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Regenerative landscapes

Rejuvenation of linked livelihoods and catchment ecosystem services

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Report for Royal Institution of Chartered Surveyors

Report written by:

Dr Mark Everard
University of the West of the England (UWE Bristol)
mark.everard@uwe.ac.uk

RICS Research team

Dr. Clare Eriksson FRICS
Director of Global Research & Policy
ceriksson@rics.org

Katherine Pitman
Global Research Project Manager
kpitman@rics.org

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Glossary

Anchor service: an ecosystem service that is the desired focus of ecosystem use or management, that can serve as an 'anchor' around which consequences for other interlinked ecosystem services are assessed and, where possible, optimised.

Anicut: a low dam across gently sloping land built to retain water during monsoon flows.

Chana: chick pea (Hindi).

Chauka: 'rectangle' (Hindi) pits dug in Laporiya to intercept monsoon run-off.

Dahl: lentil (Hindi).

Ecosystem services: the multiple, diverse but often overlooked benefits that ecosystems provide to people.

Externalities: unintended negative outcomes.

Flood-retreating cropping: a common production method in dry regions with seasonally variable rainfall, exploiting stored soil moisture in the margins of water bodies for cropping as water levels recede.

Gram Sabha: village council (Hindi).

Gram Vikas Navyuvak Mandal, Laporiya (GVNML): an NGO (translating as 'village growth youth board, Laporiya') based in the village of Laporiya (in the Jaipur District of Rajasthan state, India) working on water and ecosystem management for community security.

ICW: integrated constructed wetland.

Jal Bhagirathi Foundation: Indian NGO with interests in promotion of water self-sufficiency, primarily working with rural communities.

Johad (plural 'johadi'): a generally semi-circular dam built across a drainage line in the landscape to intercept monsoon run-off.

Naadi: a low bund surrounding fields on land with a low slope (Hindi).

Nexus: a linked set of interacting parameters, often in sustainable development discourse highlighting the integrally interlinked nexus of food, water and energy that may limit human development.

Out-scaling: promotion of wider geographical pervasion of successful initiatives.

Payments for ecosystem services (PES): a market-based instrument in which the beneficiaries of ecosystem services make payments to ecosystem stewards influencing the provision of those services.

Regulatory lag: time lag entailed in revision of the regulatory environment to reflect evolving understanding and priorities.

Sustainable Catchment Management Programme (SCaMP): water quality protection initiative in the north-west of England based on landscape management.

Socio-ecological systems (SES): tightly linked ecosystems and the socio-economic activities and prospects of people dependent upon and also influencing them.

System: a complex whole (a cell, a universe, an atom, a watch, a corporation, etc.) comprising interacting or interdependent component parts, each surrounded and influenced by its environment and other elements of the system.

Systemic solutions: "…low-input technologies using natural processes to optimise benefits across the spectrum of ecosystem services and their beneficiaries" (Everard and McInnes, 2013).

Taanka: a water-harvesting structure (WHS) adapted to water capture in flat, arid lands.

Tank: monsoon water interception and storage system.

Tarun Bharat Sangh (TBS): a Gandhian-based NGO based in Alwar District (Rajasthan state, India) working on water and ecosystem management for community security.

Up-scaling: replication of successful schemes at larger scale to increase overall benefits.

Upstream Thinking: a water quality protection initiative in south-west England based on landscape management.

WaterHarvest: the rebranded name, adopted in 2017, for the community-facing NGO Wells for India.

Wells for India: a community-facing NGO established initially as a UK-based charity in 1987 with water management, sanitation and self-sufficiency goals, with an operational base in Udaipur (Rajasthan, India).

List of abbreviations

CRP	US Conservation Reserve Program.
eNGO	Environment NGO.
GPS	Global Positioning System.
GVNML	Gram Vikas Navyuvak Mandal, Laporiya (Indian NGO).
IMAWESA	Improved Management in Eastern & Southern Africa (Nairobi).
IWSN	International Water Security Network.
NFM	Natural flood management.
NGO	Non-governmental organisation.
PES	Payments for ecosystem services.
REDD+	The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries.
SCaMP	Sustainable Catchment Management Programme.
SES	Socio-ecological systems.
STEEP	A conceptual framework comprising social, technological, economic, environmental and political elements.
SuDS	Sustainable drainage systems.
TBS	Tarun Bharat Sangh (Indian NGO).
TCW	The Converging World (NGO).
TDEF	Tropical dry evergreen forest.
US EPA	United States Environmental Protection Agency.
WHS	Water-harvesting structure.

Executive Summary

Context

Global humanity made significant, if regionally variable, social and economic progress during the twentieth century. Previous research has shown that human pressures resulting from land and other resource management strategies implemented to serve our rapidly growing demands for food, fresh water, timber, fibre and fuel have resulted in the serious and continuing degradation of most global major habitat types. Ecosystem damage over the last 50 years of the twentieth century was greater than in any comparable period of human history, with estimates that the demands of contemporary global society effectively consume 1.5 'Planet Earths'.

There is a pressing need to use landscapes and other ecosystems in more sustainable and integrated ways if the prognosis of non-renewable landscape exploitation is to be slowed, halted and eventually reversed. This report highlights the need and the means for rebuilding ecosystem carrying capacity across rural, urban and other cultural landscapes. The term 'regenerative landscapes' refers to uses and management of natural resources not simply for narrow purposes, but instead in ways that ensure as many as possible of the multiple supportive capacities of the ecosystem are retained or restored, building system resilience and supporting a diversity of linked socio-economic benefits.

Purpose and scope of this report

The focus of this 'regenerative landscapes' report is to highlight the need and the means for rebuilding carrying capacity across rural, urban and other cultural landscapes, with a significant emphasis on water.

The aim of this research is to identify how linked environmental and socio-economic rejuvenation can be achieved, by: (a) examining community governance approaches within landscapes degrading water and soil resources; and (b) collating case studies to illustrate and characterise the breadth of potential regenerative approaches to landscape management. Three important concepts are utilised throughout the report and underpin more systemically informed, more sustainable decision-making and practice:

- **Socio-ecological systems** (SESs) describe the inextricable interdependencies between nature and the socio-economic activities and prospects of people dependent upon them.
- **'Anchor services'** describe the primary outcomes for which ecosystems are used or managed, such as for food production or water supply.
- **'Systemic solutions'** are techniques working with natural processes that seek to optimise all ecosystem service benefits.

Methods

The study is based on primary research conducted in two Indian states during 2015/16: (1) semi-arid Alwar and Jaipur Districts of Rajasthan state; and (2) the Coromandel Coast of Tamil Nadu state. Secondary research also draws upon relevant examples from a wide global range. The main findings from these sources are collated into a knowledge base, and these findings are then stratified around the STEEP (social, technological, environmental, economic and political) framework to characterise key features behind the success of regenerative approaches, critically including the systemic relationships between constituent elements of the STEEP framework. The study identifies transferrable success factors to accelerate progress towards regenerative ecosystem uses both in study regions and for more generic application.

Main findings

(1) Reanimating the water cycle in Indian and other drylands

Many of the pressing challenges in the developing world, also relevant to increasingly pressured areas of the developed world, relate in one way or another to degradation of the water cycle. Regenerative examples are drawn from primary research in semi-arid Alwar and Jaipur Districts of Rajasthan State, India. Evidence from these case studies and others drawn from Pakistan and multiple other drier regions of the tropical developing world demonstrate that the reversal of former cycles of SES degradation is achievable when water management techniques are framed on a local basis. Local geographical conditions and the needs of local people should inform design, supported by investment and continued ownership and co-management.

(2) Forest restoration to secure ecosystem services for human wellbeing

Trees play multiple, significant roles in the water cycle, including landscape rehabilitation and the provision of societal benefits often remote from where these services are produced. Primary research in schemes restoring tropical dry evergreen forest (TDEF), a now highly fragmented, but once pervasive, locally appropriate forest type on the Coromandel Coast of Tamil Nadu, India, demonstrates how forest restoration funded by the marketable 'anchor service' of climate regulation can result in the regeneration of a range of linked societally beneficial ecosystem services.

A range of other forest-related examples from the literature, drawn from across a diversity of biogeographical zones and states of development (Costa Rica, New Zealand and the UK) endorse how investment based on a range of marketable 'anchor services' or priority policy outcomes (water, biodiversity, carbon, tribal lifestyles and others) can drive conservation and regeneration of forests, also yielding a diversity of linked ecosystem service co-benefits. The significance of forests for supporting SESs has been recognised and promoted by a range of international agreements about halting and reversing forest loss and degradation.

(3) Landscape management for multiple ecosystem services

Ecosystem-based landscape and waterscape management can protect water quality as an 'anchor service', mobilising management attention and investment whilst simultaneously co-generating a wider set of ecosystem service benefits such as water storage, soil retention and quality, nutrient cycling and habitat for biodiversity, all increasing the capacity of landscapes to sustain human wellbeing.

Principles of success

There is no simple objective criterion defining indisputable public good or equity. Today's challenges are not unidimensional but are 'wicked problems', difficult or impossible to solve because of incomplete, contradictory and changing requirements, and complex interdependencies.

Ecosystem services offer a framework to articulate this complexity by recognising the multiplicity of interconnected outcomes that arise from all interventions in ecosystems. Ecosystems services thereby provide a more integrated basis for decision-making and the formulation and implementation of policies. This systemically framed approach also implicitly reconnects people to decision-making, illuminating the needs of and impacts on all ecosystem service beneficiaries. Framing this connection within the broader political and technological dimensions introduced by the STEEP framework helps make this tractable in complex socio-political systems.

Systemic failures have been described in terms of narrow interpretation and/or lack of integration between several interlocked factors, the reversal of which conversely comprise success criteria underpinning regenerative outcomes. Headline principles underpinning regenerative SESs are:

- **Social considerations**
  - **a.** Inform the design and operation of ecosystem uses and management with locally articulated needs.
  - **b.** Integrate the views of multiple stakeholders into decision-making.
  - **c.** Recognise traditional knowledge and practices as a legitimate and locally appropriate source of knowledge.
  - **d.** Out-scale successes using proven and important social networks.
  - **e.** Recognise local people as the owners of, and key actors in, resource use.
  - **f.** Link differing social needs across geographical scales.
  - **g.** Encourage social cooperation, applied in a manner sympathetic with natural supportive landscape functions.
- **Technological considerations**
  - **a.** Avoid imposing uniform, 'top down' solutions, which tend to result in net degradation.
  - **b.** Adapt technical solutions to localised geographical and cultural contexts, also taking account of their long-term consequences.
  - **c.** Develop 'systemic solutions' to optimise outcomes across a range of ecosystem services.
  - **d.** Progressively integrate evolving best practice into farming techniques and the associated policy environment.
- **Environmental considerations**
  - **a.** Recognise that the services of natural ecosystems are a core resource generating multiple benefits.
  - **b.** Work in sympathy with natural processes operating both locally and at scales broader than parochial land ownership.
- **Economic considerations**
  - **a.** Recognise that all ecosystem services have tangible value.
  - **b.** Take account of the systemic ramifications of solutions for costs and benefits across all ecosystem services and their associated beneficiaries.
  - **c.** Take a 'systemic solutions' approach to identify innovations that work with natural processes, optimising the overall societal value of investments in ecosystem management and use.
  - **d.** Progressively integrate an expanding range of services into markets.
  - **e.** Challenge assumptions that multi-service outcomes are not profitable.
- **Political considerations**
  - **a.** Delegate decision-making to a level most appropriate to account for local geographical and cultural contexts.
  - **b.** Recognise the significant roles that non-government organisations play in mobilising local activity and liaising with funders and formal government.
  - **c.** Utilise nested governance arrangements to avert fragmented management.
  - **d.** Take into account potential effects on interrelated ecosystem services, spanning disciplinary interests, in regulatory decisions.
  - **e.** Co-design programmes between government and local people around common agreed goals to achieve pragmatic, locally relevant and accepted solutions.
  - **f.** Address driving policy or other development priorities as 'anchor services', around which outcomes for all ecosystem services and hence net societal value are optimised.

A systemic approach to all of these interconnected factors is essential. As with any system, **all aspects of the STEEP framework have to be addressed in an integrated way**. Regenerative outcomes are possible only when all facets of the system inform decision-making and resource use. When choices, for example about technology selection and operation, are made accounting for protection of natural processes and human needs, these tend to promote long-term sustainability, equity and economic viability. When this virtuous circle is achieved, many co-benefits can result.

To provide a practical context to application of the derived Principles of success, two contrasting 'real world' challenges are elaborated in the Appendices. Appendix 1 comprises a developing world case of out-scaling regenerative water management more widely across Rajasthan. Appendix 2 addresses the developed world priority of influencing mainstream intensive farming onto a more regenerative path. These analyses provide insight into the primary questions to ask and obstacles to overcome, such as integrating market and other policy drivers to create greater synergy between the aspirations of nested layers of society. They also highlight opportunities, such as the potential for co-learning based on localised successes.

This regenerative landscapes report takes an optimistic view of the potential and means to review established practices to achieve regenerative uses of landscapes and natural resources. It intends to stimulate a review of policy and decision-making processes concerning agricultural and other land uses the influence of business on natural resource use and policy areas from transport to defence. The report is intended to reflect that all spheres of human activity and interest have a bearing and influence on the pursuit of setting SESs at all scales on a regenerative course.

1.0 Introduction

Global humanity made significant, if regionally variable, social and economic progress during the twentieth century. However, human pressures resulting from land and other resource management strategies implemented to serve our rapidly growing demands for food, fresh water, timber, fibre and fuel have resulted in the serious and continuing degradation of most global major habitat types (MEA, 2005a). Ecosystem damage over the last 50 years of the twentieth century was greater than in any comparable period of human history, with estimates that the demands of contemporary society effectively consume 1.5 'Planet Earths' (Global Footprint Network, 2016).

Efforts to ensure the provision of affordable food, construction materials, fuel and other commodities are both laudable and desirable. However, economic systems have tended to reward farmers for the production of cheap food and other commodities, such as food and timber, but have not succeeded in providing incentives to protect, maintain or improve the other ecosystem services that landscapes provide to society. If wider impacts on supporting ecosystems are overlooked, it is likely that tightly linked socio-ecological systems (SES) as a whole will degrade. Global resource exploitation habits are degrading the integrity, functioning and supportive capacities of ecosystems globally at an increasing pace, compounded by population growth, climate instability and globalised supply chains (MEA, 2005a). This pervasive model of habitat exploitation for narrow benefits tends to create 'degenerative landscapes': landscapes locked into a spiral of linked ecological, ecosystem service and socio-economic decline.

There is a pressing need to use landscapes and other ecosystems in more sustainable and integrated ways if the prognosis of non-renewable landscape exploitation is to be slowed, halted and eventually reversed. This report highlights the need and the means for rebuilding ecosystem carrying capacity across rural, urban and other cultural landscapes. The term 'regenerative landscapes' refers to the use and management of natural resources, not simply for narrow purposes, but instead seeking to optimise the full range of processes and benefits that landscapes perform and provide.

1.1 Research aim and objectives

The aim of this research is to identify how linked environmental and socio-economic rejuvenation can be achieved by: (a) examining community governance approaches within landscapes degrading water and soil resources; and by (b) collating case studies to illustrate and characterise the breadth of potential regenerative approaches to landscape management. Both degenerative and regenerative landscape examples are drawn from the developing and the developed world. The report's objectives are to:

1. identify case studies where spirals of degradation have been halted or reversed;
2. draw out the characteristics of 'regenerative landscapes' where recovering ecosystems support socio-economic benefits; and
3. extrapolate the key lessons from these case studies, developing recommendations for policy and practice.

