Dynamics of livestock population diversity in Punjab Province of Pakistan

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Abstract

Livestock is an integral part of rural household economy in Pakistan providing 35% of income to eight million rural households. The contribution of livestock sector in agricultural GDP of Pakistan is 56%. The Pakistan stands 4th in global milk producing market. Therefore, it is important to identify the livestock population density and diversity index at regional and sub regional setting and changes thereby occurring in last forty years. Data of all the districts of Punjab in last four livestock census for the year 1976, 1986, 1996 and 2006 were used for calculating variation in density and changes in diversity in different time periods. Simpson biodiversity Index was used for calculating livestock population diversity index on the basis of time and space. Livestock density is less than 1 animal per ha in Punjab. However, in 10 irrigated districts buffalo and goat density is greater than 1.5 heads per hectare. On the basis of K dominance analysis, goats were dominant in 17 where as Buffalo dominated in 18 districts of Punjab. The similarity index of livestock is high in Punjab (80%). Simpson reciprocal diversity index ranges in between three to five in various districts representing medium diversity. Its value showed decreasing trend in livestock diversity in Punjab over the last forty years. Livestock population in Punjab and its districts was significantly aggregated (Chi sq. p< 0.00). Government, policy makers and planners may focus on conservation of livestock diversity in Punjab.

Keywords: Livestock, Punjab, Density, Diversity, Simpson Index.

Introduction

Agriculture is the mainstay of rural economy in Pakistan contributing 19.8 percent in GDP and employing 42.3 percent labor force (GoP 2015-16). Livestock is the dominant sector of Pakistan's agriculture contributing 58.6 percent in agricultural value added and 11.7 percent in GDP. Livestock is the asset of poor rural population living below 1$ per day [1]. Pakistan's wealth of livestock sector include cattle, buffalo, sheep, goat, camel, horses, mules, asses and poultry accounting for 42.8, 36.6, 29.8, 70.3, 1, 0.4, 0.2, 5.1 and 1016 million heads respectively during 2015-16. The contribution of these species in national economy is in terms of milk, beef, mutton, poultry meat, wool, hair, bones, fats, blood, eggs, hides and skins which account for 43818, 2017, 686, 1170, 45.1, 26.5, 852.3, 271, 66.1 thousand tones and 16188, 15.9 and 54.3 million numbers respectively. The contribution of cattle and buffalo in gross milk production of the country is 36 and 61 percent respectively.

Biodiversity in agriculture sector may be defined as all kind of biodiversity within and among species present in household livestock production system [2] due to human efforts [3] or result of some evolutionary process. The Food and Agriculture Organization of the United Nations [4] defines "breed" as: "either a sub-specific group of domestic livestock with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups within the same species; or a group for which geographical and/or cultural separation from phenotypically similar groups has led to acceptance of its separate identity".

Punjab is major the contributor in livestock of Pakistan. The contribution of Punjab in population of cattle, buffaloes, sheep, goats, camels, horses, mules, asses and poultry is 49, 65, 24, 37, 22, 47, 41, 52 and 35 percent respectively [5].

Feed resource base is the major determinant of livestock density in the area. Livestock productivity is low in Punjab due to limited feed resource base [6]. More the feed resources mean more the livestock density. Using nonconventional feed resources can improve livestock productivity in Pakistan [7]. Rainfall and temperature are also important in determining livestock density in any area [8].

Diversity is combination of richness, abundance and evenness. Richness refers to number of species, abundance deals with number of individuals of given specie in a population and evenness refers to relative abundance of all species in a population [9]. Diversity is life on this planet and is important is production of food for the mankind. Livestock biodiversity is important in enhancing livestock production in the country.

Livestock is considered as wealth of the farmer. More livestock in a farm household mean less poverty as it provides daily balanced nutrition to the farm household and also support in unforeseen in the farmers life. The richness and abundance of livestock in administrative boundaries represent the wealth of that area. Simpson diversity index is used to determine the richness and evenness of livestock in different administrative boundaries of Punjab. The

more value of index represents more wealth. Livestock density and diversity is used to indicate the livestock assets in different districts of Punjab.

