Pak. J. Bot., 53(5): 1801-1806, 2021. DOI: http://dx.doi.org/10.30848/PJB2021-5(18)

ECONOMIC VALUATION OF ECOSYSTEM SERVICES IN ALPINE PASTURES OF WESTERN HIMALAYAS: A CASE STUDY OF KAGHAN VALLEY, PAKISTAN

ANWAR ALI[1], MUHAMMAD AYAZ KHAN[2], MUHAMMAD IRFAN ASHRAF[3*] AND MUHAMMAD ARIF GOHEER[4]

[1]Director, Forestry Research Division, Pakistan Forest Institute, Peshawar, Pakistan
[2]National Project Manager, Sustainable Forest Management Project, Ministry of Climate Change, Islamabad, Pakistan
[3]Assistant Professor, Department of Forestry & Range Management, PMAS Arid Agriculture University, Rawalpindi, Pakistan
[4]PSO/Head Agriculture, Forestry & Land Use Section, Global Change Impact Studies Center, Ministry of Climate Change, Islamabad, Pakistan
[*]Corresponding author's email: drirfancanada@gmail.com ; irfanashraf@uaar.edu.pk

Abstract

Alpine pastures of Kaghan valley are one of the most productive grazing lands in Pakistan. These pastures provide many ecosystem services which are important for livelihood of the local people, nomadic graziers and economy of the country. Alpine pastures of Kaghan spread over an area of 71,939 ha constituting 28% of the total area of the valley. Present study was conducted to quantify the economic value of provisioning ecosystem services i.e. forage production in the study area. The data was collected from 40 fenced experimental plots laid out at eight sites during June-September 2019. Livestock population was estimated through a field survey by interviewing 485 graziers. Results indicated that 65% of the vegetation was comprised of forbs, 24% grasses and 11% was shrubs. Average dry weight of forage was calculated as 2,900 kg ha^{-1}. Total forage production in the grazeable areas of alpine pastures of Kaghan Valley was estimated as 146,035 tonnes per year. The average price of air-dried forage in the area was Rs. 12,000 per tonne or US$ 74.48 per tonne. Therefore, total economic value of forage production in the grazeable areas of Kaghan valley was Rs. 1,752 million or US$ 10.87 million per year. Total livestock population of the Alpine pastures of Kaghan valley was estimated as 163,550 animals. About 56% of the livestock grazing in the pastures comprised of goats, 39% sheep, 2% cows, 2% horses, 1% donkeys, 0.4% mules and 0.3% buffaloes. It was concluded that the alpine pastures of Kaghan valley are very productive and have a key role in the local economy. Sustainable management of alpine pastures will ensure the continuity of valuable ecosystem services.

Key words: Alpine, Pasture, Forage, Ecosystem services, Livestock, Grazing, Range.

Introduction

Ecosystem services are conditions, progressions or productions of natural systems that benefit humans, either directly or indirectly as inputs into the production of other goods and services that enhance social welfare. These services attempt to transform the benefits from nature into economic terms. For instance, the pollination of agriculture crops and forest trees bestowed by insects and birds contributes to food production is a valuable ecosystem service to humans (Johnston, 2018).

The Millennium Ecosystem Assessment identified four major categories of ecosystem services: provisioning, regulating, cultural and supporting services (Reid *et al*., 2005). The provisioning services are material things produced by nature such as food, water, timber and fuel whereas regulating services make life possible on the earth by controlling various processes for example climate system, hydrological cycle, pollination and decomposition. The cultural services are intangible values that substantially contribute to human wellbeing such as aesthetic gratification, recreation, spiritual fantasies intellectual and social development whereas supporting services of ecosystem allow basic life form to sustain e.g., nutrient cycling, soil formation, photosynthesis and primary production (Reid *et al*., 2005).

