ECOSYSTEM SERVICE PROVISIONING – UNDERLYING PRINCIPLES AND TECHNIQUES

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ABSTRACT:
Globally, development has to coincide with the securing of natural resources and the services they provide. However, under the current scenario, this seems to be a significant challenge. Moreover, climate change is affecting developing countries, and it has made the challenge even more prominent. United Nations Sustainable Development Goals has mandated the Governments to integrate the ecosystem services information while planning their development and climate adaptation strategies to adopt a green economy for sustainable natural resources. Moreover, organizations dealing with the conservation of natural resources are making it a fundamental aim of their programs to incorporate ecosystem services into their plans to help the public and private sectors work collectively for attaining broader socioeconomic goals. This review paper highlights the concepts behind ES assessments and how it is useful to help conserve natural resources with specific emphasis on the UT of Jammu and Kashmir.
Keywords: Ecosystems; Service provisioning; GIS; Remote sensing; Modelling

INTRODUCTION:

Life support systems of Earth are dependent on the services ecosystems provide and the natural resources that yield them (De Groot, 2010). Human economic systems are dependent on ecosystem services as a result of their contribution to human welfare. Ecosystem services are challenging to assign market values. That is the reason they are often given low weight in the policymaking hence compromising the sustainability of the human race in the biosphere (Burkhard et al., 2012). The whole of the socioeconomic systems will disintegrate if ecosystems stop providing their services. So in actual terms, the market values of the services provided by ecosystems are immeasurable (Phelps et al., 2015).

Nonetheless, to incorporate their significance in the developmental plans of humans, it is significant to understand the changing rates of their values from their current values-a concept known as marginal value in economics (Su et al., 2012; Guerry et al., 2015). The aim of the ecosystem service assessments must be to get their outputs incorporated into the national developmental plans; however, many studies have restricted themselves up to evaluation stages only (Tezer et al., 2018). Moreover, the concept of the beneficiary flow of ecosystem services is often missing in the assessments. Meanwhile, since climate change is affecting every realm of the earth system therefore whenever assessments of ecosystem services are being carried out, incorporation of the impacts of climate change in the assessments need to be kept on high priority.

Perhaps such agendas are common in developed countries, developing countries, mainly, Himalayan regions, are far from getting research assessments done (Orfanidis et al. 2003; Arias et al., 2011). Meanwhile, to complicate the matter, differences in methods of ecosystem service assessments pose additional challenges that hamper its use in policy and decision making (Ozment et al., 2018). Over the years, considerable studies have been carried out in the field of ecosystem services assessment, and some of the important ones are presented in this review paper.

STUDY AREA:

The union territory (UT) of Jammu and Kashmir is the northern region of India. Afghanistan bounds it in the North-west and by Pakistan in the West. The UT has a significant geopolitical significance. Southern boundary is connecting with Punjab and Himachal Pradesh (JKDEARS, 2018). The borders on North, East, and West are sealed by natural barriers and is accessible only from the South. The UT of Jammu and Kashmir has a geographical area of 42,241 km^2. The hilly tract extending to the plains of the Punjab from the snowy mountains bounded the Kashmir valley on the South is called Dugar. It is the home of the Dogras, a hardy people dividing into several castes and sects, both Hindus and Muslims, belonging to the Aryan race, they speak Dogri language. The study area (Figure 1) is an oval-shaped intermountain basin called Jhelum basin, a sub-basin of Indus River basin, running in the NW-SE direction.

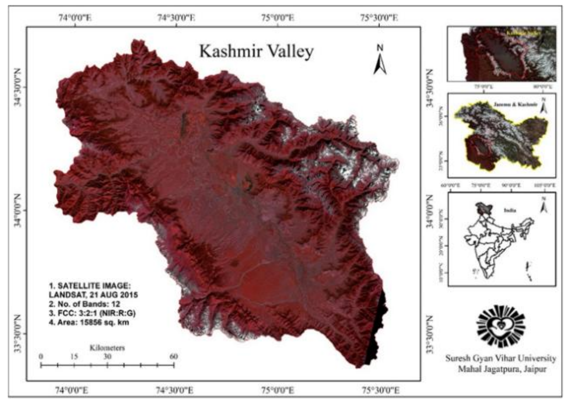

Fig. 1 Kashmir valley as shown in FCC Landsat September 2015 satellite image

There are considerable differences in the climate of UT due to its location and topography. The climate of the UT varies from tropical in Jammu with Kashmir and Jammu mountainous tracts having temperate climatic conditions. The temperature of this state varies spatially also. Annual rainfall varies from region to region, with 650.5 mm in Srinagar and 1,115.9 mm in Jammu. Geologically, the state represents constituted rocks ranging from the oldest period of the Earth's history to the youngest present-day river and lake deposits (GP) (IHS-2018). The climate of the valley displays a marked seasonality akin to the inner continental parts of the temperate latitudes. The weather is pleasant up to the middle of June. However, there is a conspicuous change in climate with altitude. As the elevation rises towards the meadow slopes ('margs') of surrounding mountains, the temperature of 24°C at Srinagar (altitude 1600m) decreases to 10°C at an elevation of 3,600m. The temperature of the valley ranges from an average daily maximum of 31ºC and a minimum of 15°C in July to an average daily maximum of 4°C and a minimum of -4°C in January. The maximum daily humidity ranges from 80-90% throughout the year and drops to 70% during winter nights and 40% during the summer. The mean precipitation at Srinagar is 659 mm per annum, and most of the precipitation occurs as snow during winter and early spring. Mean of 600 mm of snowfall takes place in Srinagar during winter and early spring, but the snowfalls on the higher slopes/altitudes are much more substantial.

