Journal of Scientific Research & Reports

27(5): 111-124, 2021; Article no.JSRR.70050
ISSN: 2320-0227

Investigation of Ecosystem Goods and Services Flows from Land: A Commentary on Experience from Watersheds in Iran

Ali Ariapour[1] and Victor R. Squires[2*]

[1]Department of Range Management, Borujerd Branch, Islamic Azad University, Borujerd, Iran.
[2]Formerly, University of Adelaide, Australia.

Authors' contributions

This work was carried out in collaboration between both authors. Authors AA and VRS Conceptualized the article. Methodology written by author AA; validation by author AA and VS; investigation, resources by author AA; Data curation by author AA. Author VRS writing the original draft preparation and review and editing. Project supervised and administration by author AA. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JSRR/2021/v27i530396
Editor(s):
(1) Dr. Grigorios L. Kyriakopoulos, National Technical University of Athens (NTUA), Greece.
Reviewers:
(1) Rambabu Tenneti, SRKR Engineering College, India.
(2) Jingjing Liu, Wuhan University, China.
Complete Peer review History: http://www.sdiarticle4.com/review-history/70050

Review Article

Received 27 April 2021
Accepted 01 July 2021
Published 06 July 2021

ABSTRACT

This paper is about the experience gained in field studies in four provinces in semi-arid Iran. We focus on assessing the flow of ecological goods and services (EG&S) in uplands that are the watersheds. The paper is in three parts. Firstly, we describe the geography, demography and climate to provide a setting for the work but we also seek to provide an explanation of the context for the case studies that form the bulk of this paper. In the second part we elaborate on the nature of the EG&S and discuss *inter alia* the use of indicators by which we gauge the flow rates of EG&S from the land and also briefly discuss the implications for introducing payments for ecosystem services (PES). Mention is made of the internationally-funded MENARID (Middle East and North Africa Regional Program for Integrated Development) with a focus on the Sustainable Watershed sub-project. Lessons can be drawn from this internationally sponsored program. The key constraints to identifying, evaluating and ascertaining the rate of flow of EG&S, especially spatial and temporal, are elaborated. Finally, we present data (both quantitative and qualitative) derived

**Corresponding author: E-mail: squires200@yahoo.com.au;*

from field sites and discuss the observed trends and projected futures. We provide some recommendations for making interventions more effective and operational, via replication and scaling up, across the vast areas of upland.

Keywords: EG&S; MENARID; indicators; PES; land degradation; spatial; temporal; constraints; valuation.

1. CONTEXT AND SETTING

The Islamic Republic of Iran has total land surface of 1.64 million km^2 and it supports a population of about 83 million inhabitants. There is a suite of vastly different agro-ecological conditions, with high mountains (several summits exceed 5000 m above sea level) vast deserts with precipitation at less than 50 mm per year and, at the opposite extreme, there are areas around the Caspian Sea where rainfall is about 2000 mm per year. Fig. 1 is a map showing Iran's drylands and their distribution based on climate zone.

Of the total land area, there are 86 million hectares (MHa) of rangelands (52.4 %), 14.2 Mha of forests (8.6 %) and 32 Mha of deserts (19.5 %). Approximately, 18.5 Mha are under cultivation, 10 Mha of which are rainfed. Being predominantly in an arid environmental zone most rivers are seasonal and their flows depends heavily upon the amount of rainfall. The geographic focus of this paper is on the semi-arid uplands that are major catchments areas. These are mainly associated with the Zagros and Alborz mountains but are also a feature of parts of south-eastern Iran along the border with Afghanistan and Pakistan.

2. RANGELANDS ARE REGARDED AS CRITICAL ECOSYSTEMS IN IRAN

Many of the rangelands in Iran are at high elevations and in relatively dry regions. These rangelands provide various ecosystem services that support the livelihoods of local people and environmental benefits such as watershed protection, biodiversity conservation, and eco-tourism promotion. Livestock raising and medicinal plant collection in rangelands are major livelihood support strategies for rural people. In addition, rangelands support many plant and animal species that are integral components of the ecosystem as they provide ecosystem services and maintain sustainability of the region. In Iran, rangelands are generally treated as common pool resources (CPR) as defined by Blomquist and Ostrom [1]. Livestock raising, using transhumance production systems, is the main land use and source of livelihood in vast areas of the semiarid and arid zones of Iran, which indeed, is probably the only way of exploiting these seasonal pastures economically. Lack forage during winter and early spring, a period of extremely low temperatures, when breeding stock are pregnant and most vulnerable, is the major constraint to improving livestock production and family income.

The existing mode of overuse and overgrazing of rangelands may lead to their depletion and ultimately push rangelands beyond the limits of sustainable yields. This depletion of CPR occurs due to either the lack of appropriate institutions for management or conflicting claims over rangeland resources [2]. Different modes of conflicts over rangeland use, such as conflicts between local communities and with government agencies, have been observed. Unclear rangeland policies and the remote location of these rangelands are major barriers for their proper management in Iran. Despite the significant role of rangelands in Iran, they are under threat from various anthropogenic stresses, including overgrazing and overexploitation of medicinal plants. Additionally, the looming impacts of climatic change in the subalpine and alpine regions are omnipresent. Climatic change can adversely impact the rangeland ecosystems and their economic potential and ecological sustainability.

