scientists were surprised when a sea urchin, *Diadema antillarum*, moved into the fish's ecological niche and ate the algae growing on the coral reefs instead. The coral reefs seemed to be faring well, but their fortunes were short-lived. Next, a disease spread throughout the *Diadema antillarum* population, killing most of the urchins. Algal growth suddenly flourished again on the coral reefs, creating an ecological tipping point, which will be difficult and costly to reverse – that is, if it is even possible to reverse.[29]

Tipping points are typified by the large impacts of very small changes which require significant investment to reverse. Simply returning the driver of the change back to its previous levels may not be enough to recreate the former state due to internal positive feedback effects.[30]

An example of where an ecological system has tipped is the Erhai catchment in China. Within a matter of months in 2001, the Erhai lake's aquatic ecosystem passed a critical transition from relatively clear, healthy water to a turbid eutrophic (oxygen-starved) state. Today, despite implementation of measures to reduce nutrient pollution from farming and sewage plants, the lake shows no evidence of returning back to its previous state. The water quality has passed across a physical boundary into the 'danger' zone.[31] ESPA research demonstrates how, in Erhai and nearby Shucheng catchments, exploiting environmental resources for farming supported many micro- and macro-level measures of development in the past, such as education and health care. However, authorities in these catchments have not yet managed to extend universal access to piped water, energy and modern sanitation, and with freshwater resources now in such a dire condition, it will be a huge challenge to meet these remaining development needs.[32]

This study demonstrates trade-offs between recent successful poverty alleviation and acute environmental degradation. It is a negative relationship, by which some elements of poverty alleviation (food) are achieved in the short term at the expense of other elements of wellbeing (human health) and the longer-term health of the environment.

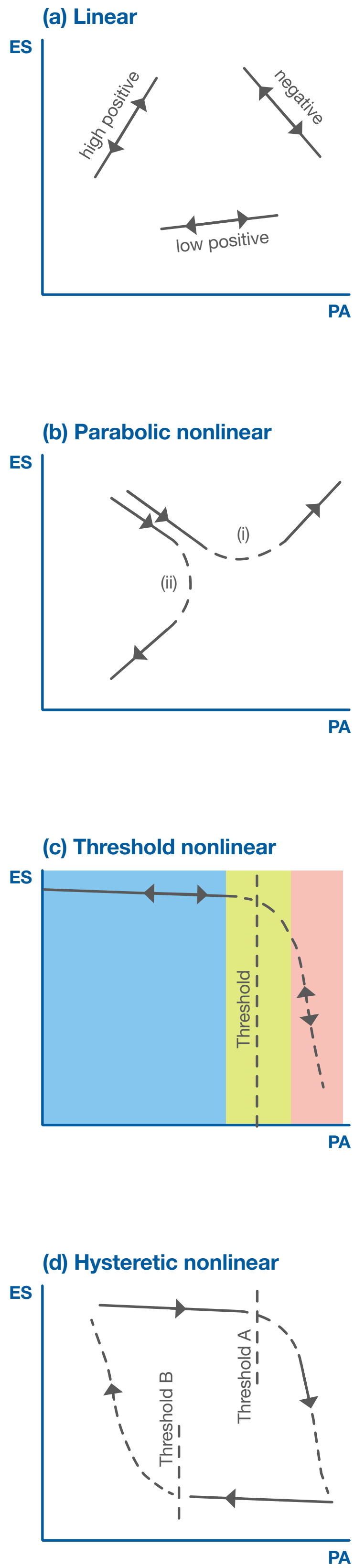
Another study, in coastal Bangladesh, found that the localised impacts of global environmental change (in this case, climate change and associated sea level rise) is having profound impacts on social–ecological systems and people's ability to live and thrive in these places. The investigation by the ESPA Deltas team in nine coastal districts of Bangladesh measured water salinity in groundwater – as affected by sea-water intrusion – and the blood pressure of local people. It found that 80% of residents relied on drinking from groundwater sources, that high blood pressure (prehypertension and hypertension) was significantly associated with saline drinking water, and that almost half of the overall population in these areas is either prehypertensive or hypertensive. This is high: from 21% to as much as 60% higher than the expected incidence of high blood pressure based on Bangladesh's national statistics. Residents aged over 35 years old and women are particularly vulnerable, and show the worst health impacts. The study also found that the population's salt intake and blood pressure are likely to increase in the coming years, foretelling much individual suffering as well as a collective impact on the public health system. It could be said that this delta system is moving uncontrollably towards passing thresholds into danger zones, where people and ecological systems may lack the resilience to withstand further changes in the climate or other ecological and social pressures.[33]

