Agro Economist - An International Journal
Citation: AE: **9**(01): 95-106, March 2022
DOI: 10.30954/2394-8159.01.2022.14

AAEBM
ASSOCIATION OF AGRICULTURAL ECONOMICS & AGRI-BUSINESS MANAGEMENT

Impact of Land-Use Land-Cover Changes on Ecosystem Services of Jammu and Kashmir, India

Ishrat F. Bhat, F.A. Shaheen*, N.A. Kirmani, K. Gautam, F.A. Lone, Baseerat Afroza and D. Baghishree

Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, J&K, India
*Corresponding author: fashaheen@rediffmail.com

Received: 10-11-2021 **Revised:** 05-02-2022 **Accepted:** 04-03-2022

ABSTRACT

The services of ecological land-use land-cover (LULC) changes, mostly unplanned, have emerged as one of the drastic problems the world is facing in recent times. These changes often manifest in the form of environmental/ ecosystem degradation, water shortage, declining food security and ecosystem service recession globally. One of the most dominant forces responsible for changing the global landscape includes the changes in LULC as prompted by a string of interconnected forces. The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the earth's life-support system. These issues made us to conduct this study to primarily focus on various LULC changes and their impact on ecosystem services in Jammu & Kashmir, India by employing secondary data with effect from 1960-61 to 2020-21. It was observed that the most notable changes of land use were observed in the form of increase in farmland and a decline in grassland. In proportionate terms while the farmland has increased by 22.4 per cent, the grassland has lost 1.4 per cent of area (64000 ha). The study revealed that the major/valuable land-use classes i.e., farmland and forest provide more ecosystem services than other land classes like barren/built-up, grassland and lakes/water bodies etc. Furthermore, results revealed that forest land-use class generate appreciably higher ecosystem services values generating 84.5 per cent of total value from all different land-use classes during 2020. During the past over six-decade period, the total economic value on the whole has declined by 1.09 million dollars between 1960 and 2020. Meanwhile, the total economic value of farm land and marshy land increased by 0.44 and 0.28 million dollars, respectively on account of increase in area under these land types. The individual ecosystem service like soil generation and fertility followed by the gas regulation provides more ecosystem services than other. The LULC changes have been driven by various forces ranging from physical, socio-economic/demographic factors resulting in pressures on land with various environmental effects and their outcomes. The study outlines for implementation of holistic land-use planning through proper balancing of human needs with integration of sustainable ecosystems.

Keywords: LULC, Ecosystem service value, Jammu & Kashmir, India

Landscape is an important and foremost characteristic feature which defines the intrinsic value of the area/region and also shapes its economy. Land is one of the most essential natural asset, as life and numerous developmental activities are dependent on it and there are barely any landscape on the earth's surface that have not been altogether changed or are not being modified by people in some way or the other. Land-use and-land cover (LULC) are two

How to cite this article: Bhat, I.F., Shaheen, F.A., Kirmani, N.A., Gautam, K., Lone, F.A., Afroza, B. and Baghishree, D. (2022). Impact of Land-Use Land-Cover Changes on Ecosystem Services of Jammu and Kashmir, India. *Agro Economist - An International Journal*, **09**(01): 95-106.

Source of Support: None; **Conflict of Interest:** None

transposable terms; however, used with different connotations in land change science. Land-use refers to 'human activities on and in relation to the land, which are usually not directly visible from the imagery' (Lo 1986), while as land-cover describes, 'the vegetation and artificial constructions covering the land surface' (Burley 1961). Land-use and land-cover matrix is intrinsic element of the landscape, having direct and indirect links with varied geophysical and socio-economic processes. The rate and spatial scale of human alterations to land surface mostly in the form of land-use and land-cover change are unprecedented and so invasive that they enormously transformed a large proportion of the planet's land surface, affecting key aspects of earth systems (Lambin *et al.,* 2001; Foley *et al.,* 2005). The controlling factor of rapidness and pattern in land-use land-cover (LULC) change by humans mainly depend on their social, economic, and political characteristics (Ojima *et al.,* 1994). Land-use and land-cover (LULC) change assessment has become central to diverse facets of human and natural environment, and interplay between the two (Foody 2002; Herold *et al.,* 2002; Ji *et al.,* 2005; Diallo *et al.,* 2009; Hegazy and Kaloop 2015; Liu and Yang 2015). Evaluating land-use and land-cover is imperative to overcome a series of environmental issues at regional level such as unregulated development, loss of agricultural lands, destruction of wetlands, and wildlife habitat (Anderson *et al.,* 1976). Moreover, the land-use land-cover (LULC) changes deserve more consideration in land management owing to their usually impending negative impact on status and integrity of ecosystem functioning (Quintas-Soriano *et al.,* 2016). With increasing pressure on land resources owing to population growth and expansion of human settlement, land-use land-cover (LULC) is also of great relevance to policies on Disaster Risk Reduction (DRR) and climate change adaptation (e.g., David *et al.,* 2016; Shaw and Banba 2017). Land-use and land-cover (LULC) change studies attempt to explain where change is occurring, what land-cover types are changing, the types of transformation which is occurring, the rates or amounts of land change, and the driving forces and proximate causes of change (Loveland and Acevedo 2006). What would be the future change patterns of the land-use and land-cover, mostly derived through modelling is also an imperative in such investigations. In order to understand when, where, and why land-use land-cover (LULC) changes occur, the models usually involve empirically fitting the evaluation system to some historical pattern of change, then extending those patterns into the future for projection (Brown *et al.,* 2000).