3. SLOPING UPLANDS: A MANAGEMENT CHALLENGE

About 30 per cent of Iran's 1.6 million km^2 area is sloping uplands. It is mostly dry. Average annual precipitation throughout the country is about 250 mm. Slope lands, especially those in watersheds provide food and livelihoods to millions of people in Iran. Slope lands constitute an important segment of the landmass. They are sensitive to disturbance and register marginal productivity with limiting soil conditions. Increasing soil erosion in slopelands is causing sedimentation in water reservoirs/dams. Another serious problem of upland areas is migration of poor villagers to the big cities. There are growing problems of population pressure, poverty and environment degradation. Most slope lands have relatively shallow and less fertile soils. The steeper the gradient, the more severe such production problems tend to be. In many slope land areas productivity is falling and there is decline in yields. An important reason of this resource degradation can be poor planning for development of slope lands for agricultural and other uses._The gradual change in climate and fast evolving technologies are rapidly eroding natural niches these lands have traditionally enjoyed._The productive use of these lands requires the adoption of strategies compatible with their intricate topography and slope. There are several important spatial and temporal considerations (see below) that aid devising and implementing slope land conservation programs. Many development agencies have traditionally focused their planning rationale within the scope of the upland portion of the watershed, stressing the need to foster sustained productivity of slope land systems by preventing erosion and loss of fertility._The dual objective of fostering both sustainable slope land agriculture and maximizing protection of downstream interests has proven to be a powerful tool for prioritizing where investment should be targeted to optimize the flow of EG&S, like water.

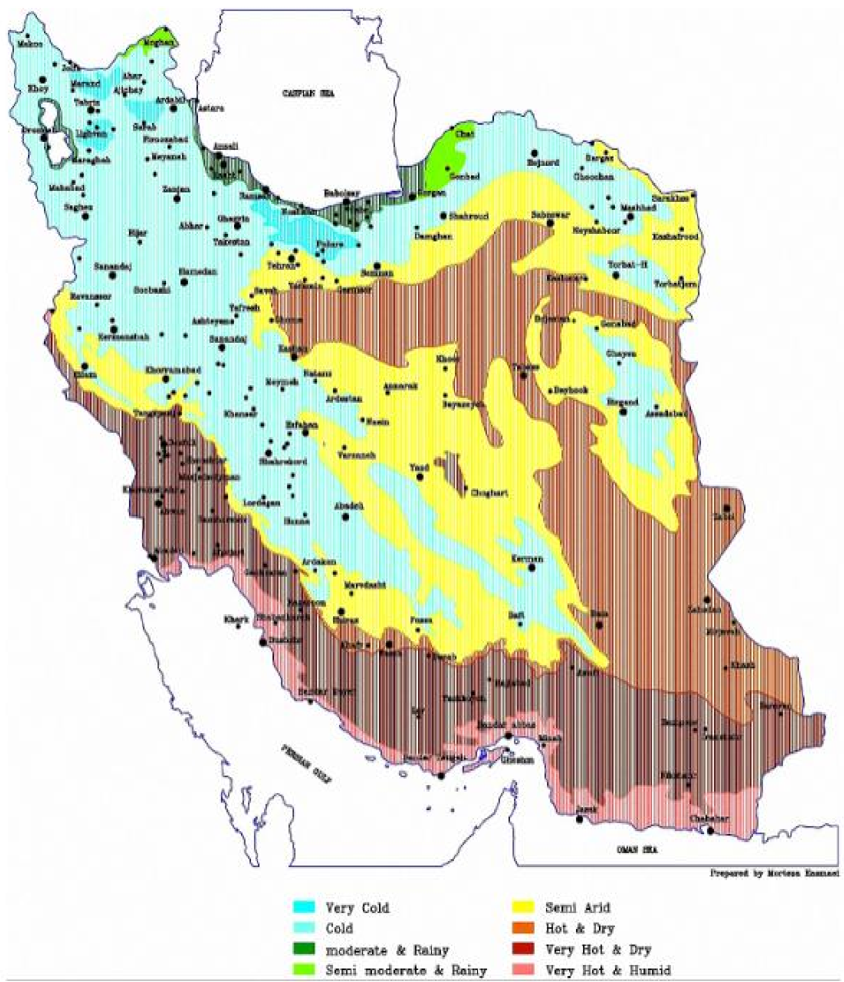

Fig. 1. Map of Iran showing climatic zones with names of some significant places including Yazd, Zabol, Kermanshah, Semnan and Sistan -Baluchistan (the location of major demonstration sites)
Source: Forest, Range and Watershed Organization)

4. WATER: A CRITICAL RESOURCE UNDER THREAT: A BRIEF OVERVIEW

Iran is faced with a series of serious challenges of which water scarcity is high on the list. Iran has experienced droughts of varying intensity in different regions Nateghi and Amiraslani [3] In recent years, damage caused by drought has included drying-up of seasonal rivers, a decline in underground water resources, degradation of farmlands, death of shrubs and trees in plantations, urban and rural drinking water shortages, and dessication of internationally recognized wetlands such as the Urmia lake, and the shrinkage of the Caspian Sea.

According to [3] low precipitation levels due to climate change have aggravated Iran's water scarcity in recent years. In the Persian year 1396 (March 21, 2017 to March 20, 2018), precipitation levels decreased by 25 per cent, felt even in historically water-rich areas in the country's north and northwestern areas. This has contributed to the reported reduction of water entering Iran's dams by 33 per cent, from 32 billion cubic meters (BCM) of surface water in 2017 to 25 BCM in 2018. This sizable reduction is threatening the agricultural sector, which consumes 92 per cent of the country's renewable water resources per year, compared to about 70 per cent in most other countries. As rainfall decreases, farmers will likely seek more sources of irrigation, including by building illegal wells, therefore forestalling or slowing the government's efforts to reduce reliance on dwindling underground reservoirs. For instance, while 42 BCM of groundwater is currently being legally withdrawn, an additional 4.7 BCM of water is being withdrawn illegally by digging their own wells or installing water pumps. In its sixth development plan (for 2016-2021), the government stated it aims to curtail overall withdrawal from ground wells by 11 BCM, but did not explain how it would achieve this. A good place to start may be with improving irrigation efficiency. Water consumption in the agricultural sector remains half as efficient as the global average. Iran is squeezed between the need to reduce water consumption in anticipation of further drought and the need to use more water to maintain food security through self-sufficiency. Tackling Iran's water crisis to avoid such social and economic crises may require politically sensitive policy shifts including partially or fully scaling down its agricultural self-sufficiency schemes and curbing population growth. This has put greater emphasis on assessing the magnitude and value ecosystem goods and services (ES&G) that flow from the upland catchment areas and encouraged participation by international development agencies.