How do decision-makers know when an ecosystem is reaching a critical threshold or tipping point? It has been very difficult to develop models to simulate these processes adequately and to capture multiple 'feedback loops' among different types of environmental, social and economic change. Simulating future changes in social–ecological systems in ways that capture thresholds has been particularly challenging.[34]

ESPA research has highlighted the notions both of 'elasticity' between poverty alleviation and environmental outcomes, and of breaching thresholds, both of which are illustrated in Box 5.

In practical terms, there are steps that policy-makers can take to monitor the interaction of social and ecological systems and their proximity to 'tipping points' and danger zones. Policy-makers can invest in research that measures indicators of environmental health and human wellbeing over decades in order

Box 5: Relationships between poverty alleviation and ecosystem services



Many theoretical and empirical relationships between human wellbeing or poverty alleviation and the quality or abundance of ecosystem services have been proposed by ESPA researchers and others. The ESPA evidence base provides conclusions about the quality and functioning of certain regional and subnational ecosystems – and how poverty and wellbeing are experienced there. However, there is not a single overarching conclusion about the relationship between wellbeing and ecosystem services over time: this is an area that calls for more research.

In the graphs presented here, ecosystem services may represent aggregated services but, more realistically, a sub-set of provisioning, regulating, supporting or cultural services. Graph (a) shows various **linear** relationships between ecosystem services (ES) and poverty alleviation (PA), and possible directions and elasticities (or strengths) of these direct relationships. Negative elasticity describes situations where poverty alleviation efforts succeed even as ecosystem services decline; positive elasticity describes situations where poverty increases as ecosystem services improve. Elasticity is either 'low' when social and ecological systems are weakly related or 'highly elastic' when the relationship is strong. Graph (b) is a '**parabolic nonlinear**' relationship between ecosystem services and poverty alleviation. On this trajectory, which is often gradual: (i) regulating ecosystem services (such as water quality) decline with agricultural intensification and then improve as poverty is alleviated and regulatory frameworks improve; (ii) activities to alleviate poverty, such as logging, cause regulating ecosystem services (e.g. forest cover, biodiversity) to decline, which eventually has negative effects on provisioning ecosystem services (e.g. forest products) and so increases poverty; at this stage, regional resource exploitation leads to growing inequalities in wellbeing. Graph (c) is a '**threshold nonlinear**' relationship between ecosystem services and poverty alleviation, where crossing a threshold causes a relatively rapid decline in ecosystem services, for example the loss of rice yield (provisioning ecosystem services) as investment in larger shrimp farms causes widespread soil salinisation. The example uses the definition of 'safe, cautionary and dangerous operating spaces' (blue, green and pink), which in theory may be reversible. Graph (d) is a '**hysteretic nonlinear**' relationship between ecosystem services and poverty alleviation, where – in contrast to (c) – threshold responses between ecosystem services and poverty alleviation may be irreversible or time-lagged, for example the loss of fish stocks (provisioning ecosystem services) as technological investment in fish catch methods transgresses threshold A; fish stock recovery requires fishing efforts to be reversed beyond threshold A to threshold B, with losses of income or livelihoods.[35]

to generate the data that makes it possible for rich analysis of long-term trends about the relationships between these variables, and the feedbacks among them. Investing in robust data collection and research will enable scientists and policy-makers to work together to assess where certain ecosystems are on the curve (Box 5) and how close the ecosystem is to reaching an ecological threshold. Policy-makers can also work in partnership with scientists to model social–ecological interactions, including using some of the approaches and building on some of the insights that ESPA projects have revealed. A general conclusion is that such modelling exercises can be repeated and refined as users learn by doing, and the models can provide useful guidance rather than predictions.