Land-use and land-management decisions have major impacts on ecosystems and the goods and services they provide to people ("ecosystem services" Daily, 1997). Ecosystem services include carbon sequestration because of its positive impact on climate regulation, nutrient retention because of its positive impact on water quality, water flow timing because of its role in flood and drought mitigation, and inputs to the production of agricultural crops (e.g., soil productivity, pollination), among others. Changes in land-use or land-management (agricultural practices, forestry practices, intensity of development) can cause changes in the provision and value of ecosystem services. However, changes in land-use or land management will increase the provision and value of some services but decrease others. Since land-use and diversity of related disciplines such as agriculture, forestry, rural planning as well as conservation all deal with spatial characteristics of landscapes (Lacher, 1998). To identify locations for different land uses (e.g., landfills, wildlife reserves, residential developments etc.) various suitability assessments have been used for several decades (McHarg, 1995). While, the general notion of trade-offs among objectives in land-use and land-management is understood in principle, in practice we typically lack the ability to predict how specific land-use or land-management decisions will affect the overall value derived from a landscape (MA 2005; NRC 2005). In other words, we often lack "ecological production functions" to predict the provision of ecosystem services as a function of ecosystem conditions (NRC 2005; Daily *et al.,* 2009).

Quantitative assessment of the effects of land use changes on the value of ecosystem services is one of the research focuses of sustainable development in science (Zhou *et al.,* 2008; Wu *et al.,* 2009). Many scholars have conducted studies in different countries, regions, and basins since the 1990s (Wang *et al.,* 2006; Wang *et al.,* 2012). The effects of coastal erosion on the value of ecosystem services in Europe

were quantitatively evaluated with the result that the loss of ecosystem service values was C23 million decrease from 1975 to 2006 (Roebeling *et al.*, 2013). In Chachalacas of Mexico, due to increased urban sprawl and the decrease of grasslands and croplands from 1995 to 2006, the net loss of ecosystem service value ($US 2006/ha/year) was approximately $7 × 105 (Mendoza-Gonzalez *et al.*, 2012). Rapid land use changes in Uruguay over the past 20 years, from grassland to plantations, had seriously affected the provision of ecosystem services (Vihervaara *et al.*, 2012). The analysis of land use changes and their consequent changes in ecosystem services value in the Huairou reservoir basin in China showed that in 2008 the ecosystem services value had increased 2.88 per cent compared with that in 1990 (Wang *et al.*, 2012). These studies offer theories and explore land use options and the sustainable development of ecosystems in these areas.

In this background, the present study aims to look into the land-use land-cover changes and its impact on value of ecosystem services in Jammu and Kashmir (J&K).

DATA AND STUDY AREA

The study was conducted in Jammu and Kashmir union territory of India, located in the northern part of the Indian sub-continent centered on the plains around Jammu to the south and the vale of Kashmir to the north. It lies between Latitude 32^{o} 17^{o} and 37^{o} 05^{o} North and Longitude 72^{o} 31^{o} and 80^{o} 20^{o} East, and has a geographical area of 101,387 sq kms. With diverse land forms; plains in the Jammu region and uneven rugged mountainous terrain in the Kashmir valley. The vast majority of the union territory is mountainous, and the physiography is divided into five zones that are closely associated with the structural components of the western Himalayas. From west to east, those zones consist of the plains, the foothills, the *pir panjal* range, the valley of Kashmir, and the great Himalayan zone. This geographical location has a wide scale land degradation in the Jammu region at Himalayan foothills**.** The present study made use of secondary data obtained from diverse sources. The state-level information on land use pertaining to the period from 1960 to 2020, has been collected from the Directorate of Economics & Statistics, Government of Jammu & Kashmir, Department of Financial Commissioner Revenue, Jammu and Kashmir, Department of Agriculture, Jammu and Kashmir, Department of Horticulture, Jammu and Kashmir, various published reports, books, journals, and other official records from outside and within the UT. The data on different land use classes and land cover types were re-classified as forest land, farm land, built up/barren land, marshy land, grass land and lakes/rivers/dams etc, from 1960 to 2020. To calculate the ecosystem service value for each land cover type, framework identified by Costanza *et al.*, (1997), Xie *et al.*, 2003; Ziliang wang *et al.*, 2015, ecosystem service valuation model was used.

ANALYTICAL PROCEDURES

Change detection: Change detection of individual land-use land-cover (LULC) classes were computed to describe the extent of changes between periods.

$$Area\ change = (A_2 - A_1)$$

Where;

A_1= Area in year/decade 1st.

A_2=Area in year/decade 2nd of a land-use land-cover (LULC) class (ha.)