1.2 Structure of this report

This report comprises four principal sections. This section (Section 1) introduces the concept of ecosystem services. It also explains how different uses of landscapes and other natural resources may result in either the degradation of ecosystems or, alternatively, their protection or regeneration. It explains how these impacts on ecosystems in turn have impacts on associated ecosystem services supporting a diversity of human needs. The reasons why it is important to reverse such pervasive degenerative cycles widely observed in SES are also discussed. Section 2 provides details of the research methods. Section 3 outlines the main findings from the primary and secondary research, providing examples of regenerative ecosystem management from both the developing and developed worlds. Section 4 outlines the principles of success in the achievement of regenerative landscapes, stratifying them into social, technological, environmental, economic and political considerations. These principles are illustrated with examples from the case studies. This section also provides observations on systemic design, outcomes and transferrable lessons.

1.3 Understanding ecosystems services and degenerative landscapes

1.3.1 Understanding systems and ecosystems

A systems view addresses how things work together as parts of an interconnecting network. The internal linkages and functions within systems give rise to emergent properties; exceeding and not automatically predictable from the isolated parts. Examples of the emergent properties of systems include:

- enzymatic, hormonal, structural and other properties generated by sequences of simple amino acids in proteins;
- complex genetic information encoded by the sequences of simple nucleotides; and
- digital data coded by strings of binary building blocks.

Ecosystems are complex systems, defined as '…a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit' (Convention on Biological Diversity, Undated), their properties arising from dynamic interactions between living and abiotic constituents.

1.3.2 Ecosystem exploitation for narrow benefits

The properties of ecosystems arise from dynamic interactions between their living and abiotic constituents. Society's technical capabilities to exploit ecosystems have advanced dramatically, yet the consequences for ecosystem integrity and functioning, and their capacities to support continuing human wellbeing, have commonly been overlooked (MEA, 2005a).

The Millennium Ecosystems Assessment (2005a), The Economics of Ecosystems and Biodiversity (TEEB 2010a and 2010b), national studies such as the UK National Ecosystem Assessment (2011 and 2014) and various related studies conclude that resource exploitation for narrow benefits constitutes a principal driver of ecosystem degradation.

Globally, agricultural activities are amongst the greatest threats to wetland and other terrestrial ecosystems and their broad range of ecosystem services (MEA, 2005a and 2005b). Power (2010) lists several negative ecosystems impacts resulting from contemporary intensive farming systems. These include:

- degradation and erosion of topsoil at rates vastly in excess of their renewal;
- mobilisation of stored carbon and nutrients;
- reduction of biodiversity; and
- changes in the aesthetic value of farmed landscapes.

1.3.3 Socio-ecological systems

SES are complex systems in which humanity influences and is influenced by the ecological system with which we co-evolved. To date, this tight interdependence between humanity and the functioning of ecosystems has been only poorly internalised by regulations, markets, fixed assumptions and vested interests. There is an urgent need for better internalisation of ecosystems functioning into human economic and social systems. Rising human numbers and increasing technological power has led many to recognise a new geological age; the Anthropocene. The Anthropocene has been described as 'a new geological epoch' where humanity's impact on the earth's biophysical systems has become dominant; 'decelerating and accelerating natural processes, focusing energy in extraordinary ways, [and] altering, destroying and creating ecosystems', in which humans have become a dominant influence shaping Earth's ecosystems (Crutzen and Stoermer, 2000).

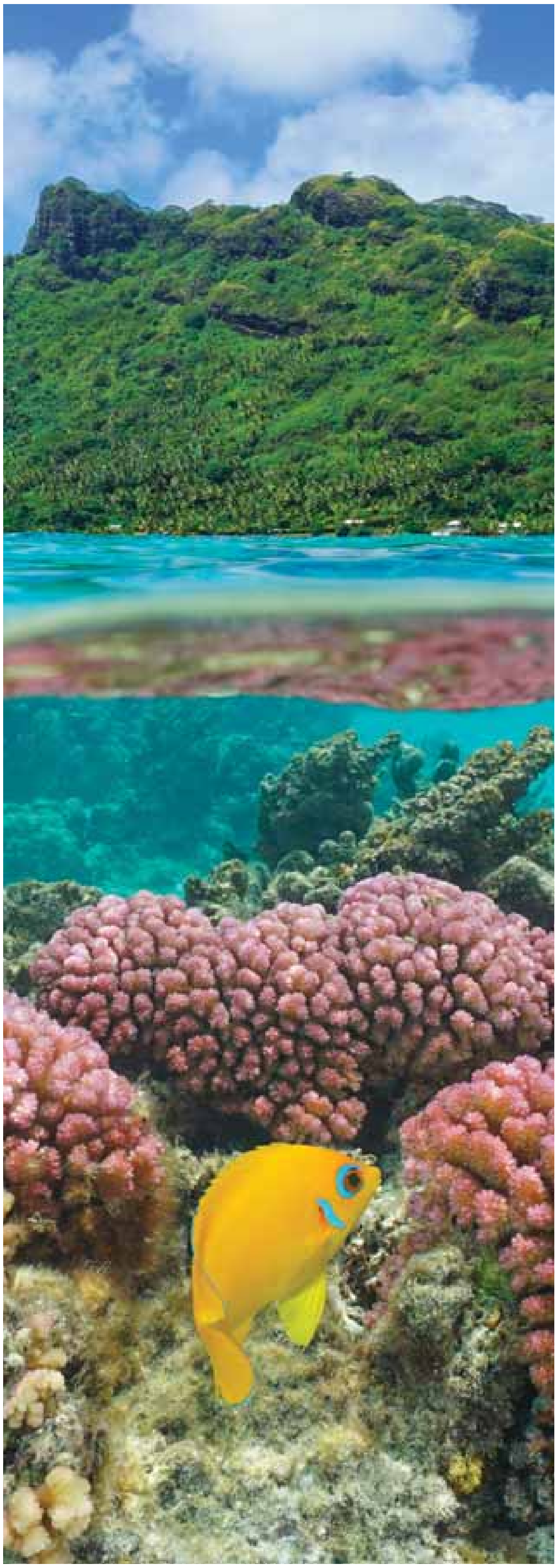
Interdependence between human and ecological systems underpins the concept of ecosystem services, which are defined as '…the benefits that people derive from nature' (MEA, 2005a). Ecosystem services are therefore by definition anthropocentric, comprising multiple dimensions by which natural systems contribute to human wellbeing. A globally consistent classification of ecosystem services derived by the MEA is provided in Box 1.1. Although various subsequent reclassifications have been developed (see for example the summary in Everard, 2017), they tend to share common roots with the MEA model.

A scientific basis for deciding how to manage socio-ecological systems is essential as today's challenges are not unidimensional but are 'wicked problems', difficult or impossible to solve because of incomplete, contradictory and changing requirements and complex interdependencies (Rittel and Webber, 1973). There is no simple objective criterion defining indisputable public good or equity. Ecosystem services offer a framework to articulate this complexity and to recognise the multiplicity of interconnected outcomes that arise from all interventions. This approach provides a more integrated basis for decision-making and the formulation and implementation of policies. It also implicitly reconnects people to decision-making, illuminating the needs of and impacts on all ecosystem service beneficiaries.

Box 1.1 **Ecosystem services classification of the Millennium Ecosystem Assessment**

The Millennium Ecosystem Assessment framework recognises four qualitatively different categories of ecosystem services:

- **Provisioning services** can be extracted for human uses, including food, fibre, fresh water, biochemical substances and energy.
- **Regulatory services** moderate, for example, flows and quality of air and water, erosion, diseases, climate and pollination.
- **Cultural services** comprise non-material benefits such as spiritual enrichment and educational, tourism and recreation opportunities.
- **Supporting services**, redefined in some subsequent classifications as processes rather than directly exploited services (TEEB, 2010b; Braat and de Groot, 2012), remain important elements to factor into policy and management to protect the characteristics, integrity, functioning and resilience of ecosystems and their capacities to supply other more directly utilised services. They include soil formation, oxygen generation, primary production, cycling of nutrients and water, and habitats for wildlife.



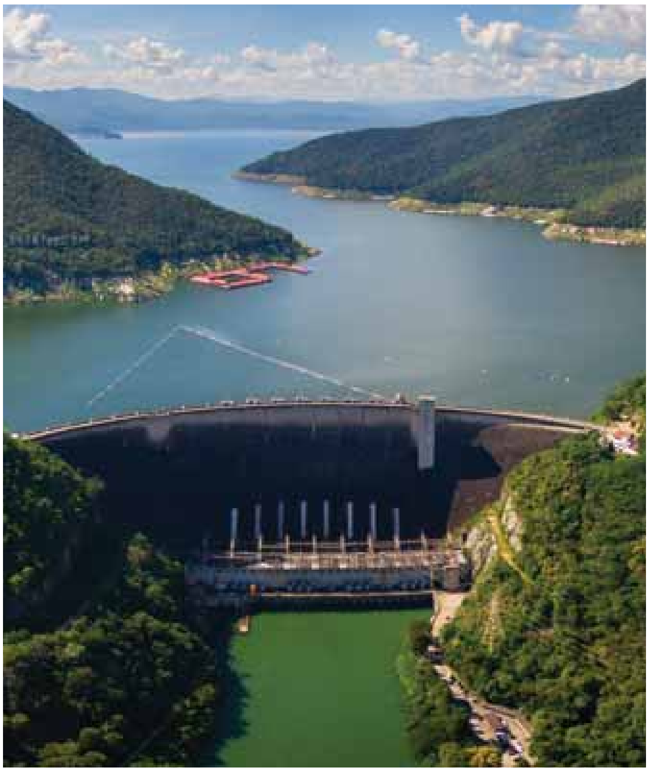
1.3.4 Degenerative landscapes

The systemic nature of ecosystem services is fundamental to their correct understanding and implementation. All services are part of an integrated whole. Many contemporary societal resource use habits are effectively 'mining' terrestrial and aquatic ecosystems for short-term benefits. The exclusive focus on a particular ecosystem service, such as food production or mined materials (both provisioning services), without regard to the repercussions across the ecosystem and its integrally linked ecosystem services benefits and beneficiaries, is likely to result in progressive degradation of the SES.

The world is full of non-systemic outcomes, often driven by good intentions but generating a diversity of externalities (positive or, as is common with ecosystem uses, negative consequences affecting other services and their beneficiaries). Box 1.2 provides a range of examples where human efforts to exploit a landscape (or sea scape) for one ecosystem service have created unintended negative outcomes. Box 1.3 provides evidence of the cumulative impact of degenerative landscape and resource use at the global level.

Box 1.2 **Unintended negative outcomes arising from the narrow exploitation of ecosystems**

- **America's 'Dust Bowl':** approximately 3.5 million people moved out of the Plains states in the United States between the 1930s and 1940s (Worster, 1979). These people were displaced because of the rapid degradation of farmland, which had been converted from prairieland (Hakim, 1995) under efforts to combat the disastrous effects of the US Great Depression. Removal of the protective prairie vegetation combined with the use of deep ploughing technology and a severe drought destabilised the soil, making it vulnerable to severe erosion by wind and rain. The resulting dry lands across the American Midwest created dust clouds that engulfed farmsteads and rural towns.
- **Collapse of the Newfoundland cod fish stock:** in Newfoundland, the introduction of supertrawlers[1] combined with a lack of effective fishery management policies, enabled fishing vessels to catch 8 million tons of cod over a 15 year period; the same amount as had been caught over the previous 100 years (Myers et al., 1997). By the 1990s, cod stocks, along with the local industry and economy, had entirely collapsed, and the whole coastal ecosystem had undergone an apparently irreversible shift into a different state almost devoid of cod (Kurlansky, 2010).
- **Large dams:** these water retention and diversion schemes impose a significant 'take' on land, water and other natural resources. Where landscapes were formerly in common stewardship, the dispossession, disempowerment and displacement of landless people is common (World Commission on Dams, 2000). Large dams fundamentally change riverine ecosystems by simplifying the hydrology. This halts the regeneration of soil fertility on downstream floodplains, destabilises fish stocks and provides an ideal environment for vectors of water-borne diseases. Likely ecosystem service outcomes arising from the proposed Pancheshwar Dam on the India/Nepal border in the Himalayas revealed a highly asymmetric distribution of benefits and costs between already privileged constituencies and potentially millions of people suffering as a result of the degradation of the flows, nutrients, sediment and biodiversity of the Kali river system (Everard and Kataria, 2010). All of these factors compromise the livelihoods of an often 'silent' majority of people living in watersheds surrounding large dams.



1 Ships with powerful engines allowing them to access more remote and deeper waters, equipped with larger nets and hold storage capacity and highly sophisticated GPS and sonar technology to locate and track fish shoals.

Box 1.3 **Evidence of 'degenerative landscapes' comprising linked ecological and socio-economic decline at the global level**

The Millennium Ecosystem Assessment (2005a) found that:

- The number of species on the planet is steeply declining and homogenising through the introduction of invasive species. Over the past century, human actions have increased the extinction rate by up to 1,000 times over background rates.
- Approximately 20% of the world's coral reefs were lost and an additional 20% degraded in the last decades of the twentieth century.
- The atmospheric concentration of carbon dioxide has increased from 280 to 410 parts per million between 1750 and 2017; well over 60% of that increase occurring since 1959. This has been primarily due to fossil fuel combustion and land use changes (Kahn, 2017).

The United Nations observed multiple desertification effects (United Nations, Undated):

- 52% of drylands used for agriculture are moderately or severely affected by soil degradation, affecting 1.5 billion people with hunger globally. This degradation has severe future food security, conflict potential and other implications.
- An estimated 27,000 species are lost each year through desertification.
- Arable land loss is a major global problem, occurring at 30 to 35 times the historical rate with 24 billion tons of fertile soil – one of the most significant, non-renewable geo-resources – eroded from global landscapes annually.

Tropical forests continue to disappear at an accelerating rate (Hansen et al., 2013):

- Global forest area reduced by approximately 40% in the last three centuries, three-quarters of this occurring during the last two centuries (Shvidenko et al., 2005). Forests have completely disappeared in 25 countries, with greater than 90% loss of forest cover in another 29 countries.
- At least half of recent global deforestation is caused by demands for land to serve commercial agriculture, with 49% of tropical deforestation between 2002 and 2012 due to illegal conversion (Lawson et al., 2014).
- Forest loss remobilises vast reserves of stored carbon from biomass and soil, generating nearly 50% more greenhouse gases than the global transportation sector (Nabuurs et al., 2007).
- Deforestation destroys habitats for a diversity of species. It also degrades ecosystems capacity to store and purify water, and removes the natural buffer for storm energy: a buffer that also prevents soil erosion.

1.4 Optimising ecosystem use through the adoption of systemic solutions

All uses of and management interventions in ecosystems come with a wide range of ramifications in addition to the intended beneficial use, as neither natural nor managed ecosystems deliver ecosystem services in isolation. Linked sets of ecosystem services are often referred to as ‘environmental services’ (Schomers and Matzdorf, 2013) or ‘bundles’ (Balvanera et al., 2016). There is almost invariably a central need or management priority driving decisions about ecosystem exploitation, ranging from food production to flood protection, water and soil conservation, or a policy priority such as biodiversity protection or amenity provision. Historically, these needs have generally been pursued in a narrowly framed way, blind to multiple potentially adverse unintended consequences. However, desired outcomes could instead be viewed as an ‘anchor’ around which consequences for other interlinked ecosystem services are assessed and, where possible, optimised in collaboration with other ecosystem beneficiaries. An ‘anchor service’ is defined as a desired service outcome that is considered in conjunction with other ecosystem service outcomes.

The optimisation of overall societal benefits may be achieved by solutions that are ecosystem-based such that overall functioning is enhanced, along with a bundle of linked environmental service benefits. These management measures constitute ‘systemic solutions’, defined as ‘…low-input technologies using natural processes to optimise benefits across the spectrum of ecosystem services and their beneficiaries’ (Everard and McInnes, 2013). Systemic solutions recognised under the initial definition include wetland, washland and urban ecosystem-based technologies optimised to achieve multiple benefits. The principles implicit in ‘systemic solutions’ are that all ecosystem services, along with the rights of beneficiaries to those ecosystem services, are systemically considered in any decisions. Such an approach encourages the optimisation of net societal value from ecosystems services; the benefits are not skewed towards a favoured few at the cost of benefits to any other (often overlooked) beneficiaries, often including future generations. A systemic solutions strategy implies a transition towards a more participatory and collaborative approach seeking optimal and sustainable outcomes.