The economic valuation of ecosystem services has recently gained momentum due to its critical connection with wellbeing of human society (Lienhoop *et al*., 2015). Prosperity and poverty reduction of the mountainous communities depend on maintaining the flow of benefits from ecosystems (Rasul *et al*., 2011). Further, the conservation and sustainable development of natural ecosystems can receive proper allocation in public investment when they have sound economic justifications (Sukhdev *et al*., 2010). Economic valuation is also essential for designing payments for ecosystem services (PES) which has the potential to create new financing opportunities for conservations and sustainable management of ecosystems to promote green economy. Assessment of ecosystem services is valuing nature. It provides a foundation for sustainable development and stipulates important information for resource conservation and management. This is an emerging sector and many ecosystem services do not have a market value yet and are ignored during economic valuation (Ortega *et al*., 2014).

The mountain ecosystems of the Hindu Kush Himalaya (HKH) provide diverse ecosystem services to one fourth of the global human population. Alpine pastures of Western Himalayan region deliver many valuable ecosystem services which are not only important for livelihood of the rural mountain communities but also for food security and socio-economic uplift of downstream areas (Khan, 2012). These ecosystem services include sustaining fresh water supply to the downstream areas for irrigation and hydropower generation, soil conservation, habitat for biodiversity, carbon sequestration and tourism. Despite these vital services, alpine pastures have been offered

little attention by the policy makers and ignored in the development agenda due to insufficient information about the economic value of these ecosystem services (Rasul *et al*., 2011). These services are taken for granted, not included in the calculation of Gross Domestic Product (GDP) and are rarely acknowledged in government policy. Resultantly, these ecosystems are under-valued and under-estimated. Consequently, natural resources of alpine ecosystems are being degraded due to anthropogenic factors and no efforts are being made for their conservation and sustainable management (Shaheen *et al*., 2017).

Alpine pastures are extended over an area of 1.375 million ha constituting 1.6% of the total land area of Pakistan. Alpine pastures of Kaghan Valley are important natural ecosystems which provide a wide range of services, having significant social, economic and ecological values. These pastures are attractive destination for graziers and tourists. Traditionally, continuous seasonal grazing is practiced by the local as well as nomadic graziers (Rahim *et al*., 2016). During early summer, livestock are driven up to alpine pastures which continuously graze untill late autumn.

Present study attempted to recognize and quantify the economic value of the important provisioning ecosystem services i.e. forage production in Kaghan valley. This study provides essential information for policy formulation and planning regarding conservation and sustainable development of alpine pastures in Pakistan.

Material and Methods

Description of the study area: The focus of the present study was Kaghan valley of district Mansehra. The valley is considered to be a jewel amongst the beautiful valleys and is located in the North West mountainous region of Pakistan. The study area is a unique combination of sub-tropical chir-pine, moist temperate, dry temperate, sub-alpine birch forests and alpine scrub. In Kaghan valley, 71,939 ha area is under alpine pastures (Bukhari *et al*., 2012). Kaghan valley is situated between latitudes 34°14′ and 35 °11′ N and longitudes 72° 49′ to 74° 08′ E, located 250 kilometers away from the capital city Islamabad and is a popular destination for local and international tourists.

Generally, the climate of Kaghan is warm and temperate with a significant rainfall throughout the year. The conventional Köppen-Geiger climate classification of the region is Cfb, which represents temperate climate without dry season and warm summer. The coldest month averaging above 0°C, the annual average temperature is 12.6°C and the total annual rainfall is 893 mm (Anon., 2020). The average elevation of Kaghan valley is 2026 meters above sea level (Awan *et al*., 2011).

Grazing season: The diurnal mean temperature of 6°C and above defines the growing season for agricultural crops (Arsvoll, 1995). The growing season in Kaghan starts around middle of June and lasts by the end of September with mean daily temperature around 10°C. It was found during the field survey that most of the pastures are covered with snow up to first week of June. Thus the growing season in pastures of Kaghan consists of about 100 days. There is a slight elongation in the growing season due to climate change in these high hill areas as compared to the past. An increase of 0.78°C has been recorded in the mean annual temperature of these areas during 1961-2000 (Bukhari and Bajwa, 2012).

Grazing pattern: The schedule and duration of grazing were explored by collecting information from local people as well as personal observation. The sources of drinking water have critical connection with grazing pattern. Therefore, the availability of water and the movement pattern of animals were also watched.