Benefit Transfer Method to estimate the Ecosystem Service Value (ESV): Due to a desire for more benefits and a lack of knowledge of ecosystem service values, humans have globally developed many natural ecosystems into cropland and building land in the past, resulting in altered and destroyed functions of ecosystem services and the reduced provision of ecosystem goods and services to society. To calculate the value for ecosystem services the benefit transfer method was used in this study based on the results of other studies (Jing Chen *et al.*, 2014).

$$ESV_n = \sum_k \sum_f A_{nk} \times VC_{kf}$$

Where;

A_{nk} is the area of land use for type k in n year,

n is 1960, 1970, 1980, 1990, 2000, 2010, 2020).

VC_{kf} is the value coefficient of ecosystem services value for type f, with land-use type k.

Finally, to analyze the impact of land-use changes on the value of ecosystem services in six decadal periods (1960-1970, 1970-1980, 1980-1990, 1990-2000, 2000-2010, 2010-2020), we calculated the change rate of ecosystem service values at decadal points. The change rate can be calculated with the formula:

$$\partial_{i-j} = \left(\frac{ESV_{nj}}{ESV_{ni}} \right)^{1/(j-i)} - 1$$

Where;

$\eth_{i-j}$ is the rate of change in six decadal periods (1960-1970, 1970-1980, 1980-1990, 1990-2000, 2000-2010, 2010-2020),

ESV_{nj} is the value of ecosystem services in n_i year;

n_i is 1960, 1970, 1980, 1990, 2000, 2010, 2020.

RESULTS AND DISCUSSION

Change in land-use over the years

The land considered in this section includes land as per village papers (reported area) and area under demarcated forests. The decline in this area necessitates proper land-use surveys through remote sensing supplemented with cadastral mapping. The various land use classes were re-grouped based upon relative likeness and put under six major classes for decade endings (Table 1). Between 1960 and 2020, the most notable changes of land use were observed in the form of increase in farmland and a decline in grassland. In proportionate terms while the farmland has increased by 22.4 per cent, the grassland has lost 1.4 per cent of area (64000 ha). The state has a dearth of fodder for most part of the year owing to increasing demand in livestock that led to fodder imports. The state is 40 per cent deficit in fodder on dry matter basis and the deficiency is more pronounced in the segments of green fodder and concentrates (Wani *et al.*, 2014). The decline of area under this category may worry livestock owners. Strategies need to be framed for improving the productivity of pasture lands, grazing lands and other supporting lands. The decline of forest area by 6000 ha since 1960s in the mountainous region like J&K should be a concern for ecologists and planners. This decline could be well attributed to deforestation and these trends are more likely to pose severe implications, including adverse agro-climatic changes (Baba *et al.*, 2019). The results have shown that the area under lakes/rivers/dams etc have also reduced over the years and this portion is hypothesized to have come in the form of marshy land or got in some other uses. The land use description keeps no separate account of land under built-ups as it is combined with land put to non-agricultural uses. Behaviour of the data indicates that the area under this category has shown a marginal increase which seem under-estimated compared to the ground level observations where residential pockets have come up as sporadically across all land use categories though more widely across farmlands. The increasing land demand for creation of infrastructure and urbanization is expected to further bring more area under non-agricultural uses/built-up area.

The Union Territory (UT) of Jammu and Kashmir (J&K) in general and valley of Kashmir in particular is losing its prime agricultural land and wetlands to rapid urbanisation and faulty land-use policy. Unplanned construction with respect to residential colonies, factories, brick kilns, shopping complexes and other commercial infrastructure has severely damaged the agricultural and ecological resources of the Union territory (UT). Apart from private sector developments, a handsome conversion of prime agriculture land and wetland area including the karewas (uplands) come under the hammer of public infrastructural projects like railways, four lane highway projects, ring-road projects besides, hospitals, schools and colleges etc.

Extent of Land Use changes from 1960 to 2020

During the period of 6 decades, the area occupied by farm land increased by about 6.7 per cent mainly as a result of shift of land from grass-land to this class. The increase in the area under farm-land was more significant during first decade (1960 to 1970) following by the decade of 2000-2010 and the increase was mainly due to expansion of area under fruits and vegetables. Corresponding to increase in area under farm land, the area under grass lands has decline and the magnitude was more during 1980s followed by 1970s and 2000s. Like grass land, forest area have also reduced by about 6 thousand hectares from 1960s to 2020s. Area under lakes/water bodies etc was the second most dominant land-use class after grass

Table 1: Change in land-use over the years (000 ha)

Sl. No.	Land use	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2020-21	2020-1960
1	Forests	2693 (59.9)	2673 (59.5)	2676 (59.6)	2676 (59.6)	2681 (59.7)	2685 (59.9)	2687 (60.1)	-6.02
2	Farmland	938 (20.9)	960 (21.4)	964 (21.5)	971 (21.6)	978 (21.8)	995 (22.2)	1001 (22.4)	63
3	Grassland	251 (5.6)	243 (5.4)	227 (5.1)	200 (4.5)	198 (4.4)	185 (4.1)	187 (4.2)	-64
4	Marshy land	–	–	–	–	–	05 (0.1)	06 (0.1)	06
5	Lakes/rivers/dams etc.	68 (1.5)	62.4 (1.4)	56.8 (1.3)	53.4 (1.2)	51.2 (1.1)	45.6 (1.0)	40 (0.9)	-28
6	Built-up/land put to non-agricultural uses	549 (12.2)	551 (12.3)	565 (12.6)	586 (13.1)	582 (13.0)	569 (12.7)	552 (12.3)	03
	Total	4499	4489	4489	4486	4490	4485	4473	-26.02

Figures within parentheses indicate percentage of reported area.