If decision-making sought to optimise linked ecosystems services, the cumulative value of linked marketed and non-marketed services would be substantial. For example, an overall ecosystem service value for global forests has been calculated at over $16 trillion (Costanza et al., 2014). In this calculation only 6% of temperate forest and 1.6% of tropical forest value is generated from the ‘raw materials’ that are sought after in global markets, and which often provide primary management drivers (de Groot et al., 2012).

2.0 Research methods

2.1 Theoretical framework

Ecosystem services have been described in detail in the introduction. By addressing the diverse and interconnected benefits that nature provides to humanity, the ecosystem services framework provides a systemic basis for assessment of the outcomes of ecosystem use and management, both degenerative and regenerative.

Since publication of the MEA, a number of revised classifications of ecosystem services have been proposed. These include The Economics of Ecosystems and Biodiversity (TEEB, 2010a), the Common International Classification of Ecosystem Services (CICES, 2016), the valuation model of UK National Ecosystem Assessment (UK NEA, 2011) and the model underpinning Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Díaz et al., 2015). Though these classifications share common roots with the MEA framework, they tend to focus on provisioning, regulatory and cultural services, reclassifying supporting services as underpinning functions. For the purposes of this report, the MEA (2005a) classification is used because the recognition of supporting ecosystem processes (underpinning production of other more directly consumed services) in decision-making is vital for continued ecological integrity, functioning and resilience.

In order to examine how ecosystem services can be managed within a modern societal decision-making context, this research utilises the STEEP framework (an acronym for its five constituent elements; social, technological, economic, environmental and political) as a means to address environmental and social implications in technological, political and economic contexts. STEEP has proven useful for exploring systemic relationships in other domains of human activity[2]. The STEEP model was developed to encourage and broaden thinking in business strategy; thinking beyond established assumptions, ensuring multiple external factors impacting an organisation were addressed (Morrison and Wilson, 1996). One such application to which STEEP has been applied is addressing sustainability goals (Steward and Kuska, 2011). STEEP can be applied as a simple classification scheme and it can also be used as a systems model in which interdependencies between all five constituents are considered.

2.2 Research design

The research utilises both primary and secondary data to develop a comprehensive overview of the key characteristics of degenerative and regenerative landscapes.

2.2.1 Field visits

Empirical observations were made of effective community-based water and ecosystem management practices in two primary locations in Rajasthan state, India. The Rajasthani case studies provide examples of restored community-based water harvesting infrastructure in a semi-arid environment, respectively in the hilly terrain of Alwar District and on flatter topography with underlying saline groundwater in Jaipur District.

A variety of government, NGO, village council and villager interviews were held in each case study location. Though points were captured and collated around STEEP elements, which also served as prompts for questions and for interviewees to expand on their answers, the interviews themselves were semi-structured. A semi-structured approach was necessary to reflect both the heterogeneity of sites and the wide diversity of geographical and cultural perspectives of interviewees. Observations and interviews at all field sites were recorded in writing at the time of the visit.

2.2.2 Collation of a knowledge base

Case studies derived from a range of associated global examples of regenerative landscape management were also collated. In all case studies the need for, and means of, rebuilding ecosystem capacity were considered with respect to where leadership has been demonstrated, or could be most helpfully provided, across different sectors of society.

2.2.3 Analysis of the knowledge base

The global evidence base of regenerative approaches to landscape and natural resource use were analysed by stratifying success factors according to the constituents of the STEEP framework. Social, technological, environmental, economic and political (governance) features were collated from across this diversity of 'regenerative landscape' case studies and examples, paying attention to the systemic interconnections between them.

2 There are variation on this model, such as PEST, PESTEL, PESTLE, STEPJE, STEP, STEEPLED and LEPEST.

3.0 Main findings

Many pressing challenges in the developing world relate in one way or another to the degredation of the water cycle. Water cycling is inextricably linked to the landscapes onto which precipitation falls, through which water flows, and to the human livelihoods it supports. The water cycle is also integrally dependent on the patchwork of habitats that exist within any particular catchment landscape. Flows of water are primary agents in the production of many of the benefits these landscapes provide, such as soil fertility, hydrological buffering and a spectrum of other ecosystem services. Inspiring examples of regenerative of SESs though landscape reanimation are found across the world.

3.1 Rehydrating the drylands

Most of central India's rain falls during a short monsoon period. This has resulted in increasing dependence on groundwater. Groundwater supports over 85% of India's rural domestic water requirements, 50% of urban and industrial water needs and nearly 55% of irrigation demand (Government of India, 2007). India has adapted to this situation through a rich, centuries-long tradition of locally geographically and culturally attuned water harvesting structures (WHSs) and water management practices. These practices are based on traditional knowledge and community-based collaboration, intercepting monsoon run-off to recharge groundwater, protected from high evaporative rates and accessible throughout the year. Just some of the diversity of locally adapted WHSs across India include Baudis, Khatris, Kuhls, Taanka, Naula, Dongs, Garh, Johadi, Virdas, jheels, Kattas and Eris (Pandey et al., 2003).

A range of developments in recent decades have broken down the community structures of collaboration that are essential for WHS operation and resource sharing. Technologically, mechanised tube wells can tap into deeper, often receding and now increasingly contaminated groundwater on a non-renewable and competitive basis. There has also been a technocentric trend since the 1940s favouring the construction of large dam-and-transfer schemes to supply water to areas of high demand (cities, industry and large-scale irrigation). These schemes generally overlook the consequent impacts of water diversion on the catchments from which the water is diverted. These technology choices are driven by a policy environment seeking to maximise water supply for urban economies, irrigation and other intensive uses without regard for the need to balance resource use with recharge. This approach has broken down the community basis underpinning historic sustainable water use and sharing, degrading water resources and other linked ecosystem services. The net consequence has been increased aridification, driving farmland and village abandonment across significant areas of central India. In India, and also across drier regions of the developing world, a number of initiatives are working to reverse prior cycles of linked ecological and socio-economic degeneration.

3.1.1 Reanimating Rajasthan's desert edge in Alwar District

Alwar District, to the north east of Rajasthan state, India, is semi-arid with much of its craggy landscape shaped by the undulating Aravalli Hills. The NGO Tarun Bharat Sangh (TBS) has developed a global exemplar programme of community-based catchment regeneration in Alwar District (reviewed by Sinha et al., 2013 and Everard, 2015). Focused predominantly on the rural Arvari (or Arwari), Sarsa and Baghani catchments (see Figure 3.1), TBS began working with local people from 1985 against a backdrop of economic and ecological decline, rural depopulation and the loss of perennial flows in rivers. Founded on the Gandhian ethos of Jal Swaraj ('water self-governance'), early TBS efforts addressed natural resource conservation methods through local community participation (Jayanti, 2009).

The initial focus of TBS was education. However, discussions with village elders highlighted a lack of water as the main cause of poor health, malnutrition and poverty, rather than education. TBS's focus therefore shifted towards reintroduction of traditional water-harvesting structures and innovation of novel structures based on traditional knowledge. Singh and colleagues took advice from a lower-caste older lady to restore or create small, localised traditional water-harvesting structures (WHSs) known as johadi (plural of johad) to intercept run-off during monsoon rains, allowing it to percolate into and recharge soil moisture and groundwater (see Figure 3.2).

The first TBS-initiated johad was a small structure hand-dug in 1985 in collaboration with villagers of Gopalpura. Though outcomes were uncertain, this first johad functioned as hoped, restoring soil moisture and ecology for improved food production, rejuvenating local grazing and other vegetation, and re-establishing some vitality to the Sarsa River (Singh, 2009). Interest in constructing WHSs followed from adjacent parched, depopulating villages and the demand-led construction of hundreds of johadi followed, with TBS contributing typically 30-70% of costs as it attracted funds primarily from international donors. Village contributions were not only financial but also shramdan (sweat equity: collective labour for common good linked to Gandhian ideals of self-sufficiency).

Figure 3.1 Location of the Arvari, Sarsa and Baghani catchments in north Rajasthan

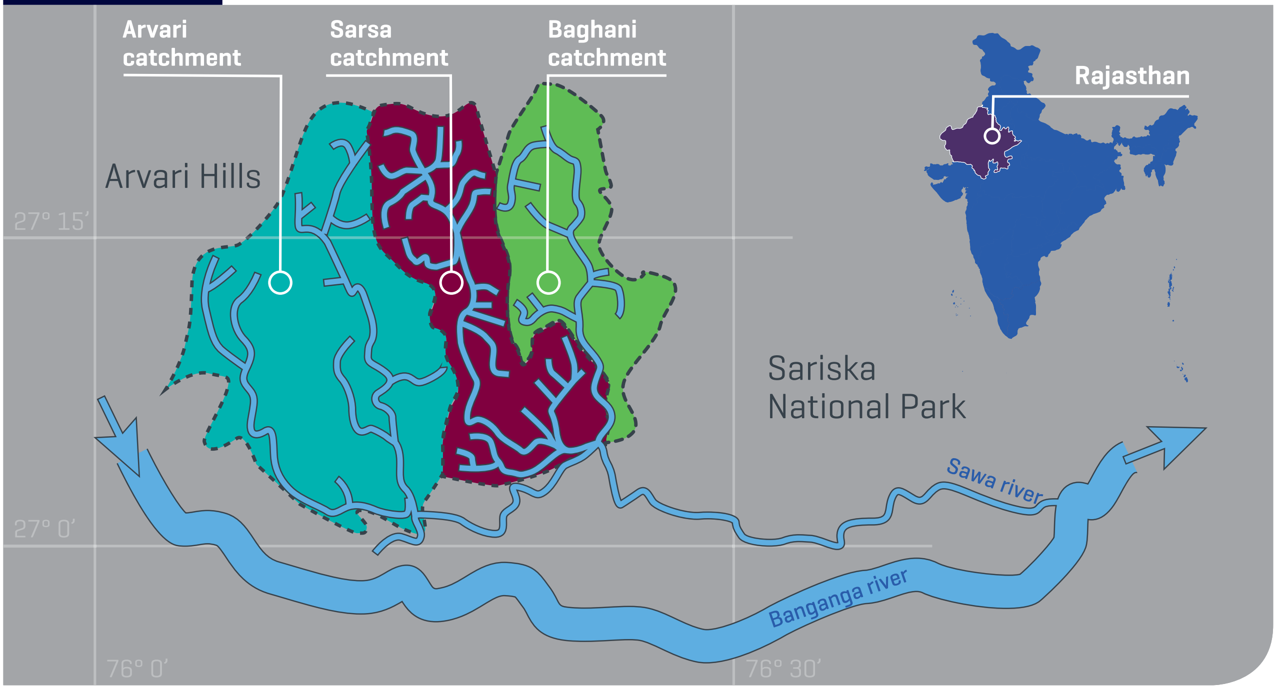


Figure 3.2 A mature johad intercepting run-off from a dry hill slope, contributing to moisture in a formerly treeless and unproductive valley bottom near Harmeerpur village

Image source: © Dr Mark Everard

TBS today co-designs and supports villagers in the construction and management of a range of locally appropriate types of WHS. TBS-promoted WHS schemes are always demand-driven and tuned to local landscapes, community needs, traditional knowledge and available budgets. WHSs consequently vary widely in design and size. They always serve the primary purpose of groundwater recharge, but many store additional surface water for livestock watering and other uses throughout the dry season. For example:

- Tree-planting and regeneration on degraded hill slopes restores catchment hydrology, some trees also shading johadi to reduce evaporation.
- Anicuts (flat bunds) built to attenuate water flows across low-topography valleys have also been constructed to retain bodies of surface water during monsoon rains. These anicuts also recharge groundwater and moisten and carry nutrients into soils that can be subsequently cropped more efficiently for mustard, channa (chick peas), bindi (okra or lady's fingers) and wheat.
- Check dams intercept episodic monsoon flows in monsoon rivers, promoting percolation into groundwater (Figure 3.3).

Construction and management of WHSs builds upon traditional knowledge and technologies. The social infrastructure necessary to operate them is as important as the physical infrastructure. Ostrom's (1990) common-pool resource (CPR) model reviewed and systematised the many ways in which informal, traditional governance arrangements by communities across the world have served to innovate collaborative approaches to the sustainable use and allocation of their shared environment. The construction and maintenance of johadi depends upon the restoration of traditional village institutions and the communal practices they promote and govern (Kumar and Kandpal, 2003). Significant amongst traditional village decision-making bodies are Gram Sabha (village councils) (Jayanti, 2009). Some Gram Sabha became dormant after johad construction, but many have remained active and have made progress in tackling additional issues such as protecting forests, building schools and other developmental works (Kumar and Kandpal, 2003). Gram Sabha have also undertaken important decisions pertaining to zoning and regulating land uses to avoid ecological and socio-economic degradation (Singh, *pers. comm.*). At the village scale, the distribution of benefits and the shares of costs of WHS construction and

Figure 3.3 **Check dam to arrest flows enabling groundwater percolation, this one in Kumbhalgarh Wildlife Sanctuary, Rajasthan**

Image source: © Dr Mark Everard

management are a key issue. This includes agreements about the zoning of grazing on common lands and the proportions of investment in WHSs required from those most directly benefitting from cropped lands and wells.

Responding solely to the demand from villages local to water sources potentially risks fragmenting action across landscapes (Kumar and Kandpal, 2003). From 1998, TBS initiated a more integrated approach, forming an Arwari Pad Yatra ('Arvari Water Parliament') to determine water sharing and management issues across the Arvari catchment. The responsibilities of this parliament also included dispute resolution and activities such as reforestation (Rathore, 2003; Jayanti, 2009).

Further catchment-scale arrangements between villages in progressively regenerated catchments – the Bhagani-Teldehe, Arvari, Jahajwali, Sarsa and upper Ruparel (Jayanti, 2009) – have restored perennial water bodies, recovering livelihoods and repopulating villages. Singh has remarked that "we never realised that we were recharging a river. Our effort was just to catch and allow water to percolate underground" (Down to Earth, 1999). The reappearance of perennial water bodies has enabled recolonisation by aquatic wildlife, regenerating an associated set of traditional medicinal and other cultural values (Everard, 2016a).

To spread the lessons of these local successes to national scale, TBS launched the Rashtriya Jal Biradari ('National Water Brotherhood') in 1998. This comprised individuals from diverse backgrounds who were concerned about water, forest and soil conservation and the re-establishment of community water rights through awareness programs. Jal Sammelans ('water conferences') were instigated, aimed at influencing and developing people-oriented national and state water policy.

Significant challenges were encountered in reconciling national and state government aspirations with effective localised solutions. State and national government perspectives on water management differed from those of TBS, Gram Sabha and Pad Yatra, even if the overarching aspiration of water self-sufficiency was shared. Under India's national legal framework, water is owned by the state, which also has sole control of its management. Community-based action to restore local water management structures and institutions could be considered illegal, as could water retention for community use under the Rajasthan Drainage Act of 1956 if not explicitly approved by government. The reclamation of the rights to local and common resources from state or private agency control has become increasingly common amongst indigenous people across India, with NGOs playing significant roles in mobilising citizens (Fenelon, 2012; Subramaniam, 2014).

Notwithstanding these conflicts, restoration of community-based management building on traditional techniques demonstrably makes contributions to state and national goals relating to sustainable land and water systems, drought resilience, erosion control, regeneration of forests, wildlife and the socio-economic status of villages. The conflicts between state aspirations, local needs and the law highlight the need for policy reform to increase coherence between government aspirations and effective localised solutions. This is consistent with the common observation that rebuilding community-based social capital is a central success factor in groundwater management elsewhere across the world (Lopez-Gunn, 2012).