Vegetation composition: The vegetation was identified for three categories: grasses, forbs and shrubs. The composition of vegetation was estimated measuring the dry weight of the vegetation harvested from the fenced sample plots. The sample plot was 2 m long and 2 m wide and in total 40 sample plots were laid out at eight sites in the study area.

Assessment of forage productivity: Eight pastures (sites) were randomly selected for estimation of forage production in alpine pastures of Kaghan valley. Five fenced sample plots (2x2 meter) were established in May-June, 2019 at each site to protect the grass from grazing. Therefore, a total of 40 fenced sample plots (cages) were established for assessment of pasture productivity. GPS-coordinates and pictures of each cage were recorded. The list of experimental sites is provided in Table 1 and shown in Fig. 1.

Table 1. List of experimental sites and their GPS coordinates in the study area.

Site No.	Site name	GPS coordinates		Elevation (m)
		X	Y	
1.	Basal	73.935843	35.048549	3240
2.	Barhwai Nala	73.874122	34.924344	2994
3.	Barhwai	73.861547	34.939316	2964
4.	Lalazar	73.767165	34.927362	2975
5.	Batakundi	73.754528	34.933416	2659
6.	Paya Seri	73.483539	34.616985	3053
7.	Kund	73.296593	34.575971	2444
8.	Kund Bala	73.293869	34.578081	2469

Forage production was estimated at the end of grazing season in September 2019. The grass inside the fenced sample plots was harvested and fresh biomass was weighed by digital balance. These samples were put in labeled bags and brought to Pakistan Forest Institute Laboratory for determination of air-dry weight of the grass. The air-dried forage production was calculated in tonnes per hectare (Hussain *et al*., 2015). At each site one fenced sample plot was harvested three times to compare the forage productivity of single cut with multiple cuts. In case of single cut, the plot was cut on 30th September i.e. after 120 days of fencing. In case of multiple cuts, the plot was cut after every 40 days i.e. first cut on 10th July, second cut on 20th August and third cut was on 30th September.