Table 2: Change (ha, %) in different land-use classes in 1960 to 2020

Land use	1960 to 1970		1970 to 1980		1980 to 1990		1990 to 2000		2000 to 2010		2010 to 2020		1960 to 2020	
	Change	%	Change	%	Change	%	Change	%	Change	%	Change	%	Change	%
Forests	-20.0	0.7	3.0	0.1	0.0	0.0	5.0	0.2	4.0	0.1	2.0	0.1	-6.0	0.2
Farmland	22.0	2.3	4.0	0.4	7.0	0.7	7.0	0.7	17.0	1.7	6.0	0.6	63.0	6.7
Grassland	-8.0	3.2	-16.0	6.6	-27.0	11.9	-2.0	1.0	-13.0	6.6	2.0	1.1	-64.0	25.5
Marshy land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	1.0	20.0	6.0	0.0
Lakes/rivers/dams etc	-5.6	8.2	-5.6	9.0	-3.4	6.0	-2.2	4.1	-5.6	10.9	-5.6	-12.3	-28.0	41.2
Built up/land put to non-agricultural uses	2.0	0.4	14.0	2.5	21.0	3.7	-4.0	0.7	-13.0	2.2	-39.0	6.9	-19.0	3.5
Total	-9.6		-0.6		-2.4		3.8		-5.6		-33.6		-48.0	

land which has steadily decreased by 28 thousand hectares since 1960-61. The area under barren land including area put to non-agricultural use after increasing during first three decades has exhibited a declining trend and has reduced by 3.5 per cent of its area during 1960 as depicted in (Table 2). Despite emergence of residential pockets sporadically across the farm and non-farm land, the area accounted for the less coverage, and the behaviour of the data have shown aggregate decline in the land-use class.

Ecosystem service values

The equivalent ecosystem service values for different land use types calculated through a framework developed and put in use by Costanza *et al.*, 1997, Xie *et al.*, 2003; Ziliang Wang *et al.*, 2015 was adopted in this study. The equivalent value of ecosystem services per unit area, as explained by these studies, is the latent ability of any ecosystem services in monetary terms and was defined as the economic value produced by one hectare of each land cover category (Table 3).

Changes in ecosystem services

The average equivalent value per unit area of ecosystem services was equated with the area under different land use category to get an aggregate economic value of ecosystem services from available land. This practice was repeated for different decadal endings so as to have an idea about the change in these values over time with the land use land cover changes. Result findings presented in the Table 4 indicate that forest land use class generate appreciably higher ecosystem services values to the tune of 84.5 per cent of total value from all different land use classes during 2020. Following this, farm land and lakes/water bodies ranks second and third respectively in providing ecosystem services in value terms, though the difference in economic ecosystem service values between these two land use

Table 3: Equivalent value per unit area of ecosystem services for terrestrial ecosystem (Zhiliang Wang *et al.,* 2015)

Ecosystem Services	Farm land	Forest land	Built up/barren	Marshy land	Grass land	Lakes/water bodies
Climate stability*	0.89	2.7	0	17.1	0.9	0.46
Gas regulation	0.5	3.5	0	1.8	0.8	0
Soil generation & fertility #	1.46	3.9	0.02	1.71	1.95	0.01
Water regulation and supply	0.6	3.2	0.03	15.5	0.8	20.38
Waste treatment	1.64	1.31	0.01	18.18	1.31	18.18
Food production	1	0.1	0.01	0.1	0.3	0.10
Biodiversity protection $	0.71	3.26	0.34	2.49	1.09	2.49
Recreation & cultural	0.01	1.28	0.01	4.34	0.04	4.34
Raw materials	0.1	2.6	0	0.01	0.05	0.01
Sum	6.91	21.85	0.42	45.97	7.24	45.97

*Climate stability includes climate and disturbance regulation; #Soil generation and fertility includes soil formation, nutrient cycling, sediment retention and erosion control; $ Biodiversity protection includes biological control, refuge, pollination, and genetic resource (Costanza *et al.,* 1997).

Table 4: Ecosystem values of different land use classes 1960 and 2020 (million dollars)