Policy-makers can recognise that development pathways are constantly evolving. Policy and practice can be understood as requiring a constant 'nudging' of development trajectories in directions that don't close options, avoid undesirable ones, and stay away from known or suspected thresholds – learning and adapting along the way (see 'Learning and adapting', page 29).[36]

Beyond simple definitions of poverty and wellbeing – taking a fair and just approach

One of the most important findings of ESPA research is the need to recognise different values. When it comes to identifying development activities, whose view and judgment is seen as the most valid? How are the different opinions of different stakeholder groups weighed and resolved?

ESPA research has highlighted, for instance, that the notion of what it means to be 'poor' – and also its opposite, what it means to feel well and fulfilled – differ according to culture and circumstance. Therefore, it is important for people impacted by decisions over environmental resources to articulate **how** different outcomes will affect them.[37,38]

Understanding wellbeing in this more nuanced and differentiated way – as ESPA research has done – highlights inevitable trade-offs over the access to and use of environmental resources. Approaches to decision-making and governance based on environmental justice help with the value judgements necessary to resolve these trade-offs. For instance, participation in decision-making over access to and use of environmental resources is important because it brings to light what is important to affected people. When people's values are recognised and their concerns addressed (or mediated), then they are more likely to support the outcomes of the decision process. The outcomes should be fairer and better sustained. Part III investigates core principles of good governance in more detail, with ESPA examples.

Existing frameworks to measure human wellbeing do not adequately capture the highly context-dependent indicators of human wellbeing used by rural communities that rely on ecosystems for their primary source of subsistence. These communities frequently place greater emphasis on the intrinsic value of natural resources (e.g. ritual, symbolic, cultural, identity). Studies that take a more comprehensive and non-utilitarian approach can contribute to the agenda by privileging local views and understandings of ecosystem services (particularly those of the most vulnerable).[39]

Development policies and programmes – identifying the hidden costs and potential for resource-dependent people

Many development policies and programmes that are based on the extraction and use of environmental resources are being designed and implemented without adequate recognition of who currently stewards and uses environmental flows, who will be affected by development interventions, and how.

> Some of ESPA's research has highlighted environmental protection initiatives that engender different benefits or disadvantages for women and men.

ESPA research highlights the risks of oversimplifying our understanding of human–environment relationships and the importance of assessing socially disaggregated outcomes. This has implications for the design of interventions that are intended to alleviate poverty.[40] There is abundant evidence on how development programmes that are based on natural resource extraction and use are failing to achieve their poverty reduction goals – or are even inadvertently disadvantaging the poorest people. ESPA research provides further evidence from its portfolio.

Changing agricultural policies in Rwanda have affected local people's livelihoods and wellbeing. An ESPA study shows that lower-income households are struggling to benefit from policies that back intensive monocultures, compared to mixed-crop farming systems that previously dominated.[41]

The charcoal industry is among the most important semi-formal economic sectors in sub-Saharan Africa and a key cash income source for local households who produce it. There is a debate around the role of charcoal production in alleviating rural poverty. ESPA research in southern Mozambique found that charcoal production is failing to lift its producers out of acute poverty – when poverty is measured by a composite of nine indicators: sanitation, water security, mortality of children under 5, access to equitable health care, formal education, food security, access to services, associations and credit, assets owned and housing.[42]