This review paper analyses the concept of ecosystem services to be applied in the Kashmir zone of the UT of Jammu and Kashmir, aimed to model the supply of and demand for the focal ecosystem services such as sediment retention, dry-season base-flows and flood risk reduction under changing climate.

ECOSYSTEM FUNCTIONS AND SERVICES

Ecosystem functions are the properties and processes of ecosystems that they provide for sustenance to the biosphere, such as habitat, etc., while strictly speaking ecosystem services are the benefits humans derive from ecosystems such as food etc. (Jakeman and Letcher, 2003). It is better to write functions and services as one standard ecosystem services to avoid any ambiguity (Kontogianni et al., 2010). There is no simple relationship between the functions and services of the ecosystems (Nelson and Daily, 2010). While many times, functions provide services and, in other cases, services come up together and provide functions (Tucker et al., 2009).

Further, interdependency condition of the ecosystem functions, need to be emphasized to know the flow of the services towards the beneficiaries. For example, food is the outcome of primary productivity, which in itself is dependent on the respiratory products of the consumption of the food. So the output becomes the input of the process itself, in turn, supporting human welfare (Seppelt at. 2013).

NATURAL CAPITAL AND ECOSYSTEM SERVICES

The stock of materials at any point in time is referred to as the capital. Stocks are dependent on other stock capitals, and there exists an interconnected flow of services that help in the production of services from one another that in turn govern the spatial structure of the ecosystems and the human benefits thereof (Groot et al., 2002). However, once the service becomes in use of humans, the actual stock does not remain the same (Troy and Wilson, 2006).

There are different manifestations of the natural capital stocks, such as trees, ecosystems, hydrosphere, atmosphere, etc., while the manmade stocks include infrastructure and the humans themselves. So far, now human intelligence and the data and information are also the capital stocks of the biosphere (Zhu and Stackpoole, 2010). In short human welfare is the outcome of the flow of matter, energy, and the information integrated with the humanmade capital services. Though the only realm where human wellbeing and the capital stocks have not been much researched is in the case of space colonies, which right is a distant and unlikely priority of humans (Palmer, 2002).

Conversely, we may conceptualize how much investment shall be required to replicate the services ecosystems provide so that we may know what their actual market value is. Thus, natural capital assessment shall take a definition that is suitable in the perspective of the human welfare (Bullock et al., 2011; Bhagabhati et al., 2014). The overall concept is that natural capital is zero, then human wellbeing is also zero since humans have no means to rely on the artificial means entirely. Everything humanmade directly or indirectly come from natural capital (Groot et al., 2002; Häyhä and Franzese, 2014). Hence it is imperative to understand the natural capital value concerning human welfare, and beyond that, it is impossible to ascribe market values to every natural entity.

Ascribing market values to the hydrosphere or lithosphere is insignificant as their benefits are immeasurable. Instead what important is, is the understanding of the fact how changes in the natural capital would impact the human welfare (Carpenter et al., 2009; Lester et al., 2010; Koschke et al., 2012; Li et al., 2017) as such changes shall alter the whole delicate balance of the biosphere that provide welfare to humans.

VALUING OF ECOSYSTEM SERVICES

Human progress is dependent on the services ecosystem provide, and it is essential to ascribe cost-based values to them to avoid any untoward miscalculation about the cost-benefit ratio of the developmental projects (Yoon et al., 2002; Yung En Chee, 2004; Metzger et al., 2007).

Many argue that the attribution of values to intangible services is impossible such as that of human lives, the environment, or the sustenance ecosystem provide. Still, seldom they understand we value such intangibles every day we attribute or acknowledge values to the safety of human beings. For example, we are spending more money to make more robust construction for human protection. So indirectly, we do attribute values to such things. While many others believe that only based on the moral and ethical conditions, ecosystems should be protected, and valuation is not necessary.

However, all such arguments fail to convince the very fact of how to engage governments to protect ecosystems if they don't know what their value is, cost-wise. So this is the real moral argument that is in direct conflict with the human developmental theories of economy and sustenance (Kenter, 2016). Such an actual moral obligation to protect and conserve the ecosystem while targeting social developments has laid a particular specific set of norms and language of discourse (Keeler et al., 2012).