Because of the growing population of Iran, there has been an increase in the people, livestock and farming intensity on ever-more fragile lands. This has resulted in rapid land-use change on marginal lands leading to serious land degradation in these areas [4]. This, in turn poses a significant obstacle to the country's development and a long-term threat to the functioning, integrity and services from ecosystems. Catchments provide important environmental and economic services, such as climate and water regulation, and water and food to local communities and to downstream users, including major urban areas [5] the challenge is how to measure and value these EG&S. The establishment and operationalization of the internationally funded MENARID project marked a turning point.

5. MENARID PROJECT IN IRAN

The MENARID project in Iran is an example of an attempt to engage experts, land users and water managers in an integrated approach to deal with several objectives. It involves several provinces -- Semnan, Kermanshah, Yazd and Sistan-Baluchistan (see Fig. 1) and four demonstration sites. In the framework of the MENARID project, integrated watershed management practices have been implemented in these four demonstration sites. These measures/interventions include soil and water conservation practices, improving farming practices and improved livestock management, as well as technology transfer to land users. This last-mentioned aspect is what may have been missing in historical projects where the land users (mainly farmers/herders) were designated as the 'target'.

Assessing the impact of these new practices on catchment areas poses a certain number of challenges. The complexity of the interventions requires a holistic approach that is far more complex than plot and farm level and beyond traditional "what" and "where" factors of economic and environmental priorities with "who" and "how" aspects of social actors and institutions. It is not just simply assessing performance of various management practices that affect the flow of ES&G. Given that the systems generally have multiple scales of interaction and response: high frequency of non-linearity, uncertainty, time lags, multiple stakeholders with contrasting objectives and a high degree of context specificity it is no surprise, that monitoring and evaluation is complicated. Despite these complexities we find that it is necessary to try to assess (and quantify) the benefits from implanting the practices that we hope will ensure a sustainable flow of EG&S and long term-term benefits to the major stakeholders.

Usually, there are five types of benefits/mechanisms at play as they relate to provision of EG&S such as: availability of water resources, biodiversity conservation, carbon sequestration, land conservation and aesthetics and spiritual values. For instance, water-related mechanisms target water yields, water quality (reduction of sedimentation, regularity of water flow, water source protection, and reduction of contamination). Carbon mechanisms look to offset carbon dioxide, and sometimes other greenhouse gas emissions, to the atmosphere. Biodiversity mechanisms look to protect critical keystone species and their habitats. Aesthetics and spiritual aspects involve trying to put a value on the presence of a scenic view, or an *opportunity* for meditation and reflection and maybe opportunity to follow cultural rituals. All five of these factors need not be mutually exclusive.

6. TYPES OF EG&S FROM UPLAND CATCHMENTS IN IRAN

The list of EG&S can vary depending on the world view of those who are assessing them. The Millennium Assessment [6] has typified ecosystem services on the following categories a) ***Provisioning services*** (also called Production) are the products of goods and *directly from the ecosystems*. b). ***Regulating services*** are benefits related to regulation of ecosystem processes, such as regulation of climate, water and certain diseases that affect human beings. c). **Cultural services** are non-material services that people obtain through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences, such as knowledge systems (popular), social relations and aesthetic values. d). **Essential or Support services** are the ones necessary b for producing all of the other ecosystem services. Some examples are: biomass production, oxygen production, soil formation and retention, nutrient recycling,

Watershed services derive from ecosystem functions or processes that directly or indirectly provide flows of benefits to humans. These can include i). Freshwater for consumption (to drink or for domestic, agricultural and industrial use) ii). Fresh water for non-consumptive use (hydroelectric generation, refrigeration and navigation) iii). Regulation flows and filtration. To elaborate – water targets water quality and especially qualities such as reduction of sedimentation, regularity of water flow, water source protection, and reduction of contamination). For example, watershed services maintain the quality of water stored in soils, watersheds and flood plains, and they can buffer flows during flooding and droughts, control erosion and sedimentation, control aquifer levels that can bring salinity to the surface, and maintain watersheds, riparian habitats, fisheries and other wildlife habitat important for migratory birds.

Carbon mechanisms look to offset carbon dioxide and sometimes other greenhouse gas emissions into the atmosphere. *Biodiversity mechanisms* look to protect keystone plant and animal species and their habitats. *Land protection mechanisms* look to maintain ecological integrity and conserve soil, the water cycle, and provision of habitats at all scales while *Scenic beauty assessment* involves putting a value of the presence of a spectacular site or panorama.

7. MAIN ISSUES AFFECTING THE ATTAINMENT OF THE PROJECT GOALS

The measurement of flow rates of EG&S across spatial scales is a key issue in impact assessment [7, 8]. For example, measures to assess the impact of erosion on the natural resources base (Such an index can be visualized as a local landscape mapping tool within the ‘stockflow’ system proposed by Pagella & Sinclair [8] for trading at other scales and quantifying the flow of ecosystem services from providers to recipients, ‘closing the gap’. (Stocks and flows differ from plot to slope-face to watershed to river basin [9]. In contrast to, say an agricultural field, there are number of ecosystem services that are distinct at each spatial scale e.g. farming system, village, watershed, landscape, regional and global [10]. And therefore, depend on the spatial pattern of adoption of measures to conserve the ecosystems and assess the flow of EG&S from the various uplands. Spatial and temporal boundaries make it difficult to evaluate the impact of management regimes and interventions. At different spatial and temporal scales, interventions can be assessed in terms of multiple objectives e.g. poverty alleviation, ecological resilience, natural resource conservation, economic growth and human and social development, that reflects the needs and expectations of different stakeholders [11]. Plot and farm-level analyses that are relatively manageable now have to expand to the unwieldly scales of the community, the watershed and even larger areas of landscapes. Scale hierarchies and a wider scope of indicators introduce numerous complicating ecological, social, cultural, institutional and political factors.