The objective of the study is to identify density of livestock in different district of Punjab and to understand changes in biodiversity of livestock in historical perspective. This introductory section is followed by methodology, results and discussions, conclusion and finally references

Materials and methods
Data structure and source
Livestock comprised of different species in Punjab like, cattle, buffalo, sheep, goat, camel, horses, mules, asses and poultry. These species of livestock are dispersed in whole Punjab. Punjab comprises of 39 administrative units. These are Islamabad, Rawalpindi, Attock, Jhelum, Chakwal, Gujranwala, Hafiz Abad, Gujrat, Mandi Bahauddin, Sialkot, Narowal, Lahore, Kasur, Okara, Sheikhupura, Nankana Sahib, Faisalabad, Toba Tek Singh, Jhang, Sargodha, Khushab, Mianwali, Bhakkar, Multan, Lodhran, Vehari, Sahiwal, Pakpattan, Khanewal, D.G.Khan District, De. Ex. Area D.G.Khan District, Rajanpur District, De. Ex. Area Rajanpur District, Layyah, Muzaffargarh, Bahawalpur, Bahawalnagar, Rahim Yar Khan and Cholistan.

Livestock census is a regular activity of Agricultural census organization of Pakistan for estimation of livestock population on decade basis. Sequential Livestock census data has been used in this study starting from 1976 to 2006. Population of all the species of livestock has been taken from these censuses. The population of poultry bird was high; therefore, it is considered as broader and different subject and is excluded from livestock data for making analysis more logical.

Analytical Methods
A diversity index is a quantitative and mathematical measurement of diversity of species in a community or geographical boundary.

Livestock Species Density in Punjab
Species density was used to estimate population of animal belonging to each species in each district of Punjab.

Livestock Species Density=$\frac{Population\ of\ one\ species}{Total\ area\ of\ District}$ eq1

Relative Abundance
Relative abundance is the presence of a species of livestock in an administrative boundary in Punjab. It also represents evenness of livestock population in the district.

Relative abundance model also support in calculating K-Dominance Species Abundance Model.

In addition to it the most abundant species was calculated by:

Relative Abundance of livestock =
$\frac{Total\ number\ of\ individuals\ of\ one\ species}{Total\ number\ of\ individuals\ of\ all\ species}$ x 100 eq----2

The Simpson Diversity Index
Livestock species diversity of each habitat representing an administrative boundary (districts) was calculated by using Simpson Biodiversity Index [10]. Simpson's diversity index is a measure of diversity which takes into accounts both richness and evenness [11, 12]. Species richness is the number of different species present. However, diversity depends not only on richness, but also on evenness. Evenness compares the similarity of the population size of each of the species present. As species richness and evenness increase, so diversity increases [13]. Simpson index measures diversity of livestock population on the basis of time and space. Time included changes in population during different decades. Space included various geographical and administrative units. Simpson index calculates diversity on the basis of richness, evenness and abundance of a particular species in certain locality. Relative abundance of livestock in different districts helps us to categories livestock species through Bury Cutis similarity index of different species of livestock in different districts of Punjab. Sample size is important in drawing reliable results of Simpson diversity index [12].

Simpson index values (D) are between 0-1 while calculating final result it was divided by 1 to correct the reciprocal proportion.
$D = [\Sigma\ ni\ (ni - 1)\ ] / N\ (N - 1)$ ----eq3
$D = 1/D$

Where:
D is Simpson Diversity Index
n_i is number of individuals belonging to i species
N is total number of individuals
When value of Simpson reciprocal index is 1 mean zero diversity. Its maximum value is the number of species present in the geographical boundary. As the value of index increases, diversity of livestock increases in that administrative boundary.

Clustering
It was possible after species diversity estimation to cluster different districts by using Bray-Curtis Cluster Analysis to represent geographical distribution of livestock in Punjab. Statistical tests were applied using software Biodiversity Pro Ver. 2.