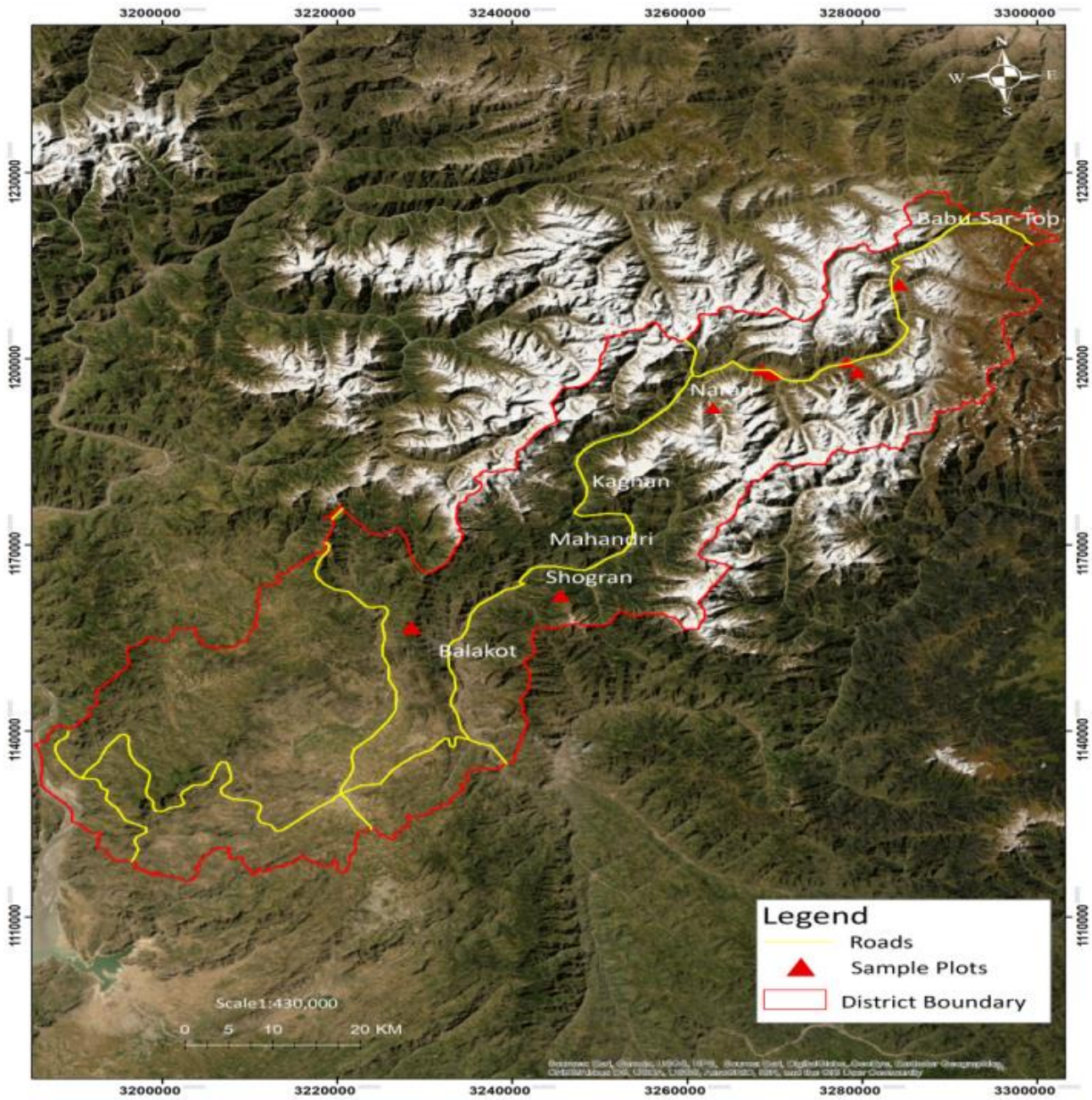

Fig. 1. Location of Sample Plots in the study area.

Estimation of livestock population: A field survey was conducted to determine the number of livestock grazing in the alpine pastures of Kaghan Valley during July-September 2019. The data was collected from 485 graizers in the valley. The collected data was cross checked with the heads of graziers called 'Muqaddam' who collects grazing fee from the graziers and interacts with landowners on their behalf. A total of 10 Muqaddams were interviewed independently. The graziers were initially hesitant to disclose actual number of animals. However, efforts were made to socialize with them and win their confidence to know actual number of livestock. The data was recorded using a proforma designed for the study. Socio-economic data on different aspects of the grazing patterns was collected from the individual graziers including both nomads and semi nomads.

Economic valuation of the forage: Direct use value method was adopted to estimate the economic value of forage production in Kaghan (Turner *et al*., 2004). The price of the forage was obtained by interviewing local graziers and community members. For this purpose, five graziers/community members were interviewed at each of the eight pasture sites. Thus, a total of 40 respondents were interviewed to know market price of forage. The average price was taken for compuation of forage value.

Results and Discussion

Grazing pattern: It was observed during field visits that the nomads usually reach the pastures in the third or last week of June and stay there till last week of September. However, some of them start back journey in second or third week of September. They travel for 15 to 30 days on

either way to reach their destination. Some of them follow main road while others traverse through forests or rangelands. The semi-nomads start arriving at pastures during last week of June and stay till the middle of September. They travel 2-7 days on foot to reach their destinations on either way.

The graizers stay in pastures for about three months. All the animals except horses, mules and donkeys are driven to the grazing areas in the morning and brought back to the huts in the evening. The livestock graze freely for 10-12 hours daily whereas the horses, mules and donkeys may stay in pastures as long as 24 hours. The horses, mules or donkeys are brought to the huts only when they are required for any service such as packing or riding. This pattern of grazing sometimes results in over-grazing of certain areas and underutilization of other areas.

It was observed that sufficient drinking water was available in these pastures in the form of springs, snow-melt water in depression and streams. Free ranging livestock drink water during grazing without any restriction. The graziers also take care of watering for livestock on daily basis. For this purpose, the livestock were driven to watering points twice a day in the morning and in the afternoon.