With respect to temporal scales, [12] argues that longer time periods are required to assess sustainability, despite the fact that these longer periods increase the likelihood of major socio-economic or biophysical shifts taking place. Impact of the interventions on the flow rate of EG&S faces the so-called “attribution problem” that confounds the impact measurement of new practices/interventions with changes in other structural variables over time, such as changes in macroeconomic policies or environmental disasters. Therefore, impact assessment must be designed to consider long-term change and, at the same time, analyze shorter-term success or failures with regard to the achievement of the desired impact via monitoring and evaluation (M&E).

Coping with spatial and temporal considerations another spatial consideration is the scale of research plot designed to help guide decisions as to which conservation technologies should be used. Small research plots are best suited for assessing the effectiveness of conservation technologies. Conservation technology decisions made on research plots are, however, not able to be scaled up to field-level applications if larger-scale processes (e.g., landslides) are an important concern in the region. Temporal considerations that are discussed include the necessity to accommodate adoption psychology by having a stepwise approach to introduction of conservation technologies. The length of the project evaluation period is an important consideration associated with assessment of technologies. Spatial and temporal boundaries make it difficult to evaluate the impact of management regimes and interventions (see below). The temporal dimension is important in relation to water flows (see below).

Stakeholder involvement in the impact assessment process. As a result of scale hierarchies, many perspectives e.g. those of farmers and herders, rural inhabitants, community organizations, support organizations, private enterprises, scientists, donors and policy makers, can lead to conflicting objectives, interests and opinions and world views. Therefore, a central concern of the work is to both identify and assess the tradeoffs among the various stakeholders [13]. Communication breaches and distinct stakeholder perspectives pose special challenges to measuring the impact of the management inventions. These communication difficulties may, in fact, be symptoms of deeper, more fundamental differences in the ways that these groups learn and view the world [14, 15]. To make optimal decisions, it is necessary not only to analyze trade-offs to determine who will benefit from sustained (or indeed increased) flows of EG&S and who will not, but also to establish a forum for careful negotiations and collective action. The application of many interventions and changes to land management produces a broad range of impacts in communities, including many of a social nature. These changes may be difficult to accept (e.g. denial of forest access, grazing bans, water management). Notwithstanding these difficulties, trajectory changes in type and volume of EG&S (as opposed to just meeting targets) are required as soon as possible. Assigning value to non-market EG&S is time consuming and expensive, and cannot be justified for a scoping exercise such as the one reported here.

We relied instead on existing knowledge from research by the Forests, Range and Watershed Management Organization of Iran and the University of Tehran at Karaj and University of Yazd. Such an approach using existing knowledge and research at other sites can be used in a process known as “benefit transfer”. There is extensive literature (for example, [16-19] on benefit transfer (which seeks to estimate non-market costs and benefits). We were careful to match environments, land users and proposed interventions as closely as possible. The best matching results are then used as estimates of value (and/or flow rate of EG&S) at the specific site under investigation. Despite lack of precision, benefit transfer is the only available indicator of non-market values in the absence of a site-specific study at each location. It is an approach that is generally accepted as providing “order of magnitude” estimates of values and flow rates that indicate whether further site-specific work is warranted. Evaluation of changes in non-market values associated with the implementation the practices and intervention in the MENARID demonstration sites requires identification of the ways in which the practices differ under each scenario. The scale and direction of changes in the nature, volume and flow rate of EG&S will depend upon the types of measures proposed and the values held by people affected by those changes.

8. ASSESSMENT OF THE ENVIRONMENTAL BENEFITS AT DEMONSTRATION SITES

This section reports key outcomes of the studies that have so far been carried out to evaluate environmental benefits of interventions and changed management practices and provide highlights of the major benefits at the various demonstration sites. At the demonstration sites we were able to observe that project-sponsored interventions generated local benefits and contributed to peoples' livelihood and economic well-being. The benefit stream is on-going. The expected environmental benefits of retaining or enhancing the flow of EG&S include enhanced structure and functional integrity of Iran's dryland ecosystems that were/are threatened by land use and land cover (LULCC) change, land degradation, including reduced sedimentation and enhanced water quality. Provision of EG&S was enhanced, especially water-related benefits, carbon sequestration and reduction of CO_2 (a reduction of 660,000 tons of CO_2 was calculated for the Kermanshah site while habitats for important plant and animal species were conserved/enhanced. Soil and water retention was improved, including, transboundary benefits from improved land and water management in Iran's many transboundary surface and groundwater basins (such as the Kura and Sistan-Helmand).