The outcomes of TBS initiatives that promote uptake of community-based groundwater recharge have been significant. By 2010, TBS was working with more than 700 villages in Rajasthan, with many hundreds of WHSs built and maintained by villages. TBS-promoted work has increased water availability, enabling diversification of cash crops and livestock composition producing significant economic gains, greater drought resilience, reduced soil erosion and distress migration, and forest regeneration aided by village-level agreements on forest exploitation and grazing (Rathore, 2003). Preliminary evidence of the re-greening of this formerly parched and treeless landscape is provided by analysis of remote sensing data (Davies et al., 2016). An engineer's report on the outcomes of the TBS programme concluded that johadi '…are, by and large, engineering-wise sound and appropriate', and that 'there can be no better rural investment that on Johads' (Agrawal, 1996).

Another significant success of the TBS-driven community initiatives is the empowerment of women. In 1985, women typically spent 6-7 hours a day searching for water. However, rising water tables and improved water access through the installation of hand pumps and wells closer to housing has now reduced the time taken for this task to around 5 minutes. Freed from labour of their traditional roles foraging for water, fodder and fuel, women can devote more time to tackling social concerns, contributing to health services and education (particularly of girls), engaging in decision-making and other productive activities (Kumar and Kandpal, 2003; Jayanti, 2009). TBS has actively empowered women through enabling democratic engagement, education (including Ayurvedic or traditional herbal medicine), and through the formation of Women Self Help Groups (SHGs) designed to strengthen the role of women and share learning across catchments (Rathore, 2003).

3.1.2 Restoring water and livelihoods square by square in Jaipur District

WaterHarvest, a community-focused NGO active across Rajasthan since 1987 (formerly known up to 2017 as Wells for India), has supported an innovation in water management that is appropriate to the local geographical and cultural context in and around Laporiya. Laporiya village is located in Jaipur District of Rajasthan, 80km to the east of Jaipur City. Laporiya and its surrounding land comprises around 350 households with a population close to 2,000 people. Like its surrounding villages, under which groundwater has today receded to as much as 50 feet (152 metres) (Sharma, 2016), Laporiya had suffered a familiar pattern of social, economic and environmental decline in the 1970s and 80s after the introduction of energised pumps, which depleted usable water resources.

Laoporiya is situated in flat rural lands with slopes of only 3-4%. Saline groundwater lies close to the surface, making johadi an inappropriate solution. New solutions have therefore had to be innovated to address the local context in Laporiya. Laporiya village is host to the ashram headquarters of the NGO GVNML (Gram Vikas Navyuvak Mandal, Laporiya: 'village growth youth board, Laporiya'). GVNML was established by local man Lakshman Singh through a process of trial and error. Without formal education in water management, Singh and colleagues pursued local knowledge about the management of moisture through small-scale water harvesting.

GVNML's early experiments with ponds were unsuccessful as the deeper water drowned grasses and insects and the intense monsoon rains washed away bunds. The solution eventually derived was chauka (literally 'rectangle'). Chauka are matrices of pits approximately 9 inches (23 centimetres) deep, spaced 5 feet (1.5 metres) from each other (see Figure 3.4). The spoil from these pits is used to build naadi (low flatland bunds), which surround around 150-1,000 hectare clusters of chauka (Mahnot et al., 2012). During the monsoon, groups of chauka fill with water. Bypass channels built into the naadi to avert erosion by enabling excess water to cascade into fields downstream. Slowed flows of water retain pools for livestock, stimulate the

Figure 3.4 **A freshly dug chauka system showing shallow cells for water percolation and low bunds around fields to slow and retain water**

Image source: © GVNML

growth of grasses and other vegetation including trees planted on the bunds, and promote percolation into soils and groundwater. In Laporiya, chauka have proved critical in providing for the livestock watering and grazing needs of local communities, recharging wells for year-round access and also averting the underlying saline groundwater from rising to the surface and contaminating all of these uses.

Chauka depth is critical. Deeper water would drown grass roots, whereas shallow water during the rains and retained as soil moisture stimulates grass growth supporting grazing (through a rotational system), the formation of soil and the proliferation of worms and other organisms contributing to soil health. To promote this process, cow dung is left in situ on common land to rebuild the organic and nutrient content of soil. Some chaukas have deeper wells within or adjacent to them, providing access to water percolating through the soil from the replenished water table. In some larger water recharge basins, flood-retreating crops are grown on productive soil[3], exposed as water levels decline during the drier months. A participatory approach which seeks to provide for local needs is an important aspect of chauka design. GVNML has produced a Chauka manual (GVNML, Undated) to promote the approach.

As with other effective WHSs, water management solutions are planned according to the workings of the water cycle and implemented communally. Effective collaboration is vital as groundwater even a few metres below the soil surface in this region is highly saline. The replenishment of shallow groundwater is therefore critical when avoiding groundwater contamination.

GVNML now works with more than 2,000 villages in Rajasthan. GVNML's work in these areas has primarily focused on securing sustainable water supply and setting aside habitat for wildlife. GVNML has been successful in attracting some international aid investment, although in the early stages of the project chauka implementation was funded solely by villagers. At present roughly 75% of investment in chauka construction remains through voluntary village labour.

Another goal of GVNML is to identify 10-15% of village and private land that can be reserved purely for wildlife as enclosed 'ecoparks'. These 'ecoparks' provide numerous co-benefits; providing seed banks, regenerating bird populations (promoting seed dispersal); they are imbued with spiritual importance; and improving landscape porosity enhancing groundwater recharge. Other GVNML-promoted initiatives include roof water harvesting and the construction of flat check dams on common land to promote water infiltration into soil.

Local testimonies indicate the impact of GVNML work: Lakshman Singh and colleagues report that there were no trees in and around Laporiya thirty years ago, while in the present day the landscape is extensively tree-covered and there are an abundance of birds. Chauka systems on common land have also increased fodder trees and grasses by at least five times over ten years (Wells for India, 2016). This has enabled the diversification of crops from traditional dryland species such as chana (chick peas) and dahl (lentils) to crops that are heavily water dependant such as rice, potatoes and wheat. This has in turn impacted local livestock health and has enhanced the yield and quality of milk, improving local health and income resulting from measures such as a cumulative organic fertilisation of 325 ha and grass seeding on 1,600 ha between 1978 and 2009. In addition, there have been a range of health programmes such as midwife training, vaccination, food distribution and women's and children's health programme (GNVML, 2009).

Laporiya village is an example of environmental governance which combines traditional and religious practices with scientific concepts in order to tackle the challenges associated with climate change (Mathur, 2014). Unlike many villages in rural Rajasthan that depend on government-supplied water tankers in summer, levels of fresh groundwater have recovered from inaccessible depths to 15-40 feet (4.5-12 metres) beneath the ground surface. This has provided a water surplus in Laporiya; Laporiya can now supply water to 10-15 surrounding villages (Sharma, 2016).

The chauka approach builds on lessons from land management practices that have been utilised for centuries. It can improve local resilience to drought through an integrated water resources management approach that is supported by appropriately reformed policies and investment (Narain et al., 2005). The successes of the chauka system in dealing with the particular stresses associated with the flat topography and shallow saline groundwater have attracted the attention of the Rajasthan government. Rajasthan state government is seeking to promote the chauka approach as part of its Mukhya Mantri Jal Swavlamban Abhiyan ('Chief Minister's self-sufficiency mission'; MJSA). The MJSA programme aims to empower villagers in 21,000 villages to regain control of their local water supply by restoring former water management practices that are adapted to local geographical, cultural and intense episodic rainfall conditions.

3.1.3 Water resource recharge elsewhere in India and beyond

The challenges addressed in the preceding case studies from Rajasthan are common across India, where other exemplar solutions are also found. There is renewed interest in long standing, locally adapted water management practices elsewhere in India. Boxes 3.1 and 3.2 provide some examples of these and indicate that 'big engineering' solutions are not necessarily best when it comes to the efficacy of a water management scheme (Everard, 2016b).

A diversity of other locally adapted methods for interception of run-off to recharge soil moisture and groundwater are encountered across the developing world (see Box 3.3), where the community infrastructure behind their

3 A common production method in dry regions with seasonally variable rainfall that exploits stored soil moisture in the margins of water bodies for cropping as water levels recede.

Box 3.1 Flexible solutions adapted to Rajasthan's varying geography

The NGO WaterHarvest (formerly Wells for India) has been actively working since 1987 across Rajasthan state and into the drylands of the adjacent Gujarat state promoting a variety of traditional and innovative WHSs and efficient water use schemes (WaterHarvest, 2017).

In the Thar Desert in central and western Rajasthan, communities have adapted water harvesting to an extremely dry and changing climate as well as population growth throughout centuries (Jal Bhagirathi Foundation and Wells for India, 2010). Here, WaterHarvest has promoted and now widely supports the construction and use of taanka, a household- and community-scale WHS model comprising a concrete-sided and covered well recharged from monsoon rainfall collected in a circular depression in the ground. This artificial micro-catchment that captures and stores rainfall for year-round access is bounded by thorny vegetation to avoid animal incursions (Wells for India, 2016).

Image source: Yavuz Sariyildiz / Shutterstock.com

Box 3.2 Aquifer replenishment in Chennai, South India

A more diffuse approach is being encouraged around Chennai, a city of 4.7 million people (2011 census) in Tamil Nadu state, south India. Over 90% of Chennai's water supply is served by reservoirs that depend on monsoon rains. City demands for water during non-monsoonal months are mostly met by groundwater extraction when the reservoirs are emptied (Sakthivel *et al.*, 2014). City expansion has put increasing pressure on both the quantity and quality of available water.

Seeking a more sustainable approach, Chennai is promoting the replenishment of local aquifers to '...build a credit that can be drawn on in drought' (Gao *et al.*, 2014). Measures to counter saline intrusion through infiltration ponds and check dams (see Figure 3.3) are also being promoted in the periphery of the city.

Many institutions and stakeholder groups express high acceptance of this management approach (Brunner et al., 2014). Rainwater harvesting from the roofs of larger buildings has been mandatory since 2001. However, the conflicting interests of institutions and stakeholders is hindering implementation of aquifer recharge (Brunner *et al.*, 2014), for example, when there is an expectation that infiltration structures built with government support should be subsequently maintained by farmers despite the fact that the public rather than individual farmers benefit most from aquifer recharge.

implementation and operation are as important as the suitability of physical infrastructure. Significant groundwater rises are reported where community-based participatory methods have been developed at benchmark sites in several Indian states or provinces, as well as in Thailand, Vietnam and China (Wani et al., 2009). These community empowerment initiatives, bringing together institutions from scientific, non-government, government and farming sectors, have restored groundwater levels, improved productivity by up to 250%, reversed degradation of natural resources, and substantially improved the livelihoods of poor people in 368 experimental watersheds across Asia (Wani and Ramakrishna, 2005; Wani et al., 2006).

Based as these diverse methods are on accelerating the natural recharge of soil moisture and groundwater, there are many similarities between the diversity of water management techniques founded on traditional wisdom observed across Africa, Asia, the Americas and the wider drier tropical world supporting multiple benefits for dependent communities[4].

Box 3.3 Further examples of run-off interception schemes for ecosystem recharge

Farmers in Pakistan's Punjab province have succeeded in greening their lands and developing resilience against increasingly extreme weather conditions and erratic rainfall through rainwater harvesting using small dams, restoring water to the landscape and hope to farmers (Pakistan Water Partnership, 2016). Rainwater harvesting raised the groundwater table from 450 feet to 200 feet in one village. Success in pioneering villages has inspired the people of nearby villages to pool money for building mini dams to reap the benefits of agriculture.

In experimental watersheds in India, including the Bundi watershed in Rajasthan, water levels in wells close to community-constructed and maintained WHSs improved groundwater yield both quantitatively and in terms of duration compared to more remote wells (Wani et al., 2009). Groundwater level in the Bundi watershed rose by 5.7m, with a corresponding 66% increase in irrigated area (Wani *et al.*, 2003).

In Kenya, sand dams represent a low-tech means to recharge shallow groundwater and to improve the quality of water as it is filtered by the sand. The dams themselves may be made of concrete or other resilient materials but, in sandy catchments, they fill with sand after seasonal floods. This promotes water infiltration and purification, at least in locations where underlying rock strata are not highly permeable, which would otherwise result in the water infiltrating into deeper, less accessible aquifers. Sand dams may represent 'low-tech weapons' to tackle the effects of a changing climate where geological and other geographical conditions are suitable (Brahic, 2006).

Drought-sensitive farming methods and unorthodox, labour-intensive water harvesting techniques have been instrumental in regenerating farmland in the dry region of Zvishavane in south-central Zimbabwe, driven largely by local man Zephaniah Phiri Maseko (Witoshynshky, 2000; Lancaster, 2008). Phiri's efforts have progressively transformed his formerly arid eight-acre landholding, a principle method being construction of 'Phiri Pits' dug along contour ridges to capture runoff directed by low bunds during erratic rains. This has raised the water table, providing constant moisture for various trees, crops and ponds containing fish. Since 1987, Phiri's methods have been widely promoted through the Zvishavane Water Project, one of Zimbabwe's first NGOs, with visitors from all over the world learning from localised successes.

Image source: Burhan Ay / shutterstock.com

4 These methods are reviewed in Fred Pearce's book *Keepers of the Spring* (Pearce, 2004), my own *The Hydropolitics of Dams* (Everard, 2013), Brad Lancaster's *Rainwater Harvesting for Drylands and Beyond* (Lancaster, Undated) and IMAWESA's *100 Ways to Manage Water for Smallholder Agriculture in Eastern and Southern Africa* (Mati, 2007).

3.2 Trees, water and livelihoods

At the continental scale, forests generate much of the rainfall in the forest system, and also act as 'continental water pumps' cycling water from moist coastal regions progressively further inland. Forested uplands intercept moisture from oceanic air currents, generating the headwaters of river systems that irrigate whole sub-continents. Even small stands of forest recycle water efficiently, creating lush and diverse ecosystems with cool microclimates. Forested catchments are the source of more than three-quarters of the world's accessible freshwater, also supplying diverse other ecosystem services essential for human wellbeing at scales from the global to the localised (Shvidenko et al., 2005). Consequently, deforestation has generated many examples of hydrological disruption and adverse outcomes for SESs around the world. Forest management, conservation and, ideally, restoration can play significant roles in linked environmental and socio-economic rejuvenation, including halting spirals of degradation.

3.2 1 Restoration of tropical dry evergreen forest on the Coromandel Coast

In the southern Indian state of Tamil Nadu, a familiar litany of landscape degradation with associated socio-economic disadvantage is being driven by two key factors:

1. the abandonment of traditional community management of tank systems (monsoon water interception and storage; Kajisa et al., 2004 and 2007); and
2. the substantial loss of natural forest cover leading to severe land degradation and erosion.

Tropical dry evergreen forest (TDEF), a now a critically endangered habitat (WWF, Undated), was once extensive along the Coromandel Coast on the south-eastern seaboard of southern India (Blanchflower, 2005). A localised but long-term, dedicated approach to restoration of this forest type has been occurring since 1973 at Pitchandikulum Forest on the Auroville Plateau, Tamil Nadu. Starting from a 65 acre (26.3 ha) site of severely degraded and eroded land of negligible value, this restoration activity has demonstrated the feasibility of eco-restoration. There has been a well-documented recovery of an increasing range of native wildlife (Including over 300 species of woody plants; Pitchandikulam Virtual Herbarium, 2017). This in turn has supported the renewal of associated herbal traditions, forest-based livelihoods, and traditional and religious benefits, such as the enhancement of sacred groves. Nadukuppam Forest in the Kaliveli catchment of Tamil Nadu is the subject of further ongoing TDEF restoration. This restoration initially covered 30 acres (0.12 km^2) of formerly degraded and severely eroded farmland. However, there are plans to restore and put into trust a larger area as part of a longer-term programme of eco-restoration. Figure 3.5 demonstrates the location of these sites.