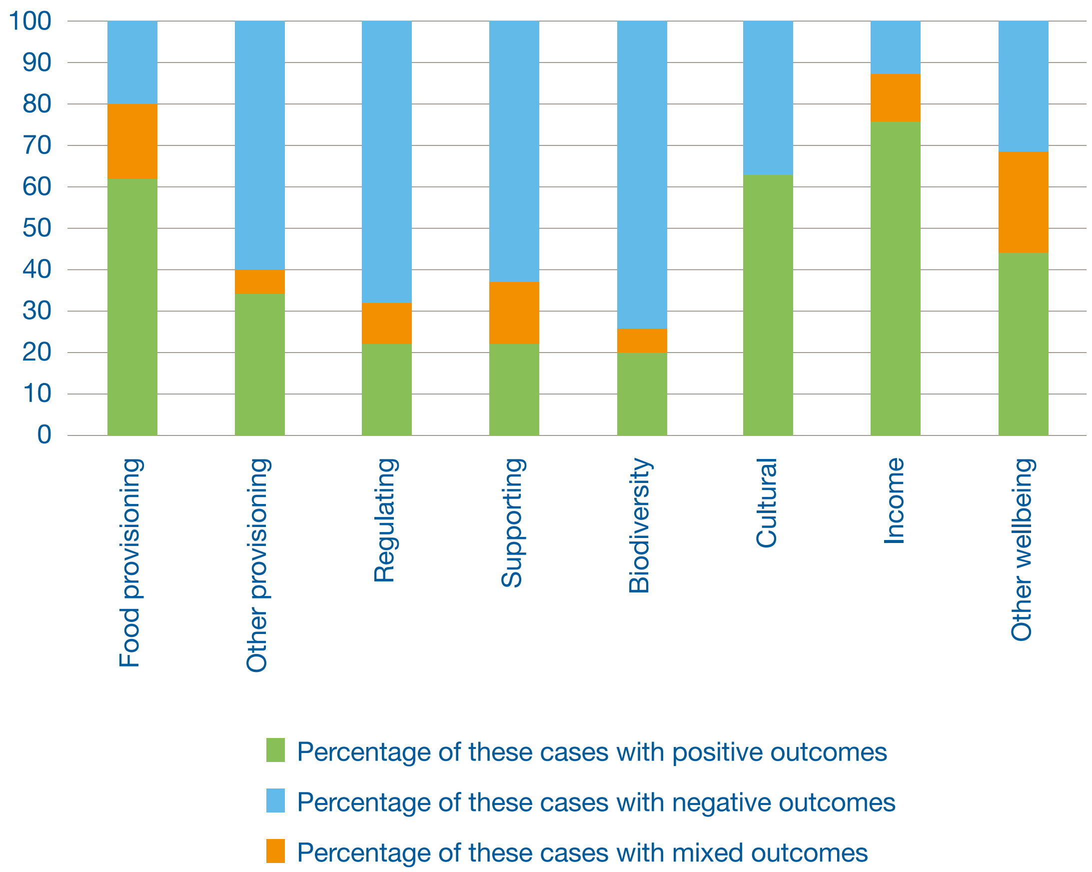
Jatropha-based biofuels have attracted private sector and government interest in Malawi in the past decade, as part of a strategy to reduce poverty and stimulate rural development, but these hopes are not yet fulfilled. ESPA research has found that jatropha production in Malawi has minimal impact on food security and poverty alleviation, and the situation is unlikely to change unless high-yielding plant varieties are tested in real conditions and market options improve. By contrast, the researchers found that food security improved and overall poverty decreased for the rural poor involved in sugarcane production (another biofuel crop) – although the environmental impacts of sugarcane depend on the location and must be assessed and tackled on a case by case basis.[43] As with the charcoal research, a multidimensional poverty index was used to assess the effects on local people's lives.

Land-use intensification is disrupting environmental resources – and requires urgent scrutiny as a development strategy

There are seemingly compelling reasons to intensify land-based production systems, such as agriculture, and yet the benefits of higher productivity have too often been accompanied by massive and detrimental contributions to global, regional and local environmental change.[44] By 2050, there will be an estimated 9 billion people on the planet, potentially requiring a massive increase in global food production. Meanwhile, there is increasing competition for land arising from other urgent global and local challenges, including the expansion of protected areas to help conserve biodiversity and the rise of bioenergy crops to help tackle climate change. Policy-makers have focused predominantly on the potential to increase agricultural yields through intensification.