Results

Geographical distributions of Livestock Species Population Density in Punjab

Major livestock in Punjab is Cattle, Buffalo, sheep and Goat accounting for 95.64% of livestock population of Punjab according to livestock census 2006. The per hectare population heads were analyzed in different districts of Punjab and summarized in Table 1. These districts were then categorized on the basis of population concentration. Results revealed that buffalo is more densely populated in irrigated Punjab as compared to other species of livestock. The population of buffalo in selected districts has crossed two animal heads on one hectare. Major reason for increasing buffalo population is the demand of milk on the basis of taste and preferences and availability of fodder. Cattle population mainly vary around one animal per ha. Sheep are less than 0.5 heads per ha. Goats are more in Punjab with stocking rate of one and between 1-2 animals per ha in most of the districts (Table 1). High livestock density may result in more incidences of diseases [14].

Livestock Population Density in Punjab

Mean livestock population density in Punjab is 3.27 ± 1.12 (Mean±SD) heads per hectare. 83 percent of the districts of Punjab have mean livestock density higher than 2 heads per hectare. Okara district is thickly livestock populated district of Punjab having livestock density almost 6 heads per hectare (Table 2). Majority of the irrigated districts have livestock density greater than three and similarly barani districts have less than three.

Table 1: Livestock distribution per ha. in different administrative units of Punjab

Specie	Districts with Animal heads per ha.				
	<0.5	0.5 -0.75	0.76- 1	1-1.5	>1.5
Cattle	Bahawalpur, Rajanpur, DG Khan, Rahim Yar Khan, Nankana Sahib, Gujrat, Jhelum, Sheikhupura	Khushab, Attock, Bahawalnagar, Gujranwala Rawalpindi, Bhakkar, Chakwal, Narowal, Pakpattan, Sahiwal	Lahore, Hafizabad, Mianwali, Faisalabad, Vehari, Kasur, Toba Tek Singh, Mandi Bahauddin, Sialkot, Layyah, Khanewal, Sargodha, Jhang	Okara, Lodhran, Multan, Muzzafargar	
Buffalo	Rajanpur, Attock, DG khan, Chakwal, Bahawalpur, Khushab, Bhakkar, Mianwali, Jhelum, Rawalpindi, Layyah	Rahim Yar Kahn, Muzzafargar	Lodhran, Bahawalnar, Sheikhupura	Multan, Sargodha, Gujrat, Khanewal, Narowal, Jhang, Toba Tek Singh, Nankana Sahib, Vehari	Gujranwala, Faisalabad, Sialkot, Sahiwal, Hafizabad, Mandi Bahauddin, Pakpatan, Kasur, Okara
Sheep	Rajanpur, Attock, Chakwal, Bahawalpur, Khushab, Mianwali, Jhelum, Rawalpindi, Rahim Yar Kahn, Muzzafargar, Lodhran, Bahawalnar, Sheikhupura, Multan, Sargodha, Gujrat, Khanewal, Narowal, Jhang, Toba Tek Singh, Nankana, Gujranwala, Faisalabad, Sialkot, Sahiwal, Hafizabad, Mandi Bahauddin, Pakpatan, Kasur, Okara Sahib, Vehari	Layyah, DG khan, Bhakkar,			
Goat	Jhelum, Layyah, Hafizabad, Faisalabad	Muzzafargar, Sheikhupura, Gujrat, Nankana Sahib, Rahim Yar Khan, Khanewal	Lodhran, TT Singh, Gujrawnwala, Lahore, Bahawalpur, Vehari, Kasur, Narowal, DG Khan, Mandi Bahaddin, Rawalpindi	Sargodha, De Ex. Area DG Khan, Bahawalnagar, Okara, Sahiwal, De Ex area Rajanpur, Bhakkar, Attock, Sialkot	Khushab, Pakpattan, Multan, Chakwal, Rajanpur