Vegetation composition: The vegetation of alpine pastures of Kaghan valley consisted of grasses, forbs and shrubs. The vegetation was composed of 24.38% grasses, 65.00% forbs, and 10.63% shrubs (Table 2). Major grass species were *Agrotis gigantean, Carex* spp., *Aira* spp., *Lolium* spp., *Poa alpine, Poa annua* and *Pennisetum lanatum*. Dominant forb species were *Arenaia filiformiss, Chenopodium album, Astragalus leucocephalus, Cerastium cerastioides,* and *Dianthus crinitus*. Major shrub species included *Artemisia vulgaris, Ephedra procera* and *Sambucus nigitiana.* Similar findings have been reported by Rahman *et al*., (2021).

Table 2. Composition of range vegetation in the study area.

Site No.	Site name	Grasses (%)	Forbs (%)	Shrubs (%)
1.	Basal	26	68	6
2.	Barhwai Nala	24	65	11
3.	Barhwai Nala	27	64	9
4.	Lalazar	26	64	10
5.	Batakundi	23	65	12
6.	Paya Seri	22	63	15
7.	Kund	22	68	10
8.	Kund Bala	25	63	12
	Mean	**24.38**	**65.00**	**10.63**

Forage production: Mean fresh weight of forage in the alpine pastures was 7,000 kg ha^{-1} (Table 3), whereas the air-dry weight was found to be 2,900 kg ha^{-1} (Table 4). The highest forage production was recorded in Basal and Kund pastures with mean biomass production of 0.90 kg m^{-2} and the lowest was recoded at Lalazar as 0.35 kg m^{-2}. This indicated that the alpine pastures of the valley are enormously productive.

Table 3. Fresh weight of grasses collected from experimental sites.

Site No.	Site name	Fresh weight (kg m^{-2})					
		Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
1.	Basal	1.730	0.985	1.146	0.450	0.170	0.90
2.	Barhwai Nala	0.905	0.565	0.760	0.825	0.605	0.73
3.	Barhwai Nala	0.790	0.110	0.085	0.085	1.435	0.50
4.	Lalazar	0.645	0.180	0.230	0.236	0.435	0.35
5.	Batakundi	2.625	0.250	0.360	0.245	0.690	0.83
6.	Paya Seri	1.285	0.930	0.795	0.240	0.620	0.77
7.	Kund	1.040	1.545	0.495	0.330	1.060	0.89
8.	Kund Bala	1.200	0.625	0.485	0.340	0.435	0.62
Mean fresh weight (kg m^{-2})							0.70
Mean biomass (kg ha^{-1})							7,000

Table 4. Dry weight of grass collected from experimental sites.

Site No.	Site name	Dry weight (kg m^{-2})					
		Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
1.	Basal	0.45	0.325	0.44	0.16	0.070	0.29
2.	Barhwai Nala	0.525	0.260	0.330	0.310	0.260	0.34
3.	Barhwai Nala	0.235	0.08	0.03	0.045	0.445	0.17
4.	Lalazar	0.275	0.09	0.95	0.135	0.145	0.32
5.	Batakundi	0.59	0.17	0.165	0.140	0.435	0.30
6.	Paya Seri	0.355	0.375	0.335	0.090	0.435	0.32
7.	Kund	0.365	0.61	0.21	0.095	0.495	0.36
8.	Kund Bala	0.47	0.26	0.17	0.110	0.200	0.24
Mean dry weight (kg m^{-2})							0.29
Biomass (Kg ha^{-1})							2,900
Biomass (Tonnes ha^{-1})							2.90

Table 5. Comparison between single cut and multiple cuts.

Site No.	Site name	Dry weight (kg m^{-2})	
		Multiple cuts	Single cut
1.	Basal	0.4500	0.2487
2.	Barhwai	0.5250	0.2900
3.	Barhwai Nala	0.2350	0.1500
4.	Lalazar	0.2750	0.3300
5.	Batakundi	0.5900	0.2275
6.	Paya Seri	0.3550	0.3087
7.	Kund	0.3650	0.3525
8.	Kund Bala	0.4700	0.1850
Mean (kg m^{-2})		0.4081	0.2616
Mean biomass (Kg ha^{-1})		4,081	2,616

Comparison between single cut and multiple cuts: The statistical test of significance showed a significant difference between forage production of single and multiple cuts at eight sites (Table 5). Average air-dry biomass for single cut was recorded as 2,616 Kg ha^{-1} whereas this productivity was 4,081 Kg ha^{-1} for multiple cuts which were cut three times during July to September. This indicated that the pastures have the potential to be grazed three times during a grazing season.