An ESPA review of the most recent research in this area revealed that land-use intensification in fact poses an increasing threat to future food production because it is degrading ecosystems so profoundly: through accelerated soil erosion, loss of biodiversity, pest damage and changes to nitrogen and phosphorous cycles. Intensification has also led to over-extraction of water and pollution of water sources, while agriculture already accounts for 70% of freshwater extraction and demand is predicted to increase by 70–90% by 2050. The ESPA review finds that local food and income are most often increased as a result of land-use intensification efforts, but even then, they sometimes decrease (see Figure 2). On the other hand, some indicators of sustainability that are widely recognised as important outcomes of land use (e.g. water purification, water regulation) are infrequently researched and, when they are, record negative outcomes in the majority of cases.

Figure 2. Proportion of land-use intensification studies reporting positive and negative outcomes for different categories of ecosystem services and human wellbeing[45]



Environmental conservation policies and programmes – hidden costs and opportunities

The architects of environmental conservation policies and programmes are also, in many cases, failing to recognise the complex relationships between people and the environment, including between people and biodiversity. As a result, many environment programmes are inadvertently making local poverty worse.

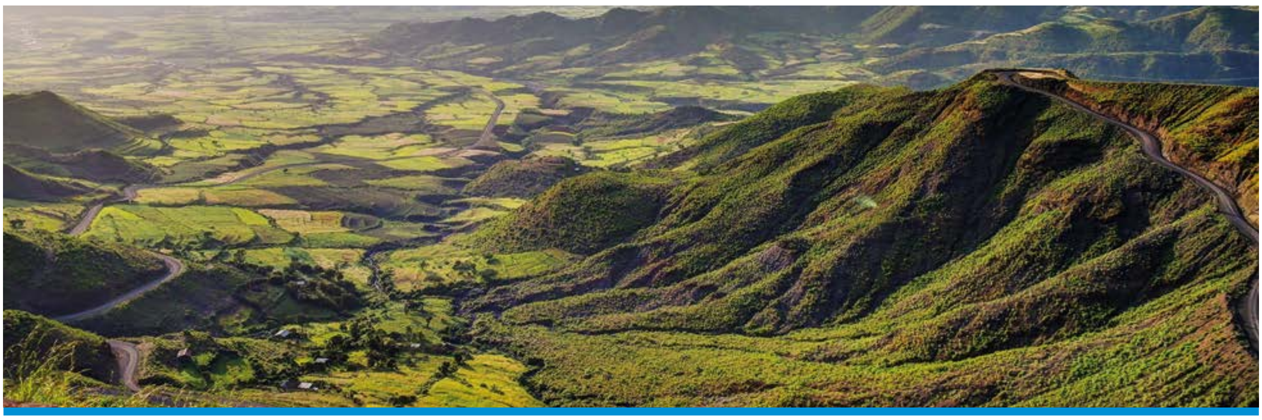
Because these relationships are not clearly identified, and some of the costs to local people are hidden, programmes are being poorly designed – to the detriment of development and environmental goals. ESPA research has found major instances of environmental programmes disadvantaging the poorest local people. Programmes for increased forest conservation to protect the global climate, programmes to ensure provision of water to downstream users and biodiversity conservation initiatives, including those intended to protect species with high tourism potential, have all been found to commonly lead to short-term losses to local populations in the availability of food, fuel and other basic needs from the environment, and/or increased prevalence of harm to local people such as farmers suffering from crop-raiding animals.[46]

Better work up front to assess impacts, identify and avoid harm, and manage trade-offs will pay dividends for people and the natural environment. While the Millennium Ecosystem Assessment identified inequity in the ways in which environmental resources are accessed and transformed into human wellbeing,[47] ESPA research details such inequities, **particularly** those resulting from environmental conservation initiatives.[48]

A key problem has been that much research on the impacts of conservation interventions does not disaggregate social data adequately to identify precisely who benefits and who loses.[49] For example, a given governance strategy may raise average incomes, but these gains may serve to make the relatively well-off richer while excluding the poorest and most vulnerable.[50]