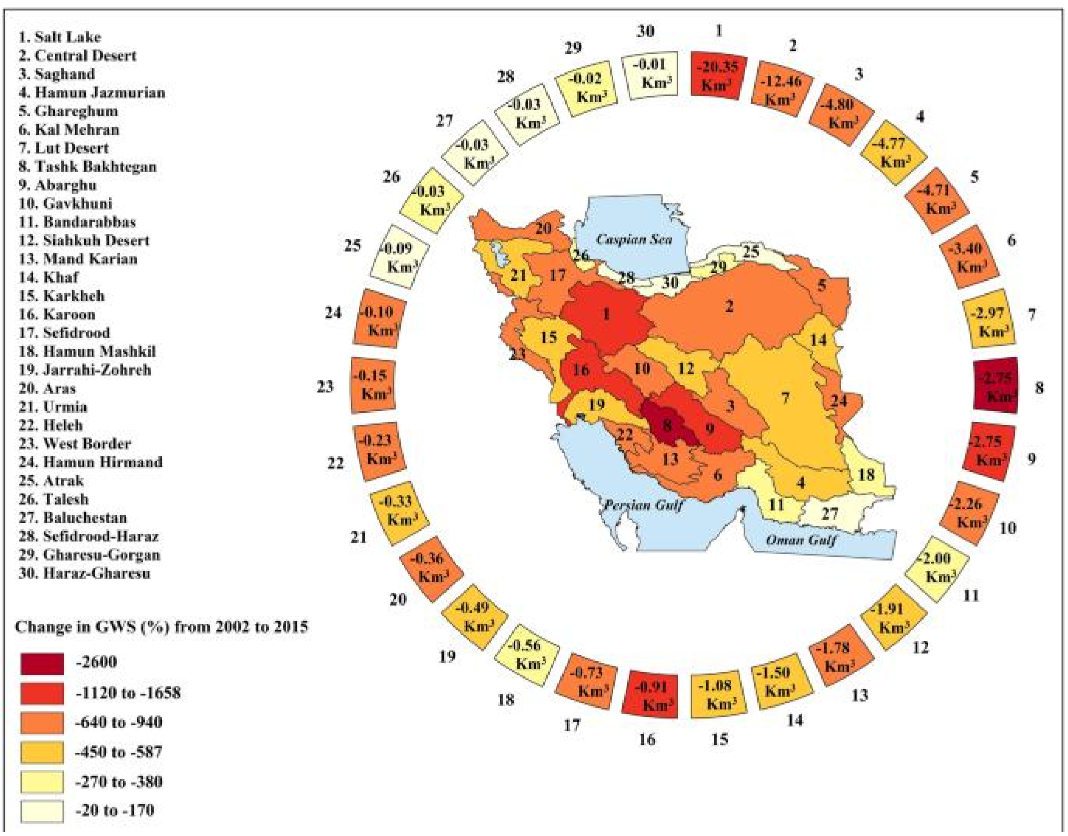

Fig. 2. Across Iran there is a trend of diminishing groundwater reserves. Serious. declines (red on this chart) have been experienced in several sites

Source: [20] Ashrafm Nazemi and AghaKouchak 2021, used with permission

Table 1. Practices and interventions in the demonstration sites

Demonstration site	Practices and technical transfers
Semnan	Strengthening of strategic planning and management for sustainable use of land and water resources Improving sustainable land and water knowledge base and implement capacity building Replication and scaling up of project learning
Razin watershed in Kermanshah province	Multi-stakeholder consultation and co-ordination, capacity building Soil and water conservation measures/practices Improved groundwater management (metering etc Introducing alternative livelihoods Improved farming practices (organic, integrated pest management, drip irrigation, minimal till Plantation of medicinal plants Improved livestock husbandry (permit systems, cooperative grazing, rangeland conservation, ecological restoration etc)

Source: Unpublished interim reports of GEF/UNDP, 2020

Table 2. Benefits arising from project interventions at local and global levels

Benefits	Local Level	Global level
Environmental benefits	Increased biodiversity (plant & animal species richness) within croplands, rangelands and forest resources. Restoration of vegetative cover and habitat diversity in areas of degraded rangelands and forest/woodlands	Protection of cultural diversity of Iran in respect of sustainable ways of utilizing drylands and watershed areas
Benefits for populations	Increased land productivity leading to increased food security. Improved water-use efficiency Livelihoods and economic well-being improved. Increased participation and empowerment of vulnerable and marginal groups due to a greater sensitivity and more participation	Maintenance of cultural and aesthetic values in Iran's drylands, especially uplands Reduced dependency on the forests and pasturelands Reversing the decline in the productivity of Iran's natural resources and maintenance of the flow of EG&S Greater carbon sequestration

Source: Unpublished interim reports of GEF/UNDP, 2020

Table 3. Environmental benefits at the demonstration sites in selected provinces of Iran

Demonstration site/location	Environmental benefits
Semnan and Tehran	Prevention of accelerated land degradation, better soil erosion control, less sediment in water, higher water yields, improvements in biodiversity and higher levels of carbon sequestration in the rangelands and forests. Fewer people migrated from rural to urban areas, improved livelihoods for local community*

Razin watershed in Kermanshah province	Prevention of land degradation, reduced soil erosion and sediment control in upstream of Karkheh river basin (a transboundary river) improvement in biodiversity, more carbon sequestration in rangelands and forests, better water quality downstream, less sediment in the Karkheh Dam (reservoir). Fewer people migrated from rural to urban areas, improved livelihoods for local community*.

Source: Unpublished interim reports of GEF/UNDP, 20209. Validation of the benefits as derived from the four demonstration sites

Box 1. Maps are important as they are a key element of Ecosystem Service Assessments; Maps provide an intuitive, visual means of communicating information amongst stakeholders

According Tim Pagella and Fergus Sinclair (available online at ecosystemsknowledge.net/ pdfs/ecosystem_mapping_ecosystem_proofed_tool.pdf). Mapping of ecosystem services is useful for: a) identifying where ecosystem services are produced and for consideration of the scales at which they manifest, b) strategic and operational decision-making relating to the exploitation of ecosystems services in a way that is compatible with sustainable development principles (for example in spatial planning or in scenarios work). c) Understanding the flow and value of benefits to human populations (ecosystem service valuation), d) determining synergies and trade-offs between ecosystem services (this is important for management and evaluation), and e) engagement and communication amongst stakeholders. Given the requirement for interdisciplinary and participatory approaches envisioned by the ecosystem approach Cowling et al. [21]

The improved management and technical interventions at the demonstration sites generate local benefits and helped promote a greater appreciation of the cultural and aesthetic values that contribute to the peoples' culture. Given the size of Iran and the diverse land management practices and ecosystems that we targeted, the project also contributes significantly to the global store of knowledge on sustainable land, ecosystem and water management [19].

At the Razin site and in Kermanshah province (Karkheh watershed) it was perceived as a key site for Carbon sequestration on cropland, pasture and forested land. The highest rate of loss of soil organic carbon was on cropland where tillage relied on methods that depleted nutrients or encouraged run-off, where crop rotation was not practiced and stubble was not retained. Under the improved regime in the demonstration site an increase of 1.6% increase of in soil organic carbon reservoir has been measured using the GEF CBF tracking tool and direct measurements on the site using [22] the *Revised Methodology for Calculating Greenhouse Gas Benefits of GEF Energy Efficiency Projects (Version 1.0).*

In the Semnan province, the extent of forests and rangelands are respectively 530,000 and 1,120,000 ha. Applying grazing user controls has allowed forests and rangelands to sequester 9.8 and 5.6 million tons of atmospheric carbon respectively. Soil erosion rates and sediment transport were reduced under the new management regime.