Ecosystem services	Farm land		Forest land		Built up/ Barren		Marshy land		Grass land		Lakes/water bodies		Total	
	1960	2020	1960	2020	1960	2020	1960	2020	1960	2020	1960	2020	1960	2020
Climate stability	0.84	0.89	7.27	7.26	0.00	0.00	0.00	0.10	0.23	0.17	0.03	0.02	8.36	8.44
Gas regulation	0.47	0.50	9.43	9.41	0.00	0.00	0.00	0.01	0.20	0.15	0.00	0.00	10.10	10.07
Soil generation & fertility	1.37	1.46	10.50	10.48	0.01	0.01	0.00	0.01	0.49	0.37	0.00	0.00	12.37	12.33
Water regulation & supply	0.56	0.60	8.62	8.60	0.02	0.02	0.00	0.09	0.20	0.15	1.39	0.82	10.78	10.27
Waste treatment	1.54	1.64	3.53	3.52	0.01	0.01	0.00	0.11	0.33	0.25	1.24	0.73	6.64	6.25
Food production	0.94	1.00	0.27	0.27	0.01	0.01	0.00	0.00	0.08	0.06	0.01	0.00	1.30	1.34
Biodiversity protection	0.67	0.71	8.78	8.76	0.19	0.18	0.00	0.02	0.27	0.20	0.17	0.10	10.08	9.97
Recreation & cultural	0.01	0.01	3.45	3.44	0.01	0.01	0.00	0.03	0.01	0.01	0.30	0.17	3.77	3.66
Raw materials	0.09	0.10	7.00	6.99	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	7.11	7.10
Total	6.48	6.92	58.84	58.71	0.23	0.22	0.00	0.28	1.82	1.35	3.13	1.84	70.50	69.41
Percentage to total value	9.2	10.0	83.5	84.6	0.3	0.3	0.0	0.4	2.6	2.0	4.4	2.6	100.0	100.0

classes and forests is very wide. The grasslands were observed to account for around 2 per cent of total value which is less than 1/3rd of the value generated in farmland. Although, the area not available for cultivation/built up and marshy land are more than grassland and lakes but their contribution in economic value terms is less. The value of the soil generation & fertility, gas regulation, biodiversity protection and water regulation/supply were the major ecosystem services flowing from forests in value terms. The role of forests in food production is less in relationship with other services. The role of farmland in waste management and soil generation & fertility management is higher and relatively lower in recreational and cultural values compared to other ecosystem services flowing from this category of land use. The contribution of total economic value generated in lakes comes from water regulation/ supply and waste treatment thereby acting as kidneys of the landscapes.

Table 5: Changes in the ecosystem values of different land uses between 1960 and 2020 (million dollars)

Ecosystem services	Farm land	Forest land	Built up/ barren	Marshy land	Grass land	Lakes/water bodies	Total
Climate stability	0.06	-0.02	0.00	0.10	-0.06	-0.01	0.07
Gas regulation	0.03	-0.02	0.00	0.01	-0.05	0.00	-0.03
Soil generation & fertility	0.09	-0.02	0.00	0.01	-0.13	0.00	-0.05
Water regulation and supply	0.04	-0.02	0.00	0.09	-0.05	-0.57	-0.51
Waste treatment	0.10	-0.01	0.00	0.11	-0.08	-0.51	-0.39
Food production	0.06	0.00	0.00	0.00	-0.02	0.00	0.04
Biodiversity protection	0.05	-0.02	-0.01	0.02	-0.07	-0.07	-0.11
Recreation & cultural	0.00	-0.01	0.00	0.03	0.00	-0.12	-0.11
Raw materials	0.01	-0.02	0.00	0.00	0.00	0.00	-0.01
Total	0.44	-0.13	-0.01	0.28	-0.46	-1.29	**-1.09**

During the past over six-decade period, the total economic value on the whole has declined by 1.09 million dollars between 1960 and 2020 and the decline was mainly on account of decrease in value of ecosystem services provided by lakes/water bodies due to significant decline in its area as well as deterioration. The decrease in the value of lakes was more prominent in water regulation & supply and waste treatment; primarily due to the degradation and unfavourable pollution of water bodies in the UT. The decline in the economic value due to grass-lands has forthcoming negative influences on livestock development and need a policy support to manage these resources. Meanwhile, the total economic value of farm land and marshy land increased by 0.44 and 0.28 million dollars respectively, on account of increase in area under these land types as depicted in (Table 5). The increase in economic value of farm land was higher in waste treatment and food production and relatively lower in recreational and cultural services. Encouragement of agro-tourism is expected to increase the flow of values from farm lands. All kinds of ecosystem service values have declined from 1960 to 2020 in forests, grass land and lakes/waterbodies. The more decrease was noted in those services whose economic value was relatively higher than other services.

CONCLUSIONS AND POLICY IMPLICATIONS

The ES are interrelated and the absence of adequate designs to sustain one can hamper other provisions as well. Understanding land use and land cover (LULC) dynamics, as well as the associated impacts on the multiple ecosystem service value (ESV), is extremely important in decision-making processes and effective implementation of an ecosystem-based management approach. The study has revealed a major shift of land from the desirable to undesirable land-use classes. There has been an increase in the net area sown in Jammu and Kashmir between 1960 and 2020. However, the most notable changes of land use were observed in the form of increase in farmland and a decline in grassland, the decline in the latter may be concern for livestock owners, particularly, the nomads who depend upon such pasture-lands. The decline of forest area by 6000 ha since 1960s in the mountainous region should be a concern for ecologists and planners. Furthermore, results revealed that forest land use class generate appreciably higher ecosystem services values (85%) across all different land use classes. During the past over 6 decades period, the total economic value on the whole has declined by 1.09 million dollars between 1960 and 2020. All kinds of ecosystem service values have declined from 1960 to 2020 in forests, grass land and lakes/waterbodies. The more decrease was noted in those services whose economic value was relatively higher than other services.