ESPA research has highlighted instances where environmental policies and programmes failed to benefit poor and marginalised households, or further harmed them, and so ultimately led local people to respond in ways that undermined the intended environmental goals. A study of who benefits from community forestry found that such schemes are more likely to generate positive change at community level rather than directly benefitting poor and marginalised households.[51]

Some of ESPA's research has highlighted environmental protection initiatives that engender different benefits or disadvantages for women and men. For instance, programmes to reduce the use of illegal fishing gear on the Kenyan coast may improve the number of large expensive fish but have a negative impact on the



wellbeing of women who rely on selling smaller fish.[52] A different study found that men and women have very different expectations of their involvement with conservancies (wildlife protection areas) around the Maasai Mara National Reserve in Kenya. Women tended to favour membership in a conservancy and they valued wage income significantly less than men. Overall, the study found that community members perceived engagement with conservancies to be positive, as long as they were able to retain some land for other purposes – and that great care is necessary to consult individuals on their preferences, to avoid harm.[53] Box 6 describes how violent conflicts have arisen from Tanzanian wildlife conservation initiatives.

In addition, more transparent, participatory governance and management of environmental resources, as explored in the next section of this report, can unlock human capital. Such processes could unlock the talents of natural resource users, including their relevant local knowledge, and could motivate them to work in partnership with others for a more sustainable collective future.

> **Incentivising particular land-use and land management strategies may give rise to new types of trade-offs because altering socio-environmental interactions directly affects local resource users, potentially exacerbating the vulnerability of some members of the community.[54]**

Box 6: Realising the potential of Tanzania's wildlife management areas

Tanzania's Community Wildlife Management Areas (CWMAs) – originally called Wildlife Management Areas – were intended to benefit both people and wildlife. However, for their first two decades, CWMAs have been characterised by land conflict, wildlife damage to people and crops, lack of tourism potential and high administration costs, among other negative impacts.

Fundamental elements of the wildlife management area design – i.e. their governance and management arrangements and the way budgets are administered and financial benefits derived – appear to be flawed and so undermine these joint poverty alleviation–environmental goals. For instance, village income from CWMAs is often insufficient to offset or compensate for wildlife damage to crops and livestock or the opportunity costs of CWMAs borne by local communities. Retention of parts of the revenue by central government and CWMA administration costs erode tourism revenues. ESPA researchers have engaged with wildlife area managers and policy-makers to recommend that the 'rules of the game' should be rewritten. Specific recommendations include:

- "Rethinking the division of CWMA revenues could make them more financially and socially viable.
- Giving CWMA villagers sustainable access to key natural resources will benefit rural livelihood security and reduce the potential for conflict.
- Revenue sharing between CWMA villages should be based on negotiations between the villages, considering costs borne related to human-wildlife conflict, tourism investments, and land surrendered to CWMA.
- Fair and transparent consultation and planning for new CWMAs will improve the likelihood of community buy-in.
- Empowering villages to make changes to CWMA plans will make CWMAs more legitimate, and so more sustainable."[55]

Understanding the interactions among society and environment better, and developing richer assessments that identify social costs and support policy-making

ESPA science has demonstrated how smarter assessments can bring to the surface both the hidden costs and the hidden potentials of resource-dependent peoples in both development interventions and environmental conservation policies and programmes. As well as demonstrating how multidimensional poverty indices can be used effectively (above), ESPA has also shown that integrated social–ecological modelling tools are useful as part of an open, participatory decision-making process.