TDEF restoration confers many societal values. Many remnant TDEF stands now form 'sacred groves' often associated with Hindu temples. TDEF patches may also contain a diversity of plants that are used by local traditional healers for medicine (Parthasarathy et al., 2008) and that are also used by local people for raft-making, haircare, religious purposes, fuelwood, edible fruits, pesticide fodder and carpentry (Kinhal and Parthasarathy, 2008). Connected with Nadukuppam Forest restoration is the adjacent 'Nadukuppam Field' and Nadukuppam School. Nadukuppam Field is a women's business collective producing herbal medicinal products and crafts derived from forest products. Women have established businesses to manage the germination and growth of indigenous forest plants, *Spirulina* (a blue-green alga) also grown as a dietary supplement. Nadukuppam School has an environmental programme permeating its learning programme and is used as a model for many schools across Tamil Nadu state.

One of the principal funding mechanisms supporting the expansion of reforestation at Nadukuppam is an innovative developed-developing world partnership, developed and operative by the NGO The Converging World (TCW), twinning aspirations for low-carbon developing in south west England and Tamil Nadu state, India (Everard *et al*., 2017a). TCW has invested funds from south west England in wind turbines installed in Tamil Nadu. This provides the joint benefits of 'offsetting' some emissions from the developed region of England, whilst promoting a lower-carbon pathway of development in Tamil Nadu. However, there is a 'multiplier effect' within the TCW model, achieved through channelling part of the surplus income from renewable energy sales into the restoration of tracts of TDEF. Over the respective lifetime of the wind turbines (nominally 20 years) and progress to maturity of the restored TDEF (assumed as 100 years), sequestration by TDEF substantially augments carbon dioxide emissions averted by low-carbon generation by turbines. This represents a significant cost-efficiency, whilst also accelerating Indian aspirations towards low-carbon development (Everard *et al*., 2017b).

In this case study, climate regulation is an 'anchor service' (*sensu* Everard, 2014) supporting the initial business case at Nadukuppam, but forest restoration also optimises a spectrum of ecosystem service outcomes for which future markets may eventually be developed (Everard *et al*., 2017a). These diverse services are significant for local people, who are key players in maintaining the 'cultural landscapes' that support their needs (Schaich *et al*., 2010).

Figure 3.5 The Kaliveli catchment in Tamil Nadu state, India, showing Kaliveli Lake and the approximate locations of Pitchandikulam Forest and the Nadakuppam restoration area

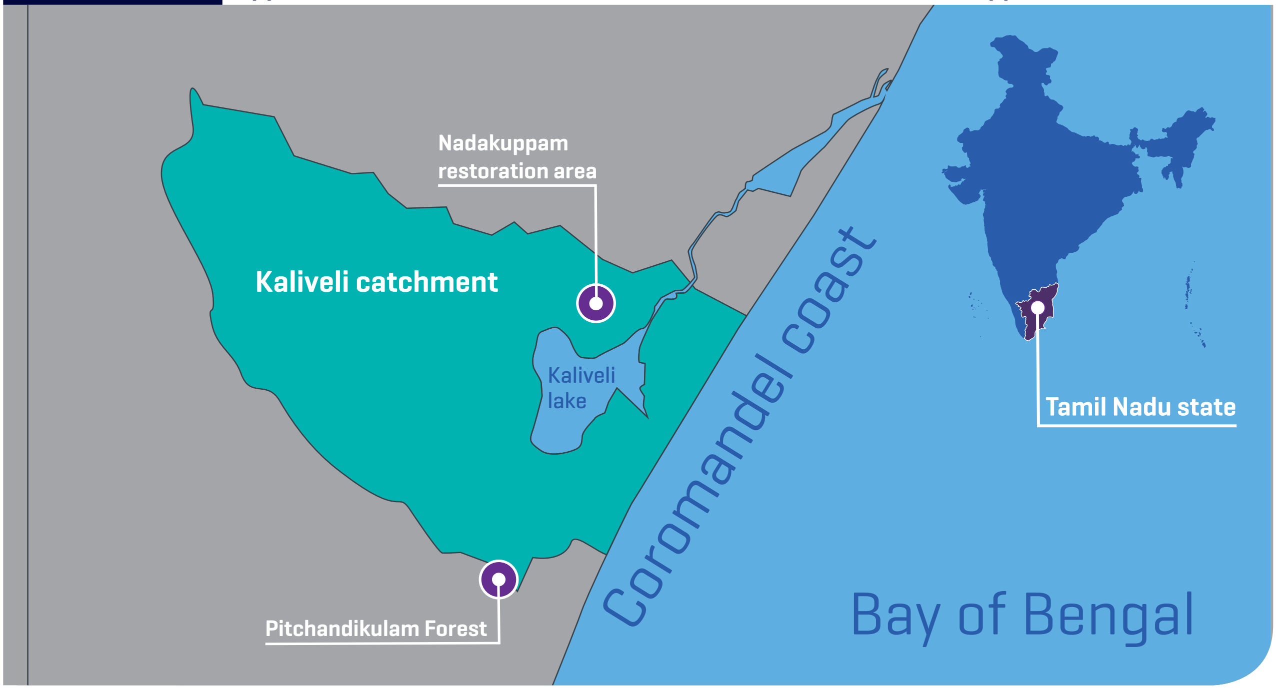


Figure 3.6 Ladies from Nadakuppam village water saplings, forming part of the restored forest

Image source: © Dr Mark Everard

3.2 2 Other forest- and tree-related initiatives underpinning SESs

A subset of other global examples of forest protection or enhancement schemes for ecosystem service enhancement from a diversity of biogeographical zones and states of development are presented here. Box 3.4 summarises case studies from Costa Rica, New Zealand and the UK as a subset of global examples highlighting how priority policy areas – water, biodiversity, carbon, tribal lifestyles and many more – comprise different interlinked benefits flowing from regenerated forest lands, potentially serving as 'anchor services' around which optimisation of other benefits may be planned.

The concept of sustainable forest management has been widely embraced at national and international policy levels, but practical implementation is lacking to the point where little progress is being made to address forest degradation globally (Shvidenko *et al*., 2005). However, the importance of forests for achieving SESs has been recognised and promoted by a range of international agreements which aim to halt and reverse forest loss and degradation (see Box 3.5).

Box 3.4 **Forest protection schemes from Costa Rica, New Zealand and UK**

In Costa Rica, Central America, the Pagos por Servicios Ambientales (PSA: Payments for Environmental Services) scheme has operated since 1996, providing economic incentives for forest conservation. PSA directs payments to ecosystem service outcomes generated by forest and agro-forestry ecosystems, replacing a former ineffective system of tax deductions to support poorly-targeted forest conservation (UN FAO, 2007; Pfaff et al., 2007). Landowners entering PSA scheme are paid for land use activities (protecting natural forest, establishing timber plantations, regenerating natural forest and establishing agro-forestry systems) producing a bundle of ecosystem services (Wünscher et al., 2006). The scheme is funded by reallocation of 3.5% of the revenues from fossil fuel sales tax, topped up by contributions from the World Bank and other international donors (OECD, 2010). Individual beneficiaries (hydroelectric plants, breweries, irrigated farms and other organisations benefiting from ecosystem services) can also pay into the scheme, negotiating contracts with service providers.

New Zealand has implemented novel forest conservation schemes, some working with indigenous Maori landowners in North Island interested in receiving payments for maintaining their land to preserve livelihoods and culture (Funk, 2006). A Maori conservation reserve program known as Nga Whenua Rahui provides economic support enabling landowners to allow land to remain in, or revert to, native bush (Nga Whenua Rahui, Undated). Nga Whenua Rahui is funded by government on the basis of wider ecosystem services benefits to offset the impacts of New Zealand's rapidly urbanising economy. Some other government incentives also support the management of erodible land and carbon sequestration.

The UK's Natural Capital Committee (NCC, 2015) recognised that 'natural capital deficits' are costly to societal wellbeing and the economy. The NCC consequently recommended that government implement a 25-year plan, outlining an economic case for investment in habitat creation and restoration including 250,000 additional hectares of woodland planting optimally located in the landscape for ecosystem service delivery. Economic returns from restored ecosystem services were calculated to be at least as great as those from investment in traditional engineered infrastructure. The UK Government has endorsed the NCC's proposed 25-year plan (HM Government, 2015).

Box 3.5 International forest protection and regeneration initiatives

REDD+ (the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) creates financial value for carbon stored in forests, such that developing countries can invest in protection of forested lands as part of a low-carbon path to sustainable development (UN-REDD Programme, Undated). REDD+ addresses deforestation, forest degradation, conservation, sustainable management and enhancement of carbon stocks through a variety of mechanisms that open up market devices for payments for emission offsets by industrialised nations, rewarding developing countries for protecting ecosystems of value for carbon storage and linked ecosystem service benefits.

The New York Declaration on Forests (United Nations, 2014), signed at the 2014 UN Climate Summit, is a non-binding global pledge endorsed by dozens of governments, thirty of the world's biggest companies and more than fifty influential civil society and indigenous organisations to restore 350 million hectares of deforested and degraded landscapes by 2030. The Declaration aims to cut natural forest loss in half by 2020 and end it by 2030, cutting between 4.5 and 8.8 billion tons of carbon remobilisation annually (approximating that emitted by the United States). Commitments to landscape restoration by other nations under the New York Declaration on Forests include:

- Ethiopia (15 million hectares);
- Uganda (2.5 million hectares);
- the Democratic Republic of the Congo (8 million hectares);
- Colombia (1 million hectares);
- Guatemala (1.2 million hectares); and
- Chile (100,000 hectares).

Many nations are expected to follow with their own commitments, with restoration of degraded land likely to qualify for carbon credits.

The Bonn Challenge was established at a ministerial roundtable in September 2011 at the invitation of the German Government and International Union for Conservation of Nature and Natural Resources (IUCN), calling for restoration of 150 million hectares of deforested and degraded lands by 2020 and facilitating implementation of existing international commitments requiring such restoration (IUCN, 2016). 150 million hectares of forest could sequester an additional 1 $GtCO_2e$ per year, a significant contribution to cutting global climate-active gas emissions, restoring ecological integrity and improving human wellbeing. Many governments, private companies and community groups have signalled their intent to align with the Bonn Challenge.

Box 3.6 **Restoring socio-ecological viability of the Loess Plateau, China**

Severe erosion resulting from intensive farming on sloping lands had formerly threatened the ecological integrity and socio-economic viability of the Loess Plateau in China's north-west, home to 50 million people. Centuries of over-use and over-grazing had created one of the highest erosion rates in the world and a consequent negative spiral of socio-ecological decline and poverty.

To halt and reverse the loss of the powdery soil that gives the Loess Plateau its name, the World Bank co-sponsored two major targeted restoration projects: the Loess Plateau Watershed Rehabilitation Project and the Second Loess Plateau Watershed Rehabilitation Project (World Bank, 2007). This ambitious, landscape-scale restoration sought to regenerate functional ecosystems, supporting sustainable agricultural production and viable livelihoods. The introduction of zoned grazing, terraced agriculture on slopes to protect soil, water and nutrients, controlled fuel wood gathering, and other forms of locally adapted sustainable farming practices have doubled the coverage of perennial vegetation.

These measures have doubled farmer incomes, enabling diversified employment, the production of a wider range of high-value products and greater productivity through the creation of conditions supporting sustainable soil and water conservation. By securing food supplies, this work has cut the need for government to respond with emergency food aid. This has increased the prosperity of more that 2.5 million of the poorest people in four of China's poorest provinces – Shanxi, Shaanxi, Gansu and the Inner Mongolia Autonomous Region. Further 'downstream' benefits include dramatic reductions in the sedimentation of waterways and the associated infilling of dams, reducing inputs to the Yellow River by more than 100 million tons each year.

The total projected costs for the first Loess Plateau project were US $252 million. Over half of this, US $149 million, was contributed by the International Development Association (part of the World Bank). The Second Loess Plateau project cost US$239 million, with an IDA contribution of US$50 million (ibid). These sums are sizeable, but the physical and economic transformation of the Loess Plateau demonstrates the scale of linked socio-environmental benefits that can be achieved if appropriate ecosystem-based restoration is undertaken in degrading areas. This can lead to sustainable outcomes and there have been multiple wider co-benefits arising from close partnerships with government, good policies, technical support and active consultation with and participation of the people.

The projects' approach has since been widely adopted and replicated throughout China. The World Bank has stated that as many as 20 million people (ibid.) have benefited from uptake of the approach.

3.3 Landscape management for multiple ecosystem services

This section considers schemes that have explicitly sought to manage landscapes from an ecosystem-based approach. Case studies in this section are drawn from both the developed and developing world, providing 'real world' operational examples illuminating the characteristics of 'regenerative landscapes'.

3.3.1 Landscape-scale regeneration of water, nutrients and soils

Given the tight linkages between the hydrological cycle and the landscape through which it operates, the management of the hydrological cycle is intimately connected with landscape regeneration and vice versa. This tight linkage is exemplified by China's Loess Plateau project (Box 3.6). This scheme demonstrates that landscape-scale regeneration of SESs is possible with vision, integrated policy, funding and involvement of local people.

Box 3.7 Integrated constructed wetlands in County Waterford, Ireland

The extensive installation of integrated constructed wetlands (ICWs) in the Anne Valley, County Waterford, Ireland, is evidence of a 'systemic solution' using natural processes to achieve multiple ecosystem service benefits. Up until the early 1980s, Waterford was naturally water rich. Wetlands characterised the landscape, performing a range of hydrological, chemical and biological functions. However, in the 1980s, agriculture improvement subsidies from both the Irish government and the EU drove the drainage of substantial areas of bog and other wetlands across Ireland. Although land drainage has boosted some facets of agricultural production, drainage of these wetlands produced a number of unintended negative effects on the local ecosystems services, including:

- reducing water storage and floodwater buffering capacity;
- substantially diminishing rivers and wetlands; and
- altering chemical cycling and biodiversity.

The ICW concept addresses multiple ecosystem service outcomes associated with wetland processes. It takes a 'landscape fit' approach, reinstating cascades of shallow, vegetated wetland cells within natural, aesthetic and working landscapes. Linked benefits include wastewater processing, hydrological buffering, regeneration of flows in watercourses, public access to attractive regenerated wetland landscapes, silt and nutrient interception, and the recovery of lost landscapes and populations of aquatic species such as otters, brown trout, salmon, sea trout and eels. Networks of ICWs in the Anne Valley now support farm profitability, manage sewage from the household or the industrial unit and up to the village scale and provide leisure opportunities and regenerate the ecology, recreational and aesthetic value of a formerly much degraded catchment ecosystem. Widespread uptake of ICWs has reanimated the Anne Valley, ecologically, socially and economically, with extensive scientific verification of ecosystem service outcomes (reviewed in Everard, 2013).

ICWs have been adopted elsewhere in Ireland for a variety of reasons. These include the treatment of landfill leachate, hotel wastewater and diffuse inputs in a city centre context, with many ecosystem service co-benefits (Everard et al., 2012). Regulatory agencies, particularly the Irish EPA, have resisted granting consents for the installation of ICWs, due largely to the narrow terms under which these licences are issued and the exclusion from consideration of inputs to their operation and the wider suite of benefits that they deliver. However, ICW design has become incorporated into Irish Government guidance under the Water Services Investment Programme 2010-2012 (Department of the Environment, Heritage and Local Government, 2010) which recognises the potential for ICWs to reverse former declines in the ecosystem services of lost natural wetlands. ICWs represent a low-input, multi-service output 'systemic solutions' approach contributing to sustainable development by optimising benefits across a range of ecosystem services and beneficiaries, increasing their net economic value.

Image source: Robert McInnes

A ‘systemic solutions’ approach to reanimate ecosystems and their multiple services across broad landscapes is also evidenced in Europe in the form of extensive installation of integrated constructed wetlands (ICWs) in the Anne Valley, County Waterford, Ireland (Box 3.7).