The availability of spatially explicit information on ecosystems and their interrelated services serves for the prioritization of ecosystem services into policy and decision-making. The result findings produced as an outcome of this study can help land use planners, government organizations, and concerned

stakeholders to recognize areas where the ecosystems are produced and help in the decision making for low impact development maintaining ecological balance and economic goals. Further studies can be attempted in the region based on GIS data and maps of different periods to overcome for discrepancies in the statistical data usually maintained by the Revenue Department of the UT which has many reservations for its accuracy as well as authenticity.

It is imperative to involve locals for community development and educate them to become an integral part in the production and preservation of natural resources. This study established the natural ecosystem that provides goods and services, such as climate stability, soil generation, soil fertility, water regulation, food production and biodiversity production etc. were very important for social sustainable development. However, the importance of ecosystem services has been acknowledged, the value of ecosystem services has thus far not been considered for any development plans. Therefore, the present study can provide the positive influence and theoretical basis for protecting the natural ecological environment, in which the contradiction is evident between sustainable ecosystem services and land exploitation. However, when land use changes deplete the ecosystem's capacities to deliver ecosystem services, long-term losses may exceed short-term gains. Land use and policy making should aim at balancing society's needs and preferences, while considering ecosystem service losses as in the long-run, it will be beneficial for all of us if natural ecosystems are preserved and used adequately. Also, there is a need to frame policies like construction of ecological restoration projects in Union Territory (UT) and should be well-implemented to optimize land-use land-cover (LULC) of Jammu & Kashmir (J&K).

REFERENCES

Anderson, J.R., Hardy, E.E., Roach, J.T. and Witmer, R.E. 1976. A land-use and land-cover classification system for use with remote sensor data. US Geological Survey Professional Paper 964, Washington, DC.

Baba, S.H., Wani, M.H., Zargar, B.A. and Bhat, Ishrat, F. 2019. Determinants of land degradation in Jammu and Kashmir: Implications for land governance. *Agricultural Economics Research Review,* **32**(2): 271-28.

Brown, D.G., Pijanowski, B.C. and Duh, J.D. 2000. Modelling the relationships between land use and land cover on private lands in the Upper Midwest, USA. *Journal of Environmental Management,* **59**(4): 247–263.

Burley, T.M. 1961. Land use or land utilization? *Professional Geographer,* **14**(5): 18–20.

Costanza, R., dArge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., Oneill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. and van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. *Nature,* **387**: 253–260.

Daily, Gretchen C., Stephen, Polasky., Joshua, Goldstein., Peter, M. Kareiva., Harold, A. Mooney., Liba, Pejchar., Taylor, H. Ricketts., James, Salzman, and Robert, Shallenberger. 2009. "Ecosystem services in decision-making: time to deliver." *Front. Ecol. Environ.,* **7**(1): 21–28.

David, K., Yetta, G., Agung, F., Sharon, H. and Alison, C. 2016. Land use planning for disaster risk reduction and climate change adaptation: Operationalizing policy and legislation at local levels. *International Journal of Disaster Resilience in the Built Environment*, **7**(2): 158–172.

Diallo, Y., Hu, G. and Wen, X. 2009. Applications of remote sensing in land use/land cover change detection in Puer and Simao Counties, Yunnan Province. *Journal of American Science,* **5**(4): 157–166.

Foody, G.M. 2002. Status of land cover classification accuracy assessment. *Remote Sensing of Environment,* **80**(1): 185–201.

Foley, J.A. *et al.,* 2005. Global consequences of land use. *Science,* **309**(5734): 570.

Hegazy, I.R. and Kaloop, M.R. 2015. Monitoring urban growth and land use change detection with GIS and remote sensing techniques in Daqahlia governorate Egypt. *International Journal of Sustainable Built Environment,* **4**(1): 117–124.

Herold, M., Scepan, J. and Clarke, K.C. 2002. The use of remote sensing and landscape-metrics to describe structures and changes in urban land uses. *Environment and Planning A.,* **34**(8): 1443–1458.

Lacher, T.E. 1998. The spatial nature of conservation and development. *In:* GIS Methodologies for Developing Conservation Strategies. (Eds. B.G. Savitsky and T.E. Lacher) Tropical Forest Recovery and Wildlife Management in Costa Rica. Columbia University Press, New York, pp. 3-12.

Lambin, E.F., Turner, B.L., Geist, H.J., Agbola, S.B., Angelsen, A., Bruce, J.W. *et al.,* 2001. The causes of land-use and land-cover change: Moving beyond the myths. *Global Environmental Change,* **11**(2): 261–269.

Liu, T. and Yang, X. 2015. Monitoring land changes in an urban area using satellite imagery, GIS and landscape metrics. *Applied Geography,* **56**: 42–54.

Lo, C.P. 1986. Applied remote sensing (p. 227). New York: Longman Inc.

Loveland, T.R. and Acevedo, W. 2006. Land cover change in the Eastern United States, US Geological survey.

MA, 2005. Ecosystems and human well-being: Synthesis Report. World Resources Institute, Washington, D.C.

McHarg, I. 1995. Design with Nature. John Wiley and Sons, New York, pp. 208.

Mendoza-Gonzalez, G., Martınez, M., Lithgow, D., PerezMaqueo, O. and Simonin, P. 2012. Land use change and its effects on the value of ecosystem services along the coast of the Gulf of Mexico, *Ecological Economics,* **82:** 23–32.