Forage production in the valley: Average forage production (air-dry) was 2.90 ton ha^{-1} (Table 4). The total area classified as alpine pasture in Kaghan valley was estimated as 71,939 ha (Bukhari *et al*., 2012). However, it was observed during field survey that the entire area was not accessible for grazing animals due to its unfavorable topographical features and vegetation patterns. Due to lack of accurate data, it was estimated through observation that about 30% area is not accessible for grazing animals (Sardar, 1997). Hence the grazeable area in the valley was estimated as 50,357 ha. Therefore, the total forage production in the grazeable areas of alpine pastures of Kaghan Valley was estimated at 146,035 tonnes per year.

Economic value of the forage production: The average price of air-dried forage in the area was Rs. 12,000 per tonne or US$ 74.48 per tonne (conversion factor: 1US$= 161.13 PKR). Accordingly, the total economic value of forage production (146,035 tonnes) in the grazeable areas of Kaghan valley was estimated as Rs. 1,752 million or US$ 10.87 million per year.

Estimation of grazing livestock population in pastures: Results of field survey indicated 485 graziers in 10 different pasture localities (Tables 7 and 8). Two types of graiziers were found grazing their animals in the pastures viz. nomadic and semi-nomadics. Semi-nomads were the graziers who come from other parts of Kaghan Valley and the adjoining areas such as Balakot, Kohistan and Chilas and spend their summers in alpine pastures. On the other, nomadic graziers come from Rawalpindi, Hassanabadal, Haripur, Attock, Taxila, Chakwal while some transitory graziers come from Afghanistan. They spend their winter in scrub zone of Attock, Rawalpindi and Haripur districts, start their journey in June and reach pastures of Kaghan in July. The type of graziers with presence percentage found in Kaghan Valley during summer season of 2019 is given in Table 6.

Total population of livestock grazing in the pastures was estimated as 163,550 animals. It was observed that the pasture of Gattidas experienced more grazing pressure due to high number of graziers i.e. 282 with average flock population of 400 and total of 112,800 livestock heads. Similarly, pasture of Paya hosted the least number of graziers due to tourism activities.

Table 6. Results of t-test assuming equal variance.

Mean	Variance	Samples	Pooled variance	df	t Stat	P(T<=t) one-tail	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail	
Multiple cuts	0.408	0.014	8	0.010	14	2.928	0.005	1.761	0.011	2.144
Single cut	0.261	0.005	8							

Alpha (α: 0.05)

Table 7. Grazier's types and count in the study area.

Grazier type	Number of graziers	Percentage
Nomadic (Pakistani)	57	12
Nomadic (Afghanistan)	50	10
Semi-nomadic (local & non-local)	378	78
Total	**485**	**100**

Table 8. Livestock population grazing in Kaghan valley.

Site No.	Site	No. of graziers	Number of livestock heads
1.	Gadtidas	282	112,800
2.	Dodhipat	39	9750
3.	Manoor gali	7	1750
4.	Patandas	15	3750
5.	Paya	3	750
6.	Jheel Saifulmalook	20	5000
7.	Kach Gali	7	1750
8.	Basal	55	13750
9.	Jhalkad	42	10500
10.	Bans Baik	15	3750
	Total	**485**	**163,550**