Source: Authors calculation on the basis of Livestock Census 2006

Table 2: Categorization of Districts of Punjab Province of Pakistan on the basis of Livestock population density per hectare according to Livestock census 2006

Livestock population density per hectare in ascending order					
<1	1-2	2-3	3-4	4-5	5-6
Bahawalpur	Rajanpur, DG Khan, Sheikhupura, Khushab, Jhelum	Attock, Chakwal, Rawalpindi, Mianwali, Bhakkar,Rrahim Yar Khan, Gujrat, Bahawalnagar	Nankana Sahib, Narowal, Layyah, Gujranwala, Sargodha, Hafizabad, Lodhran, Muzzafargar, Vehari	TT Singh, Sialkot, Mandi Bahawaldin, Jhang, Lahore, Kasur, Multan, Khanewal, Pakpattan, Faisalabad, Sahiwal	Okara

Source: Authors calculation on the basis of Livestock Census 2006

Livestock Diversity in Punjab

Livestock is the main component of rural household economy of Punjab. The province is enriched with livestock wealth. Various livestock species included in this analysis were cattle, buffalo, sheep, goat, horses, camel, mule and asses. Livestock diversity and biodiversity is a precious genetic resource [15].The Simpson index helps in calculating the richness and evenness of livestock species in the province. [16] Identified decrease in Simpson index with the increase in pasture. Eight species of livestock were included in the analysis. The values of Simpson Reciprocal Index vary from 1 to 8 as per specie number. One representing zero diversity and similarly 8 representing the maximum value of diversity in the area. Data of four census covering 40 years of period was used to understand changes in diversity of livestock.

Table 3: Historical changes in Simpsons Diversity Reciprocal Index (1/D)

Districts of Punjab	2006	1996	1986	1976
Islamabad District	3.032	3.037	3.163	
Rawalpindi District	3.081	3.383	3.346	3.437
Attock District	3.183	3.679	3.602	3.851
Jhelum District	3.495	3.742	3.604	4.16
Chakwal District	3.401	3.577	3.356	
Gujranwala District	2.914	3.009	3.109	3.808
Hafizabad District	2.522	3.566		
Gujrat District	3.264	3.111	3.353	4.32
Mandi Bahauddin District	2.831	3.076		
Sialkot District	3.035	2.934	2.763	3.368
Narowal District	3.426	3.471		
Lahore District	2.837	2.829	2.788	3.797
Kasur District	2.868	3.497	3.262	
Okara District	3.061	3.523	3.441	
Sheikhupura District	3.228	3.562	3.529	4.122
Nankana Sahib District	3.20			
Faisalabad District	3.123	3.199	3.438	4.239
Toba Tek Singh District	3.268	3.215	3.82	
Jhang District	3.966	4.19	4.34	5.148
Sargodha District	3.846	3.848	4.029	4.295
Khushab District	3.589	3.723	3.72	
Mianwali District	3.698	3.779	3.678	4.62
Bhakkar District	4.017	4.152	4.06	
Multan District	3.327	3.53	4.137	5.171
Lodhran District	3.089	3.348		
Vehari District	3.285	3.311	3.879	4.79
Sahiwal District	3.078	3.281	3.628	
Pakpattan District	3.029	3.261		
Khanewal District	3.497	3.514	4.195	
D.G.Khan District	3.552	3.659	3.897	4.358
De. Ex. Area D.G.Khan District	2.541	2.596	2.422	2.608
Rajanpur District	3.761	4.043	3.886	
De. Ex. Area Rajanpur District	2.146	1.655	1.926	
Layyah District	4.08	4.217	4.322	
Muzaffargarh District	3.5	3.864	3.958	4.857
Bahawalpur District	3.253	3.357	4.239	5.204
Bahawalnagar District	3.542	3.454	4.211	5.24
Rahim Yar Khan District	2.918	2.808	3.702	4.956
Cholistan District	2.839	2.869	3.037	

Source: Authors own calculations from Bio diversity Pro. V2 Note: Blank space mean non-availability of separate data due to late emergence of these administrative units.