3.3.2 Catchment ecosystem services for water quality

Ecosystem-based landscape and waterscape management can protect water quality as an ‘anchor service’ mobilising management attention and investment, simultaneously co-producing a wider set of ecosystem service benefits such as water storage, soil retention and quality, nutrient cycling and habitat for biodiversity. Three examples – the Upstream Thinking programme in south west England, New York City’s water supply and SCaMP in north west England (Boxes 3.8 to 3.10) – have implemented schemes that focus on systemic solutions that protect beneficial ecosystem processes rather investing in downstream technical solutions to manage more contaminated raw water. All three have produced financial benefits relating to savings in water treatment costs, whilst also yielding co-beneficial outcomes for fisheries, biodiversity, ecotourism and by stabilising farm incomes; providing greater overall societal value.

Box 3.8 **‘Upstream Thinking’, south west England**

The Upstream Thinking programme[5] in south west England operated by South West Water (SWW, the regional water utility) reinvests a proportion of water service charges into improvements to agricultural practices in catchments serving surface water abstraction points (Upstream Thinking, Undated). By reducing inputs of particulate, soluble and microbial pollutants from farmed land, raw water quality is protected as part of SWW’s aim to reduce chemical, financial and energy inputs to potable supply.

Business benefits accrue to SWW and its customers; OFWAT (the economic regulator) accepting that Upstream Thinking represents a 65:1 benefit-to-cost ratio relative to the treatment of more contaminated water. Here, water quality is the ‘anchor service’, while the solutions applied also optimise multiple linked socio-ecological co-benefits for fisheries and river ecosystems, wildlife and ecotourism (South West Water, 2012).

5 upstreamthinking.org

Box 3.9 New York City's water supply

New York City derives its water supply from the Cat/Del (Catskills and Delaware) catchments. A contract was negotiated between urban water users and farming and other rural communities in the Cat/Del catchments, in order to undertake measures to maintain high quality water. This has become one of the largest global 'payment for ecosystem service' (PES) schemes. This arrangement was formalised as a comprehensive Memorandum of Agreement in 1997. Under the terms of the MOA, the city committed funds of approximately $US350 million (£190 million) with additional investment in a watershed protection programme costing approximately $US1.3 billion (£700 million) (New York-Connecticut Sustainable Communities Consortium, 2014).

Though substantial, these figures represent only a small fraction of the financial costs and environmental impacts of alternative conventional engineered solutions to treat more contaminated raw water abstracted downstream. This partnership approach, linking rural and urban stakeholders, is key to maintaining New York City's pristine water quality and the viability of farming for the foreseeable future.

Box 3.10 SCaMP, the Sustainable Catchment Management Programme, in north west England

SCaMP, the Sustainable Catchment Management Programme[6], was instigated by the British multi-utility company United Utilities (UU), the water service provider for the north west of England. UU has substantial upland landholdings to protect water quality and support significant wildlife habitats. SCaMP was developed in partnership with the wildlife NGO the Royal Society for the Protection of Birds (RSPB).

The first phase of SCaMP in 2005-2010 entailed working with tenant farmers on UU-owned land in order to:

a) revise management practices; and

b) undertake additional capital works to restore upland habitats.

These measures were taken with the understanding that they would provide simultaneously beneficial for water production, biodiversity and farm incomes. These measures were funded through reinvestment of water service charges (Everard, 2009).

Subsequent phases of SCaMP have addressed water capture on land that is not owned by UU. Nevertheless, targeted subsidies and advice have achieved water quality and quantity benefits for the water company and its customers, as well as enhancing biodiversity and connected ecosystem services (United Utilites, Undated).

6 http://corporate.unitedutilities.com/cr-scamp.aspx

3.3.3 Landscape approaches to water quantity management

Within Europe, the management of flood impacts is making a transition from a localised 'defence' of assets at risk approach, towards a catchment-based approach. 'Natural flood management' (NFM) is defined as the alteration, restoration or use of landscape features as a novel way of reducing flood risk (Parliamentary Office of Science and Technology, 2011; Morris et al., 2005; Wheater and Evans, 2009). An impressive example of multi-partner NFM in action to address flood risk and generate a range of linked co-benefits around the town of Stroud in the English county of Gloucestershire is summarised in Box 3.11. The implementation and continued success of NFM schemes depends on:

- effective collaboration between land-owners and communities;
- long-term funding measures or incentives; and
- better use of local knowledge.

A significant obstacle to NFM is that there is at present no enforceable policy or agreed framework to recognise and economically quantify the full spectrum of ecosystem service co-benefits that NFM schemes create. This highlights the imbalance between the reality, in which economic and policy incentive structures drive land use for commercial gain, and the aspirations, which are towards sustainability (Everard et al., 2014).

Box 3.11 **The Stroud Rural SuDS Project**

An impressive example of a multi-functional NFM in operation is the Stroud Rural SuDS Project in sub-catchments upstream of the town of Stroud in the county of Gloucestershire, south-west England (Stroud District Council, Undated). Using a diversity of measures to retain water and slow flows in the upper catchment, such as large natural woody dams where safe and feasible, the Stroud Rural SuDS Project works in partnership with local community flood groups, farmers, partner organisations and major landowners including the National Trust (a UK heritage and nature conservation organisation holding lands in trust for public benefit[7]) to reduce flood risk in the lower River Frome valley. Flood regulation is an 'anchor service' driving collaboration and investment, but many linked ecosystem service benefits (water quality, biodiversity, landscape aesthetics, etc.) are co-produced.

7 www.nationaltrust.org.uk

3.3.4 Farming for human wellbeing

A regenerative approach can be applied to all landscapes. However, farming landscapes are particularly important to creating sustainable change. Some 16,000 Mha are farmed globally, although this area has been declining since the last century (Ausubel *et al.*, 2013). Much of the scientific discourse about sustainable agriculture at present concerns the trade-offs and synergies involved when attempting to balance ecosystem service benefits (Power, 2010) with the levels of agricultural productivity required to ensure they produce the 50% more food required for nine billion people by 2050 (UN FAO, Undated).

Box 3.12 addresses two examples from the US where PES-based economic instruments have been applied through 'reverse auctioning' to target public investment as subsidies to private land-owners to optimise net public benefits from selected ecosystem services.

Examples of best practice in achieving 'regenerative landscapes' that target multiple ecosystem service outcomes, and which have been influential in influencing the wider policy environment, include the UK-based Loddington Farm (Box 3.13) and the US Kellogg Biological Station (Box 3.14). Both of these programmes highlight how beneficial ecosystem service outcomes can result from innovative and profitable farming practice.

Box 3.12 **PES-based land management schemes in the US**

The US Conservation Reserve Program (CRP) was instituted in 1985 to combat soil erosion by offering financial incentives for farmland owners through 10- to 15-year contracts to cease farming activities in parcels of land such as in sensitive river valleys. It has subsequently evolved to address a broader 'bundle' of publicly beneficial ecosystem services (OECD, 2010). Contracts are now let through 'reverse auctions', in which potential ecosystem service 'sellers' submit bids indicate the minimum payment they are willing to accept for practices that deliver regenerative impacts on ecosystem services. These schemes are then prioritised according to potential environmental benefits they offer.

Another US programme of subsides for measures to reduce nutrient enrichment in the economically- and environmentally-important Chesapeake Bay. This problem is addressed through a PES approach, innovatively tackling water management problems where traditional regulation has failed (Ator and Denver, 2015). Farming interests bid for how much they are willing to accept in payment to implement pre-approved best management practice (BMP) 'bay-friendly' nutrient reduction measures. Regulators then allocate subsidies where they will achieve the greatest net benefit per unit investment through a 'reverse auction' process.

Box 3.13 **Progress with ecosystem service production at Loddington Farm**

Loddington Farm in Leicestershire, eastern England, was bequeathed to the Allerton Project (initially the Allerton Research and Educational Trust) with the aims of advancing public education and conducting research on different farming methods and their effects on the environment and wildlife.

The Game & Wildlife Conservation Trust has promoted advances in game and wildlife management in a 333 ha commercial farm context under the Allerton Project, embracing modern technologies for arable cropping, sheep grazing and the maintenance of woodland, a stream and several ponds. Traditional tillage techniques reverted to minimal tillage in 1997 and to disc cultivator drilling in 2001, changing from tyres to tracks on the tractor to reduce soil compaction. Research also expanded to address soil erosion, organic matter, soil flora and fauna, and nutrient management. Direct drilling has since been adopted as the primary cultivation tool, using a lighter tractor to reduce soil compaction with benefits for greater fuel efficiencies and reduced exhaust emissions. Water-friendly farming measures were launched in 2012 (Biggs et al., 2014).

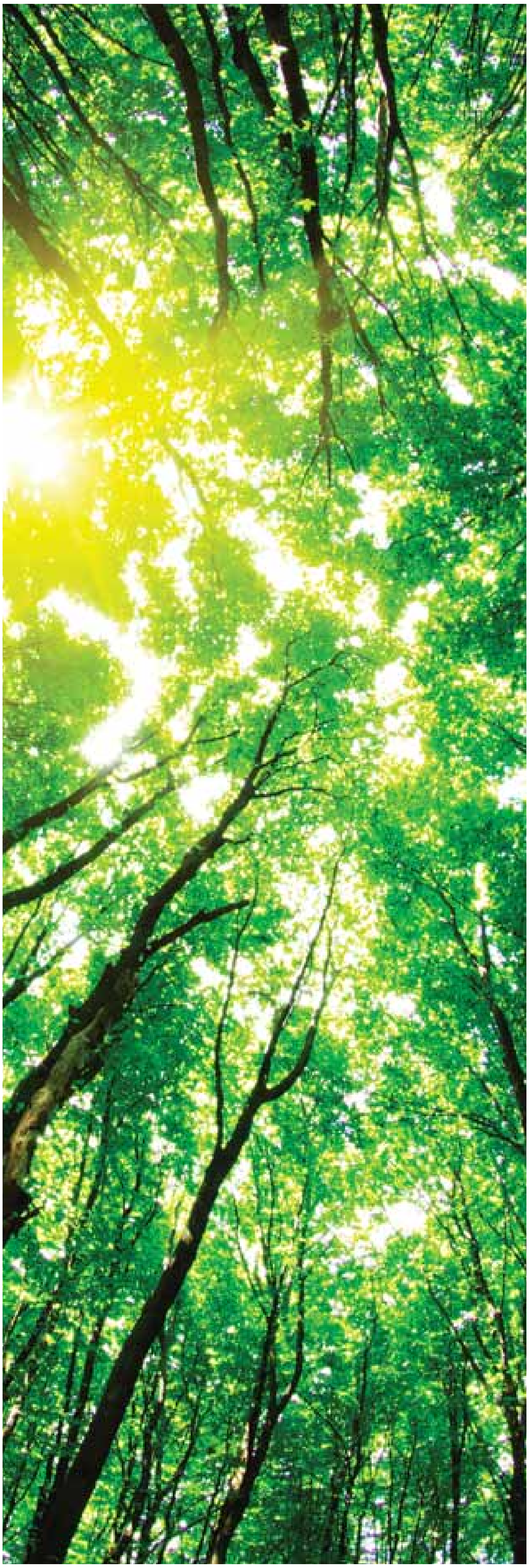
Breeding songbird numbers recovered following implementation of a game management system in 1992, rapidly doubling though with some small decline occurring after 2001, when predator control was introduced and feeding was withdrawn (GWCT, Undated a). Reduced ploughing has also enabled worm populations to increase, improving soil permeability and retention of organic matter and nutrients (GWCT, Undated b).

The Loddington experience demonstrates how economically profitable farming that also farms for wildlife, water, nutrients and other ecosystem services is feasible with off-the-shelf solutions.

Box 3.14 **Progress with ecosystem service production at the Kellogg Biological Research Station**

The Kellogg Biological Research Station, associated with Michigan State University, has been a long-term ecological research site of the US National Science Foundation. 25 years of experimentation reveal that a range of ecosystem services – clean water, biocontrol, biodiversity benefits, climate stabilisation and long-term soil fertility – can be provided by intensive row-crop ecosystems that also produce high agricultural yields (Robertson *et al.*, 2014).

Midwest farmers, especially on large farms, were willing to adopt practices that delivered these services in exchange for payments scaled to reflect management complexity and farmstead benefit. Surveyed citizens also indicated a willingness to pay farmers for the delivery of specific services. A new farming for ecosystem services paradigm in US agriculture seems attainable with appropriate policy evolution.



4.0 Principles of success

This report aimed to identify how linked ecological and socioeconomic regeneration can be achieved by examining community governance approaches within landscapes that have limited soil or water resources, drawing upon case studies to illustrate the key characteristics of regenerative landscape management where policies support recovering ecosystems. Securing future human wellbeing depends on identifying and innovating a policy landscape that promotes inherently regenerative practices.

There is no simple objective criterion defining indisputable public good or equity. Today's challenges are not unidimensional but are 'wicked problems', difficult or impossible to solve because of incomplete, contradictory and changing requirements, and complex interdependencies (Rittel and Webber, 1973).

Ecosystem services offer a framework to articulate this complexity by recognising the multiplicity of interconnected outcomes that arise from all intervention. Ecosystems services thereby provide a more integrated basis for decision-making and the formulation and implementation of policies. This systemically framed approach also implicitly reconnects people to decision-making, illuminating the needs of and impacts on all ecosystem service beneficiaries. Framing this connection within the broader political and technological dimensions introduced by the STEEP framework helps make this tractable in complex socio-political systems.

Systemic failures have been described in terms of narrow interpretation and/or lack of integration between several interlocked factors:

1. **Social factors**, such as shift from communal to individualised or corporate competitive management.
2. **Technological factors**, such as the pervasion of tube wells enabling the rapid extraction of water resource at rates exceeding natural replenishment.
3. **Environmental factors**, including the use of practices that override or overlook ecosystem resilience and natural processes regenerating water and soil resources.
4. **Economic factors**, such as the subsidisation of energy for water pumping creating disincentives for its conservation.
5. **Political factors/governance**, such as a policy approach with a narrow focus, particularly the prioritisation of short-term economic growth and resource maximisation over long-term sustainability and the viable production of other linked ecosystem services.

As exemplified by the first set of case studies in India, technocentric models of water resource exploitation can overlook the longer-term degenerative ecological consequences and their multiple linked degenerative socio-economic outcomes. As a result of this approach, increased aridification drove farmland and village abandonment across significant areas of central India. In this case, it is a lack of systemic vision rather than bad intent that results in SES degradation.

These and other examples in the knowledge base of regenerative practice across both the developing and developed worlds highlight that reversing former degrading cycles is possible. The case studies examined provide indications of the means by which the regenerative transformation of landscapes can be achieved.

This connected world view needs to progressively supersede the legacy of fragmented, narrowly-framed technical, legal and fiscal 'fixes' promoting short-term gains to only a subset of beneficiaries. Governance systems embodying this connected approach are easier to recognise at the local scale, such as traditional village governance arrangements that have been historically adaptive to achieve sustainable outcomes where people live in close proximity to supportive ecosystems. The situation is more complex in developed world situations where our needs are often served by remote supply chains. Compounding this situation is a policy environment that is barely influenced by systemic thinking and the optimisation of outcomes, much of it remaining rooted in industrial-era assumptions about the inexhaustibility of resources (Jackson, 2011). It is in this fragmented policy environment that the kinds of lessons emerging from this report can shed light, in two principal ways:

- Firstly, the consideration of issues using the ecosystem services framework can articulate in semi-objective terms the many, often historically overlooked, ramifications of apparently isolated decisions for a variety of interconnected ecosystem service outcomes. This approach also draws attention to those people affected by changes to ecosystems, both positively and negatively, through changes in ecosystem services. For decision-makers (particularly in business of government institutions), this provides a means to reveal the potential future liabilities and investment risks that might arise from formerly unanticipated consequences of decisions and, conversely, provide a more equitable and certain basis for innovation and investment.
- Secondly, a problem-solving approach utilising the STEEP framework offers the opportunity to address the linked elements within a complex and interconnected socio-political, economic and environmental context.

The following sub-sections stratify the evidence presented in this report under the constituent elements of the STEEP framework. The section concludes with a discussion of how these various factors of success can be effectively integrated.