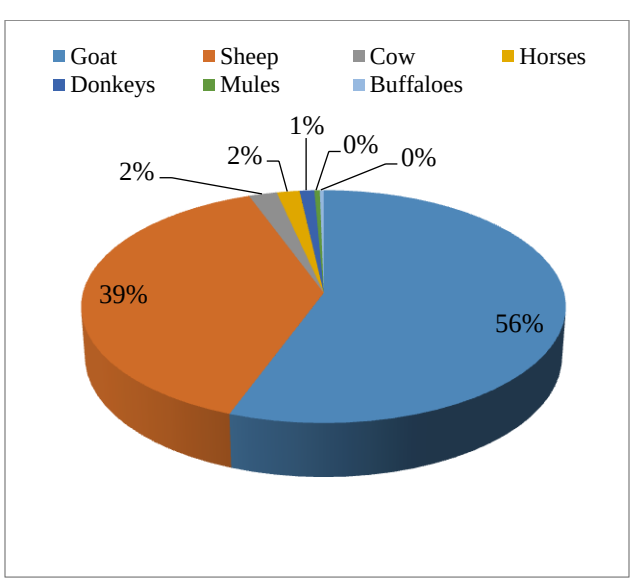

Fig. 2. Livestock composition in the study area by animal type.

Livestock composition: Results of the survey showed that 56% of the livestock grazing in the pastures comprised of goats, 39% sheep, 2% cows, 2% horses, 1% donkeys, 0.4 mules and 0.3% were buffaloes (Fig. 2). Local graziers bring all kinds of livestock for grazing while nomadic graziers bring mixed flocks of small ruminants (Sardar, 1997). Donkeys and mules also accompany the flocks which are used as pack animals by the graziers.

Conclusion and Recommendations

Alpine pastures of Kaghan Valley were found to be the most productive pastures of Pakistan. About 65% of the vegetation of alpine pastures of Kaghan comprised of forbs, 24% grasses and 11% were shrubs. Average dry weight of forage was determined at 2,900 kg ha^{-1}. About 70% area of the pastures was grazed by livestock. Total forage production in alpine pastures of Kaghan Valley was estimated to be 146,035 tonnes per year. There was a significant difference between forage production of single cut and multiple cuts. Average air-dry biomass for single cut was recorded as 2,616 kg ha^{-1} whereas this productivity was 4,081 kg ha^{-1} for multiple cuts (three times during JulySeptember). This indicated that the alpine pastures have the potential to be grazed three times during a grazing season. The average price of air-dried forage in the area was Rs. 12,000 per tonne or US$ 74.48 per tonne. Total economic value of forage production (146,035 tonnes) in the grazeable areas of Kaghan valley was estimated as Rs. 1,752 million or US$ 10.87 million per year.

Alpine pastures of Kaghan valley have a significant contribution in the local economy. Sustainable management of alpine pastures will ensure the continuity of valuable ecosystem services. A special focus should be on the conservation and rehabilitation of alpine pastures of Kaghan Valley. The economic contribution of these areas must be properly acknowledged and sufficient resources should be allocated for sustainable management of these areas. The conversion of these pastures to cropping land may be discouraged to ensure sustainable livelihood for already marginalized section of society i.e. nomadic and semi nomadic graziers. There is also a need to introduce a rotational grazing system in the area for restoration of the ecosystem.

Acknowledgement

This research study received financial support from the Sustainable Forest Management Project- A joint venture of the GEF, UNDP and Ministry of Climate Change, Government of Pakistan.

References

Anonymous. 2020. Climate-data. Kaghan Climate. Available at https://en.climate- data.org/asia/pakistan/khyber-pakhtunkhwa/kaghan-199580/ (accessed 17 January 2021).

Awan, M.R., Z. Iqbal, S.M. Shah, Z. Jamal, G. Jan, M. Afzal, A. Majid and A. Gul. 2011. Studies on traditional knowledge of economically important plants of Kaghan Valley, Mansehra District, Pakistan. *J. Med. Plant Res.*, 5(16): 3958-3967.

Bukhari, S.S.B. and G.A. Bajwa. 2012. Development of national response strategy to combat impacts of climate change on forest of Pakistan. Peshawar: Pakistan Forest Institute, Peshwar, Pakistan.

Bukhari, S.S.B. A. Haider and M.T. Laeeq. 2012. Landcover Atlas of Pakistan, Pakistan Forest Institute, Peshawar, Pakistan.