Science has found a mid-way to make the problematic and inexplicit valuation a task that can be attained if economic and moral rules are set, keeping the view the diversity of the problem. So as a society that is utterly dependent on nature, decisions have to come to defend the conservation and protection of natural capital through eye-opening valuations that although need to be strictly monetary

(Keating et al., 2017). In-short, whenever humans have to make choices, the need for the valuation of nature is binding. Economic marginal analysis has helped in a way to understand how a relatively small change in the services can affect human welfare and calculate that either in terms of monetary value or change in service benefits (Laurans et al., 2013). In other words, market or non-market values can be ascribed to such changes. For example, drinking water is supplied through market values, but the accompanying recreational and life-supporting benefits of water are considered as non-market values (Crossman et al., 2013; Bhat et al., 2014). Hence the effects of ecosystem and human welfare chain range from simple to incredibly complex and incomprehensible. For example, besides forest providing wood, it also protects soil, is habitat, holds biodiversity all that usually cannot have market values (Bryan et al., 2018).

VALUATION METHODS

Market and non-market constituents of ecosystem services have been valued using different methods (Polasky et al., 2012; Mandle et al., 2017). So far, each technique has an underlying basis of the previous studies based on which uncertainties and limitations of the new methods are dealt and tried to overcome.

The papers focussed in this review have used the methodology that estimates the willingness-to-pay of individuals for the protection of ecosystem services. One of the fundamental entities of uncertainties in the estimation of the ecosystem services is the calculation of the demand curve of ecosystem services. Further, the supply curves of the ecosystem services are nearly vertical because the economic system does not govern the increase or decrease of ecosystem services (Chen et al., 2009).

CLIMATE CHANGE AND ECOSYSTEM SERVICES ASSESSMENT

Due to the changes in the global environment, it is a significant challenge to understand how this change shall impact the ecosystems and the benefits human drive from them at all the scales of human existence (MEA, 2003; Fisher et al., 2009). It is a challenge because the Earth is a non-linear, complex, and highly unpredictable system. For example, human civilization has been shaped by the Earth system since time immemorable. Still, now the stage has reached that humans are influencing its processes such as climate, biogeochemical cycles, biodiversity, etc. and, in turn, get themselves being affected. (Gujree et a., 2017; Young and Don, 2017).

More promptly, the drivers of the environmental change are interacting with natural and human systems in such complex ways that feedbacks and counter-interactions are creating uncertainties in the assessment, which are very difficult to address and quantify. However, such limitations cannot stop the assessments as they are essential for establishing sustainable livelihood measures. Ehrlich and Ehrlich (1970) had suggested that "the subtlest and dangerous threat to man's existence is the potential destruction, by man's activities, of those ecological systems upon which the very existence of the human species depends."

Many studies have focused on these aspects of human-environment interactions and how this is important to sustain human-race on this planet sustainably (Srivastav and Srivastav 2015). Research has established that the consequence of the changing ecosystem services due to the changing climate is not subtle but dramatic (Li et al., 2016). Climate change is altering the supply, delivery, and value of almost all the global ecosystems. While the terrestrial ecosystems are more directly related to human wellbeing, they are the most affected. Hence everything from carbon sequestration, wildlife, food, and fodder to the recreation, everything is affected by the changing the climate (Mandle et al., 2017).

GEOINFORMATICS AND ECOSYSTEM EVALUATION

Ecosystem service valuation requires a spatially explicit understanding of the phenomenon of service processes. Remote sensing and geographic information systems (GIS) provide a perfect platform for the assessment of ecosystem service as they possess the spatial information entity that requires quantification (Meraj et al., 2018).

Today due to GIS and the availability of superior land cover data sets in the public domain, bio-geographic components of the biosphere such as forests, wetlands, and beaches are attributable to the ecosystem services being provided to the beneficiaries (Grêt-Regamey et al., 2008; Chen et al. 2009; Bateman et al., 2014; Rather et al., 2018). GIS has helped to integrate the biophysical and ecosystem service valuation data to understand the impact of marginal changes in the ecosystem service supply on human wellbeing (Troy and Wilson, 2006). Overall remote sensing and GIS is today used in almost all the assessments that require spatially explicit value transfer by linking analyses of non-market economic valuation data and biophysical data to be translated for the decision and policy making (Shoyama et al., 2017)

CONCLUSION

Ecosystem services assessment is one of the backbone analyses for planning the sustainable future of the planet Earth. Throughout the world, ES assessments are carried out to link ES with the economy of the regions. Earth system modeling and GIS play a pivotal role in the evaluation of ecosystem services. Specifically, it has been found that there has been very little work done on the ecosystem service provisioning under climate change in the Himalayan region. Although many global studies have been done in this field, but very few have focused on Himalaya. Further, the use of earth system modeling and geoinformatics has been found to be the central methodology in all the studies undergone in this literature review. The literature surveyed has helped to evaluate some of the significant research gaps in the ecosystem service provisioning of the regions under changing climate. Such as little or no such work has been done in the Himalayan region. Quantification of the biophysical supply of sediment retention has not been carried out on a regional scale. How the biophysical supply of major ecosystem services would shift under changing climate has also not been addressed in the

Himalayas till date. Further, no assessment in the Himalayas is in literature, wherein the degree to which areas important for providing the focal ecosystem services coincide with the biodiversity conservation priorities such as protected area networks.

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