ESPA scientists have charted how even small delays in reducing pressures on environmental systems may result in "catastrophic changes if it allows ecosystems to reach tipping points, where their characteristics and functions fundamentally change."[56] Given current technologies and monitoring systems, it is likely that scientists will be too late to detect an imminent tipping point, if at all, before an ecosystem is "committed to large shifts in state".[57] ESPA projects trialled research using smaller (e.g. regional) scale social and ecological processes as a way to conceptualise complex, global socioecological systems and concluded that such hybrid models linking human and ecological systems can be developed – and indeed, offer hope for supporting radical policies to address environmental crises.[58]

ESPA projects looked at practical ways that decision-makers can get to grips with social–economic–environmental complexity, and understand the interactions as a guide to better decisions – sometimes by applying existing approaches in new situations or adapting them to modern pressures. The Driver–Pressure–State–Impact–Response (DPSIR) is one such framework. Although first developed almost 20 years ago, ESPA researchers described how the framework can be applied in an iterative way to understand interactions among different activities and pressures in a continual cycle of learning, rather than in a linear fashion.[59] Driving forces, including socioeconomic and environmental variables, exert pressures on ecological systems. These pressures cause changes in the state of a system with impacts on individuals and communities (people or other species) that had depended on the system. These impacts cause responses, which in turn affect the driving forces on the system.

The ESPA Deltas team developed an integrated framework that describes the many complex links and drivers between the Ganges–Brahmaputra–Meghna delta environment and the wellbeing of the delta's population (see Box 7). In this vast coastal region, models show an increase in monsoonal and coastal flooding; salinity has been statistically associated with poverty and migration is often not an option for the very poor, who may be left behind. ESPA researchers have promoted collaboration between scientists and policy-makers to establish 'early warning' indicators for ecosystems, to sound the alert when an ecological threshold or tipping point may be drawing closer, and also highlighted the importance of taking precautionary measures to avert ecological damage that brings social and ecological systems nearer to unmanageable tipping points.[60]

Ecosystem service modelling tools can provide decision-makers with information on ecosystem services flows to guide certain decisions, even when the data measured are inadequate. These outputs may prove valuable in addressing questions on changing land use, valuing natural capital, and analysing co-benefits and trade-offs of different policies or activities. Because more than 80 fast-evolving ecosystem service models or assessment tools are available, technical advisors can benefit from guidance on the types of models available and considerations in choosing the models best-suited for specific policy questions. The 2013–2016 WISER (Which Ecosystem Service Models Best Capture the Needs of the Rural Poor?) project, for instance, assessed four ecosystem service modelling tools in sub-Saharan Africa and provided a general assessment of their utility (see Box 8).

Box 7: Interdisciplinary modelling for pro-poor policy-making: Experience from Bangladesh

The ESPA Deltas team undertook an ambitious, interdisciplinary study to understand the ecosystems of coastal Bangladesh and the lives of the millions of people who benefit from them. A key aim was to make the findings available to decision-makers who are seeking to protect and improve the livelihoods and wellbeing of the people who live in this dynamic delta environment. The project's many findings have been integrated into a sophisticated model, the Delta Dynamic Integrated Emulator Model (ΔDIEM).

The researchers collected and analysed socioeconomic data, including an innovative household survey. This ran in parallel to a major effort to analyse and simulate a range of biophysical and socioeconomic processes, including sedimentary, morphodynamic (landscape) and hydrological processes. Incorporating stakeholder views and an understanding of how legal, institutional and policy frameworks connect ecosystem services and poverty alleviation was fundamental to the team's work.

From this broad range of emerging knowledge, ESPA Deltas developed an integrated framework that describes the links and drivers between the Ganges–Brahmaputra–Meghna delta environment, the ecosystem services it supports, and the poverty, health and livelihoods of the delta's population. In particular, the team was interested in who would benefit from the different pathways offered by different development interventions, as well as the integrity and future of the ecosystems themselves.

The ΔDIEM is distinct in linking biophysical, socioeconomic and governance processes to consider a range of plausible futures. Given a particular development trajectory or intervention, it can assess the resulting range of impacts of change over time on the livelihoods and wellbeing of the people of the Ganges–Brahmaputra–Meghna delta, from a regional-level scale down to the lowest administrative tier (Union level, some 20,000 people), and for every year up to 2050 (2100 for biophysical change only). It can consider a wide range of environmental changes, natural hazards and climate change, and policy interventions, in various permutations. The ΔDIEM is currently being used to test the potential interventions identified by the Planning Commission of the Government of Bangladesh in line with the aims of the Bangladesh Delta Plan 2100, such as making a sea wall higher and/or planting mangrove strips. The researchers took account of stakeholder priorities and knowledge, and these issues informed the scenario development process.[61]

Box 8: How ESPA tested the role of ecosystem models in African policy-making

The WISER (Which Ecosystem Service Models Best Capture the Needs of the Rural Poor?) project evaluated the effectiveness of a range of modelling approaches for mapping several ecosystem services – stored carbon, water availability, charcoal and firewood forest products, and grazing resources – at multiple spatial scales across sub-Saharan Africa. Several points emerged from the WISER study.