Linking the environmental benefits to interventions when assessing the impact is not simple. Even though connections are plausible, they are often treated as a "black box" that cannot be analyzed [17] or explained in detail [18]. An impact cannot be attributed to an intervention unless it can be logically explained and justified. The final impact may be significant and obvious but causality is usually too subtle to measure exactly.

Selecting indicators is crucial to impact assessment but it is a difficult step. The main problems include the fact that a range of different indicators is required for each 'output, 'outcome' and 'impact'.

Chosen indicators are likely to change over time as the external environment changes and as the project objective changes. Also, stakeholders select indicators based on cultural values, priorities, information needs, and expectations. Indicators are only proxy measures of a more complex reality that are required for empirical analysis, and even when they are relevant and accurate, are influenced by practicality and cost concerns related to data collection and analysis. The techniques required to analyze provision of ES&G in biophysical terms depend entirely on the services that have been selected for assessment. It is necessary to consider the precise nature of the ES&G and its spatial and temporal dimensions. In addition, every service in every economic, environmental and social context will require a specific approach with respect to the data and required approach for analysis. For Provisioning services, surveys can reveal the flows of products harvested (or generated – as in the case of sediment) from the ecosystem. It should also be examined to determine whether this flow occurs every year or whether the harvest of say fruit or timber is a one-time harvest in order to establish the future supply of EG&S. In addition, it is also required to consider is the use of one service may impair the use of other ecosystems in the future e.g. harvest trees by clear felling now but see more sediment go into the stream in future. The survey also needs to assess the effort required to extract the EG&S from the ecosystem. In the case of natural forests/woodlands, or even the utilization of forage, this relates to labor, and possibly tools or equipment required for harvesting. In the case of products obtained cultivated land (may be as part of shifting cultivation or from terraced slopes) valuation should consider the inputs into the production process required to obtain the product. This includes not only labor and equipment but also land (rent?), fertilizers, pesticides, seeds etc. Then of course there are those non-priced EG&S like clean air, carbon sequestration, native vegetation's role in slope stability and sediment control etc.

The temporal dimension is important in relation to water flows and the contribution of snow to run off and flooding. The hydrological service can be expressed as both a reduction in peak flows (many of Iran's rivers are seasonal) and an increase in low season flow, depending on the area under consideration (flood risk versus risks of seasonal water shortages). In particular, flood risk has a distinct spatial component; the flood risk will decrease with increasing distances from the stream, depending on topography of the valley.

The spatial variation of ecological services has been extensively studied via ecohydrological models [23] and soil transport models [24]. Carbon sequestration has a spatial component as well because it depends on the build-up of carbon in the soil (or as soil organic matter) or on the surface in plants and litter. Uptake depends on the growth of vegetation, and tends to decrease as newly planted forests/plantations develop into mature stands, where there is a high recycling of CO_2 but much more limited net sequestration, depending on the type of forest and climatic conditions involved.

9. BUYERS AND SELLERS OF ECO-SYSTEM SERVICES: A BRIEF INTRODUCTION

There is much interest these days in the matter of carbon offsets and carbon trading. Although this aspect was not fully explored in the work reported here, it is possible to find out what environmental service is marketable, who the potential buyers are and how the environmental services (ES) can be restored and maintained. One of the most integral components of any payment for ecological services is to be able to define precisely who the providers and beneficiaries are. Users of the ES are the ones who are more likely to pay for the provision of the service. Every potential buyer of an ES has its own distinct interest and set of motivations for engaging in PES deals. The beneficiaries and users of the ES are often easier to define than the ES providers. Still, a key step is to define exactly who the users are. According to [25, 26] there are four categories of ES buyers; 1. *Public sector buyers*: These buyers seek to protect the public good of ES on behalf of their constituencies. They include local, regional and national governments, as well as quasi-public agencies such as the World Bank. 2. *Private sector buyers under regulatory obligation.* These buyers are mandated to offset their environmental impacts by laws such as wetland rehabilitation or greenhouse gas emissions trading schemes. 3. *Private sector buyers acting voluntarily*: These buyers may purchase ES to support their business operation, to maintain a 'green brand', or to adhere to principles of corporate social responsibility. This category includes philanthropic buyers such as conservation nongovernmental organizations (NGOs) and individual consumers. 4. Consumers of eco-certified products: These buyers participate in ES markets by paying a premium for products produced in more environmentally benign ways that benefit biodiversity. Although the form of payment is less direct than the other three categories, this market segment is important for low-income land stewards and is therefore included.

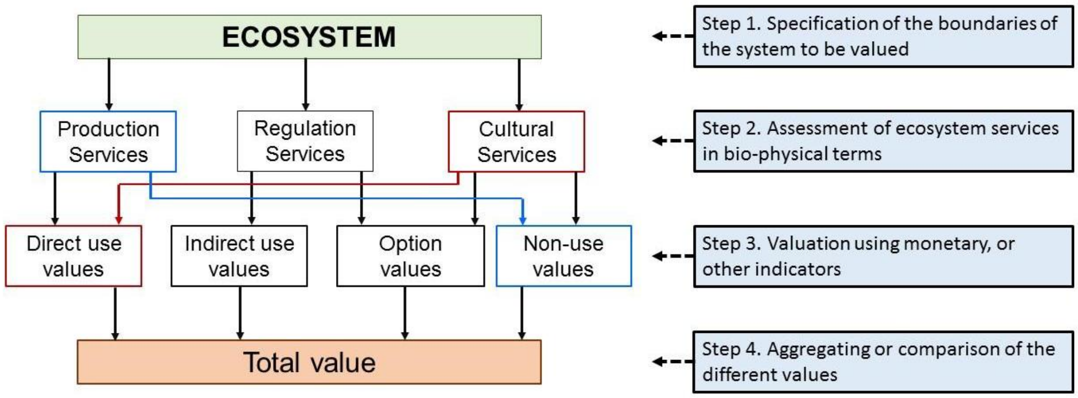

Fig. 3 The overall objective is to quantify Total value. The four steps are shown here (Adapted from [9]