4.1 Social considerations

Successful examples of regenerative SESs in the main findings position social factors centrally in scheme design, implementation and ownership. The key social success factors in regenerative landscapes are listed below, with examples drawn from case studies to illustrate the point.

a. **Inform the design and operation of ecosystem uses and management with locally articulated needs**. The needs and values of water regeneration schemes in villages in Alwar and Jaipur Districts of Rajasthan were central to appropriate scheme design and ownership, underpinning the regeneration of water, food and socio-economic security.

b. **Integrate the views of multiple stakeholders into decision-making**. Forest regeneration in Tamil Nadu was planned to produce a linked set of benefits, including benefits for schools and new business opportunities for women.

c. **Recognise traditional knowledge and practices as a legitimate and locally appropriate source of knowledge**, as a tried and tested set of adaptations to the local environmental context. The first johad constructed by Tarun Bharat Sangh at Gopalpura took account of traditional knowledge held by elders in the community about how best to address lack of water as the main cause of poor health, malnutrition and poverty.

d. **Out-scale successes using proven and important social networks**. These networks provide mechanisms for the exchange of knowledge about successful approaches, and for up-scaling. In Gujarat, widespread uptake of community-based groundwater recharge since the 1990s spread by contagion from initiatives in the Saurashtra region of Gujarat state, demonstrating the important role of people and their traditional wisdom in the informal uptake and out-scaling of regenerative water management.

e. **Recognise local people as the owners of, and key actors in, resource use**. Farmers were seen as key agents and beneficiaries of landscape regeneration solutions in the PES schemes operating in the US, and were brought into deliberative processes underpinning scheme design and roll-out. Conversely, resource dispossession through centralised government decision-making was a fundamental factor in unsustainable water management in Rajasthan and elsewhere in India.

f. **Link differing social needs across geographical and temporal scales**. Natural Flood Management (NFM) solutions to protect downstream assets only work if the perspectives and needs of upstream land users are integrated. Likewise, regeneration of catchments requires the needs of different villages to be connected via appropriate governance arrangements.

g. **Encourage social cooperation, applied in a manner sympathetic with natural supportive landscape functions**. Obstacles created by fragmented land ownership need to be overcome for communities to work with natural processes that are not bounded by human property. The construction of chauka systems enabling communities to regenerate collectively beneficial water and soil resources in Laporiya, Rajasthan, are based on natural water flows rather than the parochial boundaries of personal property.

4.2 Technological considerations

Technology alone is neither automatically beneficial nor detrimental. For example, large dams favour the already privileged recipients of diverted piped water and harnessed electrical energy, but inevitably generate many unintended negative outcomes for donor ecosystems and their dependent beneficiaries. By contrast, small dams, johadi, bunds and anicuts, designed in appropriate geographical and cultural contexts in Alwar and Jaipur Districts have regenerated ecosystems and linked socio-economic prospects. Different technologies have proven effective to achieve SES regeneration in different geographical and cultural settings, though the principles underlying their selection remain constant. Key considerations for the use and application of technology in regenerative landscapes are listed below, each illustrated by an example from the case studies:

a. **Avoid imposing uniform, 'top down' solutions, which tend to result in net degradation**. The prevalent technocentric Indian policy environment, which regards water as a transportable commodity rather than a communal asset, may yield immediate benefits to a minority but tends to result in longer-term SES degradation, as for example the linked rural, urban, irrigation and wildlife vulnerabilities created by the Bisalpur Dam. This is mirrored by the laudable but context-insensitive drivers of the American 'Dust Bowl' and contemporary intensive farming focused narrowly on commodity output but overlooking wider ramifications for supportive ecosystems.

b. **Adapt technical solutions to localised geographical and cultural contexts, also taking account of their long-term consequences**. A distributed model recognising geographical and cultural diversity across landscapes can lead to sustainable and useful technological solutions, displacing implicit assumptions that bigger or uniform technological solutions are best. As examples, large dam-and-transfer and extensive tube well schemes promoted as pro-development highlight how technologies that override natural resource regeneration rates ultimately undermine development aspirations, leading instead to hydrological, food, health and other forms of poverty.

c. **Develop 'systemic solutions' to optimise outcomes across a range of ecosystem services**. Integrated constructed wetlands (ICWs) in Ireland and the diverse WHSs found across India are practical examples of 'systemic solutions', flexibly implemented according to local geography and needs, using natural processes to achieve multiple ecosystem service benefits.

d. **Progressively integrate evolving best practice into farming techniques and the associated policy environment**. Ecosystem-sensitive farming at Loddington Farm deliberately uses 'off the shelf' technologies, indicating that technical methods are available to begin transforming farming towards regenerative, multi-beneficial outcomes if the policy and operating environment for farmers is modified appropriately.

4.3 Environmental considerations

Environmental considerations need to address not merely consider the economically exploitable natural resources, but also the values of ecosystem processes and services that underpin continued system resilience and provision of these benefits. By factoring all of these interrelated processes into decision-making, the schemes and policies outlined in regenerative case studies tend to protect or enhance the vitality of ecosystems and, in the spirit of 'systemic solutions', optimise the net benefits derived from these ecosystems.

a. **Recognise that the services of natural ecosystems are a core resource generating multiple benefits**. Restoration of regionally appropriate forest in degraded environments of the Coromandel Coast of Tamil Nadu generates carbon sequestration, natural medicine, educational, hydrological, biodiversity and other linked benefits on the Tamil Nadu. Similarly, Indian water management solutions exemplify local-scale solutions (johadi, chauka, taanka, etc.) attuned to highly localised geographical situations, achieving water security through promoting groundwater recharge processes on a geographically-sensitive basis. At landscape scale, restored ecosystem functioning including water and soil retention achieved through reforestation and re-greening underpins linked environmental, economic and social regeneration in the Loess Plateau of China.

b. **Work in sympathy with natural processes operating both locally and at scales broader than parochial land ownership**. Natural Flood Management (NFM) solutions are founded on catchment-scale hydrological processes rather than a narrower approach to 'defending' assets at risk, as well as by chauka design in which communities implement water interception by collaboration respecting natural drainage lines irrespective of land ownership.

4.4 Economic considerations

The ecosystem service benefits associated with regenerating SES have multiple and tangible economic value substantially beyond their immediate utilitarian exploitation, albeit that many of these benefits have formerly been overlooked (often resulting in system degeneration). Economic policy should consider the overall distribution of benefits, now and in the longer term, rather than having a narrow focus on short-term financial returns. Key economic factors promoting progress towards regenerative landscapes include:

a. **Recognise that all ecosystem services have tangible value**. The UK's Natural Capital Committee recognises that 'natural capital deficits' are costly to societal wellbeing and the economy, and that economic returns from habitat restoration are likely to be at least as great as those from investment in traditional engineered infrastructure.

b. **Take account of the systemic ramifications of solutions for costs and benefits across all ecosystem services and associated beneficiaries**. Technocentric approaches in India and elsewhere in the developing world that focus on mechanically efficient water extraction, but which overlook resource regeneration or the costs to those dependent on ecosystems from which water is diverted, can undermine the primary natural capital upon which future economic security and opportunity depend.

c. **Take a 'systemic solutions' approach to identify innovations that work with natural processes, optimising the overall societal value of investments in ecosystem management and use**. Through their focus on catchment processes, Upstream Thinking, SCaMP and New York City water supply schemes protect catchment landscapes primarily to improve raw water quality. Here, water quality is the 'anchor service', or focal point for scheme investment and design around which a range of ecosystem service co-benefits, all with additional value, can be achieved and optimised in scheme implementation (e.g. through visionary 'systemic solutions').

d. **Progressively integrate an expanding range of services into markets and fiscal measures**. Catchment management schemes identified in Upstream Thinking, New York City and SCaMP water supply solutions are based on tangible markets where beneficial outcomes for water supply are related to regulatory ecosystem services. This ecosystem-based approach to raw water quality protection connects 'real world' economic implications for farmers with downstream beneficiaries as a robust basis for mutually beneficial outcomes. The diversity of other payment for ecosystem services (PES) scheme examples across the world highlights the potential for bringing formerly undervalued ecosystem service benefits into mainstream markets and decision-making contexts.

e. **Challenge assumptions that multi-service outcomes are not profitable**. Farm profitability remains a priority at Loddington Farm in the UK, and economic viability is part of the assessment of practices at the Kellogg Biological Station in the US, demonstrating that ecological recovery need not be in conflict with economic returns. Furthermore, farms in the Chesapeake Bay catchment strategically subsidised through a PES-based scheme enables profitable farming with implementation of 'best management practices'.

4.5 Political considerations

Political considerations relate not merely to high-level policy but also to multiple tiers of both formal and informal governance down to the local level. There are many global examples of effective community-based governance utilised to maintain the viability and equity of natural resources in the absence of formal governance, for example as reviewed by Ostrom (1990). Key political factors to promote progress towards regenerative landscapes are addressed below.

a. **Delegate decision-making to a level most appropriate to account for local geographical and cultural contexts**. Village-scale governance through Gram Sabha ('village council') is essential for effective design, operation and continued ownership of groundwater recharge schemes in Alwar and Jaipur Districts of Rajasthan. These community-scale governance arrangements represent a form of institutional capital as important as locally adapted physical technologies for the sustainable operation and benefit-sharing of water-harvesting systems.

b. **Recognise the significant roles that non-government organisations play in mobilising local activity and liaising with funders and formal government**. NGOs in India, Africa and other regions have emerged as key institutional agents of change, harnessing community interests, interfacing with funders, and opposing (as in the case of Tarun Bharat Sangh in India) as well as working with (WaterHarvest/Wells for India) formal government bodies.

c. **Utilise nested governance arrangements to avert fragmented management**. In order to overcome the risks of fragmented management in a village, or other locally based approach, a nested approach to governance is required to account for and optimise processes operating at broader geographical scales. For example, tiers of governance with an overview of the dynamics of a catchment as a whole can optimise the overall benefits arising from cumulative local decisions. This is demonstrated by Tarun Bharat Sangh's promotion of catchment-based Pad Yatra ('Water Parliament') as a forum to promote basin-wide water sharing, dispute resolution, water body restoration, soil fertility, reforestation and associated livelihood enhancement between Gram Sabha (village councils) in the Arvari and other drainage basins in Alwar District. Further scaling up of governance includes formation of the Rashtriya Jal Biradari ('National Water brotherhood'), aimed at promoting a people-oriented approach in national and state water policy.

d. **Take into account potential effects on interrelated ecosystem services, spanning disciplinary interests, in regulatory decisions**, rather than be blinkered by an unnecessarily narrow disciplinary paradigm. A blinkered disciplinary approach can block multi-beneficial, economically efficient solutions such as consents for integrated constructed wetlands (ICWs) in Ireland. The ICW approach is now incorporated into Irish Government guidance; the guidance recognises the potential for the ICW approach to reverse former declines in the ecosystem services associated with the loss of natural wetlands.

e. **Co-design programmes between government and local people around common agreed goals to achieve pragmatic, locally relevant and accepted solutions**. In China's Loess Plateau, government aims and governance arrangements were aligned with those of local people to shape acceptable and effective solutions. Also, Natural Flood Management (NFM) solutions require an alignment of central government aspirations and arrangements for local implementation.

f. **Address driving policy or other development priorities as 'anchor services', around which outcomes for all ecosystem services and hence net societal value are optimised**. Awareness of the potential for wider linked co-benefits promotes innovation of 'systemic solutions' to optimise outcomes for all connected stakeholders. Examples include:

    i. In Tamil Nadu, the 'anchor service' of climate regulation through carbon sequestration in restored tropical dry evergreen forest provided a basis for international markets investing into the TCW model, from which a diversity of linked ecosystem service co-benefits flow.

    ii. Catchment reanimation through ICWs in Ireland and the Upstream Thinking programme in south west England were planned to deliver multiple ecosystem services benefits beyond their driving 'anchor services', which vary by location including raw water resource protection, treatment of farmyard run-off, and domestic and industrial unit wastewater treatment.

To ground the principles of success is practical challenge, the key considerations when applying the STEEP framework to two contrasting 'real world' situations (out-scaling regenerative water management in Rajasthan's semi-arid developing world context; and transforming mainstream intensive farming in the developed world) are outlined in the appendices.

4.6 Systemic design, outcomes and transferrable lessons

As with any system, all aspects of the STEEP framework have to be addressed in an integrated way. 'Cherry picking' elements of the system in isolation, for example a policy environment predicated on maximising economic productivity in the short term without regard to environmental and social consequences, is likely to favour technology choices undermining overall system integrity and long-term sustainability. Conversely, regenerative outcomes are possible when all facets inform policy decisions and choices are made about technology that promote long-term sustainability, equity and economic viability. When this 'virtuous circle' is achieved, many co-benefits can result.

Co-learning between societal actors is essential to achieve a more connected and concerted approach to regenerative resource use. For example, successes in regenerating SESs achieved by Tarun Bharat Sangh in India formerly initiated confrontation with state government, but now informs Government of Rajasthan initiatives such as Jal Swavlamban Abhiyan, as well as influencing national policies.

An adaptive management approach is essential to ensure that practical outcomes inform the revision of strategy, rather than adherence to narrow ideology. Contrasting examples from Gujarat state, India, highlight how small-scale, decentralised groundwater recharge initiatives have spread by contagion due to their efficacy in addressing water shortages.

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Appendix 1: out-scaling regenerative water management across Rajasthan

Population growth and changing lifestyle demands have driven the adoption of energised water extraction, with the progressive abandonment of inherently sustainable traditional water management. As a result, case studies of regenerative catchment management, where there has been a reversal of wider degrading SES trends across Rajasthan, are in the minority. Complex challenges arise from the growing demands from an increasing and increasingly urbanised human population. However, simply relying on increasingly mechanically efficient pumping of deeper, receding groundwater or transferring water from increasing remote sources is manifestly far from an enduring solution. The following sub-sections apply the principles of success identified in the conclusion, and develop case specific questions that can inform more regenerative outcome.

Social considerations for water management in Rajasthan

- **Inform the design and operation of ecosystem uses and management with locally articulated needs:**
  - What are the needs for which local people require water and how might these be most appropriately served, for example by managing local water flows and sources to increase soil moisture for farming? This includes factoring into decisions the needs of people that might be compromised if water is transferred from elsewhere.
- **Integrate the views of multiple stakeholders into decision-making:**
  - Are there differing needs that should be taken into consideration, both within local communities and in regions from which water may be transferred?
- **Recognise traditional knowledge and practices as a legitimate and locally appropriate source of knowledge:**
  - What local traditions already exist about the sustainable management and sharing of water, particularly those that have enabled people to adapt to specific local conditions, and how can these be adapted to contemporary needs?

- **Out-scale successes using proven and important social networks:**
  - Can civil society institutions promote traditional or innovative examples of sustainable and efficient water management to their peers?
- **Recognise local people as the owners of, and key actors in, resource use:**
  - Does the decision-making process engage and empower local people?
- **Link differing social needs across geographical and temporal scales:**
  - What are the ramifications of management options for people over the longer term and at broader spatial scales?
- **Encourage social cooperation, applied in a manner sympathetic with natural supportive landscape functions:**
  - How are the needs and rights of people best met by collaborative solutions working with natural landscape processes?

Technological considerations for water management in Rajasthan

- **Avoid imposing uniform, 'top down' solutions, which tend to result in net degradation:**
  - Is there a presumption in favour of established technocentric solutions that may need to be challenged?
- **Adapt technical solutions to localised geographical and cultural contexts, also taking account of their long-term consequences:**
  - Do proposed water management solutions fit with location-specific natural resource regenerative capacities and cultural values?
- **Develop 'systemic solutions' to optimise outcomes across a range of ecosystem services:**
  - What solutions work optimally, not merely to produce water, but to achieve a wide range of linked benefits (for example soil fertility and moisture, fishery resources, culturally valued sites and landscapes) of optimal societal value?
- **Progressively integrate evolving best practice into farming techniques and the associated policy environment:**
  - What farming practice works best with local geographic conditions, and makes the most efficient use of local resources, in meeting people's needs? What innovations and measures are required to ensure that the wider ramifications (for water yield, soil conservation, biodiversity, carbon storage, etc.) of land uses are regenerative?