- Ecosystem service modelling tools and models are a resource to help decision-makers address a variety of resource management questions, particularly in assessing how different actions will affect ecosystem services and the economic value of these services.
- Models have different levels of accuracy. Generally, more complex models are more accurate. However, in any application, the accuracy of a model cannot be known without validation against measured ecosystem service data.
- Decision-makers should be aware of the uncertainty in model predictions and its impact on their decisions. Uncertainty may be reduced by constantly improving the model's fit to the available data; continuing to gather information during policy implementation to ground-truth, assess and improve the models; and, where possible, by running multiple models for the targeted ecosystem service(s) to generate a range of possible outcomes.

An ESPA survey of 60 technical experts in Africa showed that they unanimously found ecosystem models to be useful in advising policy-makers – when there was enough data and the models were deemed sufficiently accurate. They emphasised the usefulness of modelling alternative scenarios or counterfactuals as a basis for discussion with policy-makers and to highlight the ecological consequences (and their social implications) of different measures.[62]

Joint discovery and knowledge creation

To develop sound understanding of the links between human and ecological systems requires a marriage of scientific knowledge with ground-truthed, more localised knowledge from the people who are affected by environmental decisions.

The use of modelling tools by scientists and technical experts can be part of a well-designed assessment of situation analysis, but alone it is not sufficient. Any assessment of social–ecological drivers, impacts and responses needs to be validated by representatives of the social groups involved and affected.

Some ESPA projects working at local and subnational scales have gone further than consulting – and have partnered directly with community groups to involve them in gathering information about the state of the environment and human–environment interactions, in various 'citizen science' initiatives (see Box 9).

"Ideally, 'consumers' of research become active co-producers of research. This is not only instrumental for impact, but also improves the quality of research. But co-production requires a foundation of trust between researchers and actors at different levels of governance. At the very least, researchers should discuss findings with communities, resource managers, etc. Cheap tools, such as ecosystem monitoring and web-based analysis, stimulate participatory research, build adaptive capacity, and can be extremely useful in remote areas." – ESPA Fellows, quoted in ESPA (2017).[63]

> “Ideally, ‘consumers’ of research become active co-producers of research. This is not only instrumental for impact, but also improves the quality of research.” – ESPA Fellows

Box 9: Citizen science as a way of defining a shared problem

In the Peruvian Andes, the Mountain EVO project pioneered new methods for collecting and analysing data to inform decision-making, involving volunteers from local communities. In the study area, subsistence agriculture and cattle-raising are central to local communities’ livelihoods, but heavy grazing of mountain pastures in the uplands, combined with increasing water scarcity and irregular rainfall, has created new uncertainties and vulnerabilities. The Huamantanga community is under severe pressure to implement water and land conservation practices, not only to improve their own livelihoods but also to respond to the heavy demands for water coming from the capital city, Lima, the country’s economic backbone and one of the driest cities in the world. The Mountain EVO project trained community volunteers to collect data on the water cycle, including rainfall levels, river flows and air temperature. This was combined with existing data, including satellite imagery and measurements from governmental monitoring networks, and then analysed to generate results relevant to local concerns. The information was fed back to the local community and disseminated via posters and web-based tools to decision-makers at the local and national levels. Locally, the Mountain EVO project’s introduction of participatory data collection methods has enabled communities to look at different scenarios and take informed decisions about the ideal balance between cattle grazing and streamflow, ultimately adjusting their catchment management practices to optimise this balance.[64]