National Research Council (NRC). 2005. Valuing Ecosystem Services. Towards Better Environmental Decision-Making. Washington, DC: National Academies Press.

Ojima, D.S., Galvin, K.A. and Turner, B.L. 1994. The global impact of land-use change. *Bio Science,* **44**(5): 300.

Roebeling, P., Costa, L., Magalhaes-Filho, L. and Tekken, V. 2013. Ecosystem service value losses from coastal erosion in Europe: historical trends and future projections, *Journal of Coastal Conservation,* **17**(3): 389–395.

Shaw, R. and Banba, M. 2017. Land use management in dis- aster risk reduction: An overview. *In:* M. Banba & R. Shaw (Eds.), Land use management in disaster risk reduction. Disaster risk reduction (methods, approaches and prac- tices). Tokyo: Springer.

Quintas-Soriano, C., Castro, A.J., Castro, H. and Garcı´a-Llorente, M. 2016. Impacts of land use change on ecosystem services and implications for human well-being in Spanish drylands. *Land Use Policy,* **54**: 534–548.

Vihervaara, P., Marjokorpi, A., Kumpula, T., Walls, M. and Kamppinen, M. 2012. Ecosystem services of fast-growing tree plantations: a case study on integrating social valuations with land-use changes in Uruguay, *Forest Policy and Economics,* **14**(1): 58–68.

Wang, Y., Yu, X., He, K., Song, S., Jia, G. and Huang, Z. 2012. Ecosystem services value based on land use change in Huairou reservoir watershed, *Transactions of the Chinese Society of Agricultural Engineering,* **28**(5): 246–251.

Wang, Z., Zhang, B. and Zhang, S. *et al.,* 2006. Changes of land use and of ecosystem service values in Sanjiang Plain, Northeast China, *Environmental Monitoring and Assessment,* **112**(1): 69–91.

Wang, Z., Wang, Z., Zhang, B., Lu, C. and Ren, C. 2015. Impact of land use/land cover changes on ecosystem services in the Nenjiang River Basin, Northeast China. *Ecological Processes,* **4**(11): 015-0036.

Wani, S.A., Shaheen, F.A., Wani, M.H. and Saraf, S.A. 2014. Fodder budgeting in Jammu and Kashmir: Status, issues and policy implications. *The Indian Journal of Animal Sciences,* **84**(1): 54-59.

Wu, D., Liu, J., He, T., Wang, H. and Wang, R. 2009. Profit and loss analysis on ecosystem services value based on land use change in Yellow River Delta," *Transactions of the Chinese Society of Agricultural Engineering,* **25**(8): 256–261.

Xie, G.D., Lu, C.X., Leng, Y.F., Zheng, D. and Li, S.C. 2003. Ecological assets valuation of the Tibetan Plateau. *J. Nat. Res.,* **18**(2): 189–196.

Zhou, H., Xiong, D. and Yang, Z. 2008. Effects of land use change on ecosystem service value in Yuanmou dry-hot valley, *Transactions of the Chinese Society of Agricultural Engineering,* **24**(3): 135–138.

SUPPLEMENTARY MATERIAL

Appendix I: Ecosystem service values of different land use classes from 1960 to 2020 (million dollars)

Ecosystem services	Farm land	Forest land	Builtup/ barren	Marshy land	Grass land	Lakes/water bodies	Total Values
Major land-use classes (1960)							
Climate stability	0.84	7.27	0.00	0.00	0.23	0.03	8.36
Gas regulation	0.47	9.43	0.00	0.00	0.20	0.00	10.10
Soil generation & fertility	1.37	10.50	0.01	0.00	0.49	0.00	12.37
Water regulation and supply	0.56	8.62	0.02	0.00	0.20	1.39	10.78
Waste treatment	1.54	3.53	0.01	0.00	0.33	1.24	6.64
Food production	0.94	0.27	0.01	0.00	0.08	0.01	1.29
Biodiversity protection	0.67	8.78	0.19	0.00	0.27	0.17	10.07
Recreation & Cultural	0.01	3.45	0.01	0.00	0.01	0.30	3.77
Raw materials	0.09	7.00	0.00	0.00	0.01	0.00	7.11
Total	6.48	58.84	0.23	0.00	1.82	3.13	70.50
Major land-use classes (1970)							
Climate stability	0.85	7.22	0.00	0.00	0.22	0.03	8.32
Gas regulation	0.48	9.36	0.00	0.00	0.19	0.00	10.03
Soil generation & fertility	1.40	10.42	0.01	0.00	0.47	0.00	12.31
Water regulation and supply	0.58	8.55	0.02	0.00	0.19	1.27	10.61
Waste treatment	1.57	3.50	0.01	0.00	0.32	1.13	6.53
Food production	0.96	0.27	0.01	0.00	0.07	0.01	1.31
Biodiversity protection	0.68	8.71	0.19	0.00	0.26	0.16	10.00
Recreation & Cultural	0.01	3.42	0.01	0.00	0.01	0.27	3.72
Raw materials	0.10	6.95	0.00	0.00	0.01	0.00	7.06
Total	6.63	58.41	0.23	0.00	1.76	2.87	69.90