Hussain, Z., S.N. Mirza, M.I. Ashraf and S.M. Nizami. 2015. Grassland productivity and carrying capacity of Deosai National Park, Gilgit-Baltistan. *J. Agri. Res.,* 53(3): 437-451.

Johnston, R.J. 2018. Ecosystem services. Encyclopedia Britannica. Available online at https://www.britannica.com/science/ecosystem-services. (accessed 17 February 2021).

Khan, S.R. 2012. *Linking Conservation with Sustainable Mountain Livelihoods: A Case Study of Northern Pakistan.* A Ph.D. thesis submitted to the faculty of graduate studies of the University of Manitoba. 385 p. Available online at https://www.umanitoba.ca/institutes/natural_resources/Left-Hand_%20Column/theses/PhD%20Thesis%20Khan%20SR%202012.pdf (accessed 17 January 2021)

Lienhoop, N., B. Bartkowski and B. Hansjürgens. 2015. Informing biodiversity policy: The role of economic valuation, deliberative institutions and deliberative monetary valuation. *Environ. Sci. & Policy*, 54: 522-32.

Ortega, T.R., E.O. Rozas, R.R. Bosch, M. Tichit, B.M. Lopez and A. Bernues. 2014. Applying the ecosystem services framework to pasture-based livestock farming systems in Europe. *Animal*, 8(8): 1361-1372.

Rahim, I., K. Khurshid, H. Rueff, M. Nafees and D. Maselli. 2016. Crop encroachment over alpine pastures in the Himalayan Mountains of northern Pakistan: Socio-economic implications for pastoral communities. *Rang. Manag. & Agrofor.*, 37(1): 93-97.

Rahman, I., A. Afzal, E.F. Abdallah, Z. Iqbal, A. Alqarawi, A. Hashem, E.S. Calixto, N. Ali and R. Asmarayani. 2021. Composition of plant communities driven by environmental gradients in alpine pastures and cold desert of northwestern Himalaya, Pakistan. *Pak. J. Bot.* 53(2): 655-664.

Rasul, G., N. Chettri and E. Sharma. 2011. Framework for Valuing Ecosystem Services in the Himalayas. International Centre for Integrated Mountain Development, Kathmandu, Nepal.

Reid, W.V., H.A. Mooney, A. Cropper, D. Capistrano, S.R. Carpenter, K. Chopra, P. Dasgupta, T. Dietz, A.K. Duraiappah, R. Hassan, R. Kasperson, R. Leemans, R.M. May, A.J. McMichael, P. Pingali, C. Samper, R. Scholes, R.T. Watson, A.H. Zakri and M.B. Zurek. 2005. *Ecosystems and human well-being - Synthesis: A Report of the Millennium Ecosystem Assessment*. Island Press. Washington DC USA.

Sardar, M.R. 1997. Indigenous Production and Utilization Systems in the High Altitude Alpine Pasture, Saiful Maluk (NWFP) Pakistan. Pakistan Forest Institute, Peshawar, Pakistan.

Shaheen, H., S. Aziz and M.E.U.I. Dar. 2017. Ecosystem services and structure of western Himalayan temperate forests stands in Neelum valley, Pakistan. *Pak. J. Bot.*, 49(2): 707-714.

Sukhdev, P., H. Wittmer, C. Schröter-Schlaack, C. Nesshöver, J. Bishop, P. Brink, H. Gundimeda, P. Kumar and B. Simmons. 2010. The economics of ecosystems and biodiversity: mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB (No. 333.95 E19). UNEP, Ginebra (Suiza). Available at www.teebweb.org/LinkClick.aspx?fileticket=bYhDohL_TuM%3d&tabid=1278&mid=2357 (accessed 17 January 2021)

Turner, R.K., S. Georgiou, R. Clark, R. Brouwer and J. Burke. 2004. Economic valuation of water resources in agriculture: from the sectoral to a functional perspective of natural resource management (Vol. 27). FAO, Rome, Italy.

Arsvoll, K. 1995. *Agriculture in Norway*. pp. 3-5, In: Mountain Grassland Biodiversity and Agriculture Value. FAO, Rome, Italy.

(Received for publication 27 October 2019)