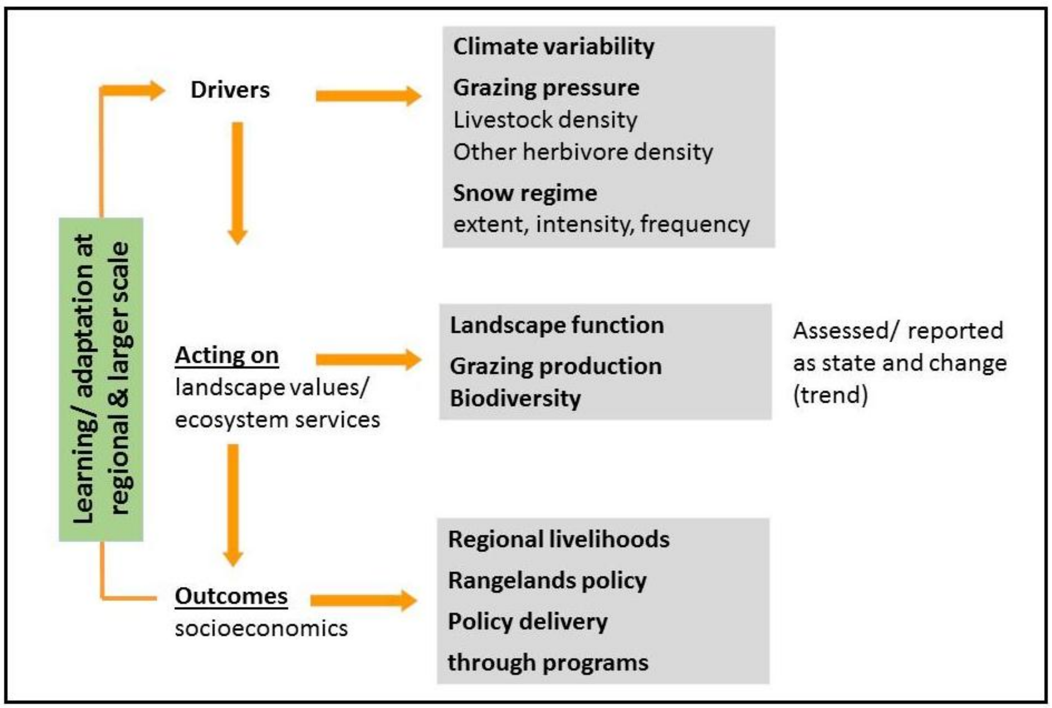

Fig. 4. The trend for any site depends on which drivers are dominant and the interplay around ecosystem service provision. (Source: Ariapour and Squires, redrawn from [9]

Public sector buyers have historically been the largest purchasers of ES, but this is changing as cap-and -trade programs for carbon, as well as various habitat restoration schemes promise to increase the role of private sector buyers acting under regulatory obligation. With this change the global portfolio of ES and the associated payments from them is shifting from a preponderance of government programs funded by tax revenue, foreign aid, and loans to a greater share of true market instruments driven by private demand and facilitated by the maturation of supporting institutions [26, 27-30]

10. CONCLUSIONS AND SUMMING UP

There is no commonly accepted protocol for assessing the value or flow rates of EG&S. We have improvised along the way in seeking to get a procedure that could be applied at the rather disparate demonstration sites. No two sites are that similar. We did distil some lessons from what we have done over the past few years of work. We conclude that it is important to address the following issues in the design of an assessment method.

Spatial and temporal boundaries. The impacts of the interventions and changes in management practices can be difficult to evaluate because of their multifaceted nature [28, 29]. At different spatial and temporal scale things change and the emphasis given to them by stakeholders can shift. e.g. poverty alleviation, ecological resilience, human and social development, natural resource conservation, livelihood level [9]. When plot and farm-level analyses that are relatively manageable expand to the more unwieldy scales of community, watershed and even larger areas like river basins there are difficulties. The hierarchies and a wider scope introduce numerous complicating ecological, social, cultural, institutional, economic and political factors.

The measurement of impacts across spatial scales is a key issue in the impact assessment of interventions and practices [7]. For example, measures to assess the impact soil erosion on the natural resource base differ from plot to slope face to watershed to river basin. We are interested in a number of different EG&S that are distinct at each spatial scale e.g. farming system, village, landscape, regional and even global like biodiversity conservation and carbon sequestration that therefore depend on the spatial pattern of adoption.

With regard to temporal scale, it could be argued that longer periods are required to assess continuity and sustainability, despite the fact that longer periods increase the likelihood of major socioeconomic or biophysical shifts taking place. Impact assessment therefore faces the ‘attribution problem’ that confounds the impact measurement of new practices with changes in other structural variables over time. Such changes may occur in macroeconomic policies or in response to environ-mental disasters like landslides, floods etc. Therefore, evaluation of EG&S must be designed to consider long-term change, and at same time analyze shorter-term successes and/or failures with regards to the achievement of the desired outcomes. To assess long-term changes different methodologies or procedures can be used, such as time series of remotely sensed variables, panel data sets, historical reconstruction of plot – or community-level trends with local people, and participatory historical mapping [9]. But, at the same, the issue of realizing results after a protracted time is not a new challenge to EG&S valuation and assess-ment alone.

Stakeholder participation in the impact assessment and valuation process (see above) can be a challenging experience. Different assessment needs, and different stakeholder expectation and interests may require parallel assessment/valuation processes conducted by external and local groups. The challenge is how to integrate the results and do the analysis [30]. A central strategy issue is to find a balance between faster general measures that facilitate comparison across sites, and slower participatory processes that empower local stakeholders and validate results and analysis.