Environmental considerations for water management in Rajasthan

- **Recognise that the services of natural ecosystems are a core resource generating multiple benefits:**
  - What natural processes could be used, enhanced or emulated to provide reliable sources of water and wider services supporting people's wellbeing?
- **Work in sympathy with natural processes operating both locally and at scales broader than parochial land ownership:**
  - How do these hydrological processes work in the local setting under consideration? Do the processes span land ownership boundaries, and can we combine management approaches for mutual benefit? Has ecosystem functioning been fully considered, rather than simply ecosystem extent, informing potential management interventions such as restoration of functional habitat or clearance of invasive species that have the potential to enhance ecosystem functioning as a contribution to water security?

Economic considerations for water management in Rajasthan

- **Recognise that all ecosystem services have tangible value:**
  - Have all ecosystem service contributions to water security and local wellbeing been recognised?
- **Take account of the systemic ramifications of solutions for costs and benefits across all ecosystem services and their associated beneficiaries:**
  - Has systemic account been taken of the balance of benefits and costs across all ecosystem services generated through proposed water management solutions?
- **Take a 'systemic solutions' approach to identify innovations that work with natural processes, optimising the overall societal value of investments in ecosystem management and use:**
  - Can restoration of functional habitat, such as forests, wetlands and other hydrologically active habitats, be protected, restored and managed on a sustainable basis for the long-term benefit of local water security? Is management to achieve the desired 'anchor service' (for example achieving water security) possible through innovations that work with natural processes, optimising the overall societal value of interventions and investments in ecosystem management and use?

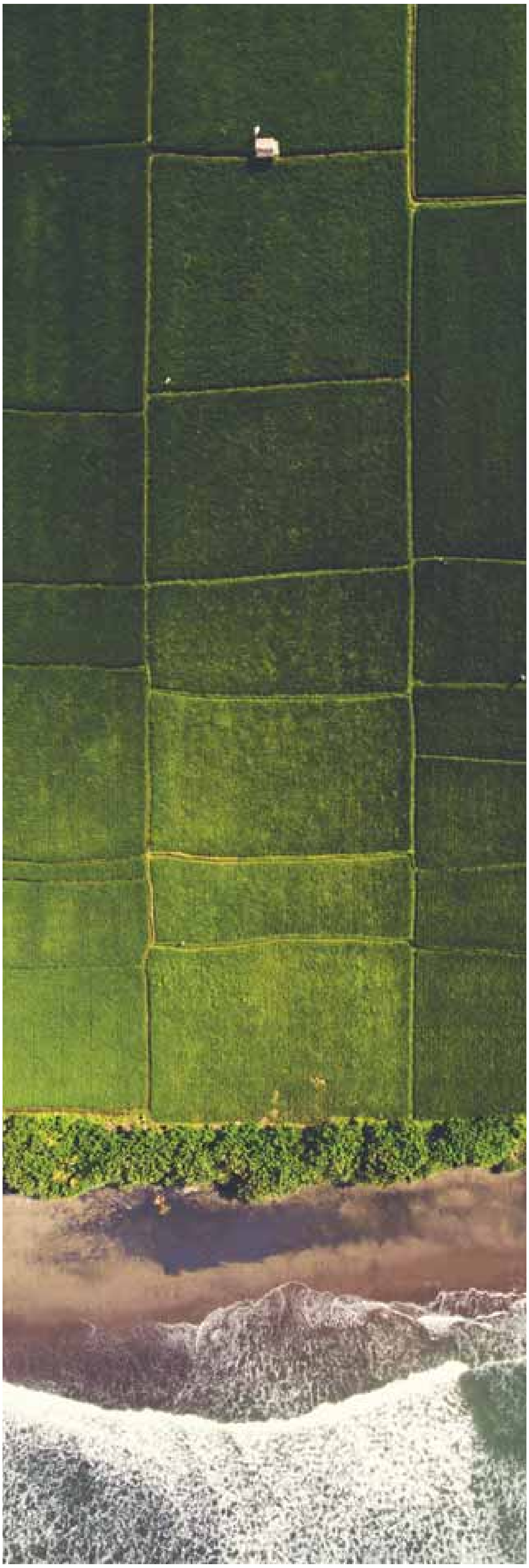
- **Progressively integrate an expanding range of services into markets and fiscal measures:**
  - Are the values of these services adequately reflected, and what are the opportunities for creating markets recognising and rewarding their contributions to water security and human wellbeing? What subsidies and taxes and other market-based instruments favour, or could be modified to favour, water management solutions that optimise benefits across a range of ecosystem services? Can an approach taking account of multi-beneficial outcomes promote the pooling of formerly 'ring-fenced' budgets (for example allocated to rural development, irrigation schemes, fishery enhancement, wildlife protection, etc.) as a cost saving that generates greater net societal benefits through building systemic outcomes into scheme design?
- **Challenge assumptions that multi-service outcomes are not profitable:**
  - Has due account been taken of all benefits arising from a proposed water management scheme, objectively taking account the net value to society across all ecosystem services when comparing options?

Political considerations for water management in Rajasthan

- **Delegate decision-making to a level most appropriate to account for local geographical and cultural contexts:**
  - What local decision-making institutions exist, or could be restored, to ensure that water management decisions reflect local geographical and social needs and contexts, averting potential costs associated with imposed solutions?
- **Recognise the significant roles that non-government organisations play in mobilising local activity and liaising with funders and formal government:**
  - Are any community-facing NGOs already active in promoting sustainable water management solutions? Can they serve as trusted intermediaries working with local communities for local benefit whilst contributing to higher-level policy aspirations?
- **Utilise nested governance arrangements to avert fragmented management:**
  - What tiered governance arrangements are necessary to ensure that localised water management and security work synergistically with other dependent communities across catchments at a range of scales, and ideally produce sympathetic co-beneficial outcomes? Are the relative contributions of local decision-making and those best taken at national and higher tiers of government understood and harmonised to achieve optimally beneficial and resilient outcomes?
- **Take into account potential effects on interrelated ecosystem services, spanning disciplinary interests, in regulatory decisions:**
  - 'Regulatory lag', in which compliance is often required with regulations that have not yet been reformed to reflect evolving understanding and priorities, may need to be resisted or flexibly implemented to implement 'systemic solutions'. Do any regulations inhibit the goal of locally adapted water security solutions, and how can they be worked around or reformed?
- **Co-design programmes between government and local people around common agreed goals to achieve pragmatic, locally relevant and accepted solutions:**
  - What government-driven schemes apply to promotion of water security, and what arrangements can be made to integrate local needs, knowledge and traditions?
- **Address driving policy or other development priorities as 'anchor services', around which outcomes for all ecosystem services and hence net societal value are optimised:**
  - What decision-making arrangements, for example linking in with a wider network of stakeholders and government department interests, should be instituted to ensure that deliberations about water management optimise outcomes for linked ecosystem services and their beneficiaries?

Systemic context for water management in Rajasthan

The above set of constituent considerations need to mesh together as an integrated system, for example with economic incentives and policy reform favouring technological solutions that work with local ecosystem processes and the needs and values of local people. A presumption in favour of piped water derived from deep aquifers and long-distance transport, is unlikely to meet these needs. All social, technological, environmental, economic and political constituents have to be integrated into decision-making, ongoing management and periodic review in order for society to make progress with water management that addresses real local needs on a sustainable and regenerative basis.



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Appendix 2: influencing intensive farming towards a more regenerative path

Developed world intensive farming is pervasive, in terms of (1) the extent of land area and on-going contributions to habitat conversion, (2) embedded presumptions in technology use, market incentives and land use rights, and (3) increasing uptake and influence on farming practices in the developing world. The application of the 'lens' of principles of success, derived from empirical study of examples of 'regenerative landscapes, is therefore a priority.

Social considerations for influencing intensive farming

- **Inform the design and operation of ecosystem uses and management with locally articulated needs:**
  - How should considerations of wider outcomes of land management beyond locally beneficial commodity production be incorporated into land use decision-making, for example in terms of impacts on landscape hydrology, soil conservation, wildlife, recreation and valued landscapes?
- **Integrate the views of multiple stakeholders into decision-making:**
  - What frameworks can better reflect the diversity of societal values and perspectives affected by farming practices?
- **Recognise traditional knowledge and practices as a legitimate and locally appropriate source of knowledge:**
  - What locally adapted farming solutions, for example rotational farming or conservation of hedgerows and 'pollinator banks', have traditionally been used to enhance production using means that make use of, and thereby conserve or restore, natural processes?
- **Out-scale successes using proven and important social networks:**
  - Can peer-to-peer farming networks help spread more environmentally and socially sensitive farming practices, and where can NGO and agricultural extension services add value?

- **Recognise local people as the owners of, and key actors in, resource use:**
  - All land users, including farming but also other interests, have rights to enjoyment of rural landscapes and roles in their sustainable management, so how can they be integrated into decision-making?
- **Link differing social needs across geographical and temporal scales:**
  - Have all ramifications of land uses for other beneficiaries, geographically and in the longer term, been factored into land use decisions, in terms both of remote negative impacts but also potential co-benefits that may arise from a collaborative approach?
- **Encourage social cooperation, applied in a manner sympathetic with natural supportive landscape functions:**
  - Can farming land uses combine knowledge and management solutions across landscapes (for example in collaboration on strategic location of functional habitats, such as hedgerows and copses to sustain populations of pollinators and pest predators, culturally valued landscape features or tree lines to wind damage) in a mutually beneficial landscape context rather than bounded by local land ownership?

Technological considerations for influencing intensive farming

- **Avoid imposing uniform, top down solutions, which tend to result in net degradation:**
  - Are farming systems based on acceptance of uniform solutions marketed by agribusiness suppliers, or are local context and natural processes used to inform decisions about technology choice?
- **Adapt technical solutions to localised geographical and cultural contexts, also taking account of their long-term consequences:**
  - Has the suitability of landform and soil informed cropping and farming choices, including native stock and strains best adapted to these specific conditions, such that production systems work with and safeguard ecosystem character and functioning in the long term?
- **Develop 'systemic solutions' to optimise outcomes across a range of ecosystem services:**
  - Have the outcomes of proposed farming practices been considered in the context of wider ramifications for ecosystem services, and how these can be optimised?
- **Progressively integrate evolving best practice into farming techniques and the associated policy environment:**
  - What farming practice best works with local geographic conditions and meets people's needs, and what innovations and measures are required to ensure that its wider ramifications (for water yield, soil conservation, biodiversity, carbon storage, etc.) are regenerative?

Environmental considerations for influencing intensive farming

- **Recognise that the services of natural ecosystems are a core resource generating multiple benefits:**
  - Do the land management practices considered regenerate soil structure, ecology and functioning, or are alternative production methods possible that can safeguard the primary agricultural resource?
- **Work in sympathy with natural processes operating both locally and at scales broader than parochial land ownership:**
  - Are agricultural practices such as the provision of pollination, pest management, soil fertility and stock watering, sympathetic to natural processes (e.g. making use of natural pollinators and pest predators, protective of water bodies, etc.)? Can processes operating at landscape scale, such as drainage lines in gullies and water storage in wetlands, storm buffering stands of trees, refuges for pollinators and pest predators, etc., be sited to optimise functioning by agreement and for mutual benefit between neighbouring land owners? Are the contributions of trees and other native species offering optimal habitat for farmland wildlife of functional benefit adequately taken into account, for example the lateral alignment of hedgerows and tree lines on slopes to aid water, soil and nutrient retention?

Economic considerations for influencing intensive farming

- **Recognise that all ecosystem services have tangible value:**
  - Are farming processes making use of ecosystem services to support agriculture, for example pollinating and pest control services or, as in the case of integrated constructed wetlands (ICWs), producing treatment benefits in naturally wet drainage lines in the landscape that are of little use for grazing or arable production?

- **Take account of the systemic ramifications of solutions for costs and benefits across all ecosystem services and their associated beneficiaries:**
  - Have the net costs and benefits for all ecosystem services been considered, and where possible offset, in determination of options for land stewardship?
- **Take a 'systemic solutions' approach to identify innovations that work with natural processes, optimising the overall societal value of investments in ecosystem management and use:**
  - Have the functional benefits of protecting or restoring habitat and species been considered as a source of multiple, long-term benefits, potentially averting expenditure on technical management solutions? For example, to what extent can refuges for wildlife in farmed land promote farming benefits? These kinds of strategies can include (1) zoned above-ground and riparian habitats that are set aside for conservation of useful species or (2) the use of minimum- and zero-till practices that may allow regeneration of worms and other soil fauna improving drainage, nutrient and carbon content of soils. Can 'anchor services' be addressed by innovations that work with natural processes to optimise the overall societal value of investments in ecosystem management and use?
- **Progressively integrate an expanding range of services into markets and fiscal measures:**
  - Are there markets for non-commodity outputs from farming, for example in terms of subsidies for wildlife, river, heritage and amenity-friendly modification of use? What reform of economic stimuli (markets, subsidies, taxes) are required to shape and reward optimal outcomes for society rather than outcomes which prioritise one provisioning service, at the cost of producing negative environmental and social externalities?
- **Challenge assumptions that multi-service outcomes are not profitable:**
  - Have assumptions been made that multi-beneficial or conservation farming is automatically unprofitable, or have options been informed by emerging scientific study of ecosystem-sensitive practices? Have the lessons of 'conservation farming' been incorporated into practice and policy?

Political considerations for influencing intensive farming

- **Delegate decision-making to a level most appropriate to account for local geographical and cultural contexts:**
  - Locally, farmers are sensitive to diversity in the landscapes they farm, but can their decisions be shaped in collaboration with other landscape beneficiaries?
- **Recognise the significant roles that non-government organisations play in mobilising local activity and liaising with funders and formal government:**
  - Can farming interests work with NGOs and other agricultural extension bodies to develop farming practices that achieve wider benefits, with NGOs potentially helping with access to support funding and share best practice and emerging learning?
- **Utilise nested governance arrangements to avert fragmented management:**
  - Can farming communities work together to ensure that landscape-scale processes (migration routes for wildlife, public byways, drainage lines, riparian fringes and areas important for exchange with groundwater, etc.) are optimised in planning at the individual farm scale? Also, how can farming interests bring their local knowledge and perspectives to bear on the national and international agreed priority of achieving sustainable farming? What are the issues that governments are best placed to tackle to promote regenerative uses of landscapes, for example in challenging and amending perverse subsidies, World Trade Organisation rules and punitive downward pressures on prices from supermarkets?
- **Take into account potential effects on interrelated ecosystem services, spanning disciplinary interests, in regulatory decisions:**
  - How can government departments and regulatory bodies collaborate to promote progress with multi-beneficial outcomes of optimal societal value, rather than be blinkered by an anachronistically narrow disciplinary paradigm? Where do regulations need to be reformed to promote farming practices aimed at multi-beneficial outcomes?

- **Co-design programmes between government and local people around common agreed goals to achieve pragmatic, locally relevant and accepted solutions:**
  - How can farming interests and government institutions work creatively to build on local knowledge towards the achievement of sustainable farming systems that work regeneratively with natural processes?
- **Address driving policy or other development priorities as ‘anchor services’, around which outcomes for all ecosystem services and hence net societal value are optimised:**
  - Commodity production is a legitimate and necessary goal, but how can it be optimised with other landscape outputs as one linked element of the overall picture shaping farming practice to achieve wider net societally beneficial outcomes?

Systemic context for influencing intensive farming

This systemic consideration of factors required to drive a transition in regenerative farming highlights the distance yet to be travelled from today’s narrowly market-driven reality. However, it also provides a road map of issues for creative visioning and development, including greater engagement of stakeholders affected by changes in the ecosystem services of farmed landscapes as well as problems for which collaborative research, knowledge-sharing and dialogue between farming interests and government may help generate systemic solutions.

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ricshk@rics.org

Greater China (Shanghai)
ricschina@rics.org

Japan
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