Appendix II: Ecosystem service values of different land use classes from 1960 to 2020 (million dollars)

Ecosystem services	Farm land	Forest land	Built up/ barren	Marshy land	Grass land	Lakes/water bodies	Total Values
Major land-use classes (1980)							
Climate stability	0.86	7.23	0.00	0.00	0.20	0.03	8.31
Gas regulation	0.48	9.37	0.00	0.00	0.18	0.00	10.03
Soil generation & fertility	1.41	10.44	0.01	0.00	0.44	0.00	12.30
Water regulation and supply	0.58	8.56	0.02	0.00	0.18	1.16	10.50
Waste treatment	1.58	3.51	0.01	0.00	0.30	1.03	6.42
Food production	0.96	0.27	0.01	0.00	0.07	0.01	1.31
Biodiversity protection	0.68	8.72	0.19	0.00	0.25	0.14	9.99

Recreation & Cultural	0.01	3.43	0.01	0.00	0.01	0.25	3.70
Raw materials	0.10	6.96	0.00	0.00	0.01	0.00	7.07
Total	6.66	58.48	0.24	0.00	1.64	2.61	69.63
Major land use classes (1990)							
Climate stability	0.86	7.23	0.00	0.00	0.18	0.02	8.29
Gas regulation	0.49	9.37	0.00	0.00	0.16	0.00	10.01
Soil generation & fertility	1.42	10.44	0.01	0.00	0.39	0.00	12.26
Water regulation and supply	0.58	8.56	0.02	0.00	0.16	1.09	10.41
Waste treatment	1.59	3.51	0.01	0.00	0.26	0.97	6.34
Food production	0.97	0.27	0.01	0.00	0.06	0.01	1.31
Biodiversity protection	0.69	8.72	0.20	0.00	0.22	0.13	9.96
Recreation & Cultural	0.01	3.43	0.01	0.00	0.01	0.23	3.68
Raw materials	0.10	6.96	0.00	0.00	0.01	0.00	7.07
Total	6.71	58.48	0.25	0.00	1.45	2.45	69.33

Appendix III: Ecosystem service values of different land use classes from 1960 to 2020 (million dollars)

Ecosystem services	Farm land	Forest land	Built up/ barren	Marshy land	Grass land	Lakes/water bodies	Total Values
Major land use classes (2000)							
Climate stability	0.87	7.24	0.00	0.00	0.18	0.02	8.31
Gas regulation	0.49	9.38	0.00	0.00	0.16	0.00	10.03
Soil generation & fertility	1.43	10.46	0.01	0.00	0.39	0.00	12.28
Water regulation and supply	0.59	8.58	0.02	0.00	0.16	1.04	10.39
Waste treatment	1.60	3.51	0.01	0.00	0.26	0.93	6.31
Food production	0.98	0.27	0.01	0.00	0.06	0.01	1.32
Biodiversity protection	0.69	8.74	0.20	0.00	0.22	0.13	9.98
Recreation & Cultural	0.01	3.43	0.01	0.00	0.01	0.22	3.68
Raw materials	0.10	6.97	0.00	0.00	0.01	0.00	7.08
Total	6.76	58.58	0.24	0.00	1.43	2.35	69.37
Major land use classes (2010)							
Climate stability	0.89	7.25	0.00	0.09	0.17	0.02	8.41
Gas regulation	0.50	9.40	0.00	0.01	0.15	0.00	10.05
Soil generation & fertility	1.45	10.47	0.01	0.01	0.36	0.00	12.31
Water regulation and supply	0.60	8.59	0.02	0.08	0.15	0.93	10.36
Waste treatment	1.63	3.52	0.01	0.09	0.24	0.83	6.32
Food production	1.00	0.27	0.01	0.00	0.06	0.00	1.33
Biodiversity protection	0.71	8.75	0.19	0.01	0.20	0.11	9.98
Recreation & Cultural	0.01	3.44	0.01	0.02	0.01	0.20	3.68
Raw materials	0.10	6.98	0.00	0.00	0.01	0.00	7.09
Total	6.88	58.67	0.24	0.23	1.34	2.10	69.45

Appendix IV: Ecosystem service values of different land use classes from 1960 to 2020 (million dollars)

Ecosystem services	Farm land	Forest land	Builtup/ barren	Marshy land	Grass land	Lakes/water bodies	Total Values
Major land use classes (2020)							
Climate stability	0.89	7.25	0.00	0.10	0.17	0.02	8.44
Gas regulation	0.50	9.40	0.00	0.01	0.15	0.00	10.07
Soil generation & fertility	1.46	10.48	0.01	0.01	0.36	0.00	12.33
Water regulation and supply	0.60	8.60	0.02	0.09	0.15	0.82	10.27
Waste treatment	1.64	3.52	0.01	0.11	0.24	0.73	6.25
Food production	1.00	0.27	0.01	0.00	0.06	0.00	1.34
Biodiversity protection	0.71	8.76	0.19	0.01	0.20	0.10	9.98
Recreation & Cultural	0.01	3.44	0.01	0.03	0.01	0.17	3.66
Raw materials	0.10	6.99	0.00	0.00	0.01	0.00	7.10
Total	6.92	58.71	0.23	0.28	1.35	1.84	69.33