ACKNOWLEDGMENTS

We have drawn heavily on the various (mostly unpublished) reports on progress in the MENARID project conducted by GEF and UNDP in conjunction with the Iranian Forest, Range and Watershed Organization (FRO). We are grateful to advice and input from Dr Hamid Solymani, Dr Hossein Badripour (FRO) and technical help from Ms Sara Torabi (MENARID Secretariat).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Blomquist W, Ostrom E. Institutional capacity and the resolution of a commons dilemma. Policy Studies Review. 1985; 5(2):383–393
2. Adams WM, Brockington D, Dyson J, Vira B. Analytical framework for dialogue on common pool resource management. Cambridge, United Kingdom: Department of Geography, University of Cambridge; 2002.
3. Nateghi D, Amiraslani F. Drought: Commencement of Desertification and Poverty. International Meeting on Understanding Future Dryland Changes from Past Dynamics — based on principal themes of International Geological Correlation Programme (IGCP)413, the University of Yazd — Yazd, Iran; 2002.

4. Souzani S, Ariapour A. Desertification in Iran and efforts to mitigate the impacts of climate variability. pp. 107-128 in; Victor Squires and Ali Ariapour (eds.) Desertification: Past current and Future Trends. NOVA Science publishers, N.Y; 2018.
5. Solaymani HR, Badripour H. Integrated Watershed Management Approach in drylands of Iran. In: M.K. Gaur and V.R. Squires (eds) Climate variability impacts on Land Use and livelihoods in drylands. Springer. 2018; 113-130.
6. Pachico D, Ashby J, Farrow A, Fujisaka S., Johnson N, Winograd M. Case Study and empirical evidence for assessing natural resource management research: the experience of CIAT. Paper presented at Workshop on Assessing Impacts in Natural Resource Management Research April 27-29, ICRAF House, Nairobi, Kenya; 1998.
7. Pagella TF, Sinclair FL. Development and use of a typology of mapping tools to assess their fitness for supporting management of ecosystem service provision. Landscape Ecol. 2014; 29:383–399.
8. Squires VR, Milner HM, Daniell KA. River Basin Management in the twenty-first century: Understanding People and Place. CRC Press, Boca Raton; 2014.
9. Izac AM, Sanchez PA. Toward a Natural Resource Management Paradigm for International Agriculture: Example of Agro forestry Research. Philippines: International Center for Research in Agriculture; 1999.
10. Isak AM, Sanchez PA. Towards a natural resource management paradigm for international agriculture: the example of agroforestry research Agricultural Systems. 2001;69(1-2):5-25
11. Scherr SJ. Hillsides research in the CGIAR: towards an impact assessment. Consultative Group for International Agricultural Research, Washington, D.C., USA; 2000.
12. Izac AM. Assessing the impact of research in natural resources management: synthesis of an international workshop, 27-29 April, 1998. International Centre for Research in Agroforestry (ICRAF), Nairobi, Kenya. International Centre for Research in Agroforestry, Nairobi, Kenya; 1998.
13. Van Dusseldorp D, Box L. Local and scientific knowledge: developing a dialogue In: W.D. Boef, K. Amanor, K. Wellard, A. Bebbington (Eds.) Cultivating Knowledge: Genetic Diversity, Farmer Experimentation and Crop Research, Intermediate Technology Publications, London. 1993; 20-26.
14. MA. UN Millennium Assessment Report, UN, N.Y; 2005.
15. Brower R. Environmental value transfer: state of the art and future prospects, Ecological Economics. 2000; 32:137-152.
16. Van den Berg TP, Poe GL, and Powell JR. Assessing the accuracy of benefits transfers: evidence from a multi-site contingent valuation study of ground water quality. In: Bergstrom J, Boyle K, and Poe G (Eds). The economic value of water quality. Northampton, MA: Edward Elgar; 2001
17. Plummer M.L. 2009. Assessing benefit transfer for the valuation of ecosystem services. Front Ecol Environ. 2009; 7(1): 38–45.
DOI: 10.1890/080091
18. Rosenberger RS, Loomis JB. Benefit transfer. Chapter 12 In: P.A, Champ, K.J. Boyle and T.C. Brown (eds) A Primer on Nonmarket Valuation. pp. Dordrecht: Kluwer Academic Publishers; 2003.
19. Borde A, Torabi S. PES mechanisms designed under the MENARID Project: three case studies. MENARID Project Report. GEF/MENARID/UNDP, Iran; 2014.
20. Ashraf S, Nazemi A, AghaKouchak A. Anthropogenic drought dominates groundwater depletion in Iran. Sci Rep. 2021; 11:9135.
21. Cowling RM, Egoh D, Knight AT, O'Farrell, PJ, Revers B, Rouget M, Roux DJ, Welz A, Wilheim-Rechman A. An operational model for mainstreaming ecosystem services for implementation. Proc Natl Acad Sci U S A. 2008; 105(28): 9483–9488.
22. GEF Revised Methodology for Calculating Greenhouse Gas Benefits of GEF Energy Efficiency Projects (Version 1.0).
23. Schoorl JM, Veldkamp A, Bouma J. Modeling Water and Soil Redistribution in a Dynamic Landscape Context. Soil Science Society of America Journal. 2002;66(5):1610-1619
24. Scherr SJ, White A, Kaimonwitz D. A new agenda for forest conservation and poverty reduction: making markets work for low-income producers. Forest Trends, Washington. D.C; 2004.

25. Milder JC, Scherr SJ, Bracer. Trends and future potential of payments for ecosystem services to alleviate rural poverty in developing countries. Ecology and Society. 2010;15(2):4-14
26. Leake JE, Squires VR. (In press) Rethinking rehabilitation of salt-affected land: new perspectives. Land 10
27. Amiraslami F, Dragovich D. Combating desertification in Iran over the past 50 years: An overview of changing approaches. Journal of Envir. Managt. 2011; 92:1-13
28. Goldsmith AA. Institutional development in national agricultural research: issues for impact assessment. Public Administration and Development. 1993;13:195-204
29. Assessing the Impact of Integrated Natural Resource Management: Challenges and Experiences; 2021. Available:https://www.researchgate.net/publication/26987209_Assessing_the_Impact_of_Integrated_Natural_Resource_Management_Challenges_and_Experiences (Accessed May 3, 2021)
30. Pieterse N, Verkroost AWM, Wassen MJ, Venterink HOC, Kwakernaak C. A decision support system for restoration planning of stream valley ecosystems. Landscape Ecology. 2002; 17:69-81

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/70050