Data revealed that livestock diversity in Punjab has decreased slightly in last forty years. This depletion of livestock diversity might be due to urbanization and tradeoff between maintaining livestock of diverse nature and benefits of household by depleting this diverse livestock [17]. Globally 16% of the livestock breeds are extinct [18]. Livestock diversity in Punjab is generally low i.e, about 3. In Jhang district of central Punjab, livestock diversity was maximum in 1976 which was 5.148 (Table 3). In Jhang district, drastic decrease in livestock diversity has been observed which reached to 3.996 in 2006. Similarly in Multan, Bahawalpur and Bahawalnagar districts of Southern Punjab, livestock diversity was high i.e, 5.17, 5.20 and 5.24 respectively in 1976. In 2006, the livestock diversity of these districts has decreased to 3.32, 3.25 and 3.54 respectively (Table 3). This decreasing trend in livestock diversity indicates the alarming state of some species in Punjab. In developed countries many species and breeds of livestock are becoming rare [19] and this phenomenon will also be happening in developing world [20, 21]. So Punjab has to focus on conservation of livestock diversity to save its precious livestock genetic resource.

Relative Abundance of livestock in different districts of Punjab

Buffalo and goat are the dominant species in Punjab. Buffalo dominated 17 districts mostly belong to central Punjab, while goat dominate 18 districts mostly from Southern and Northern parts of Punjab province of Pakistan (Table 4)

Table 4: Categorization of different geographical boundaries on the basis of Dominant specie.
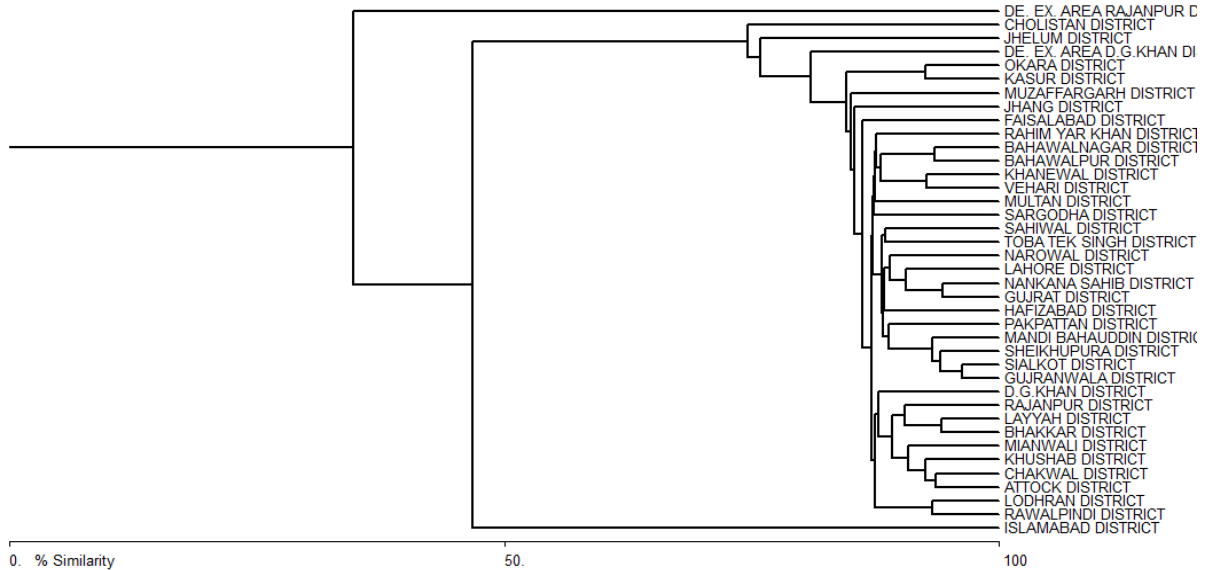
Results of Abundance Model (K-Dominant species)		
Dominant Specie	Area (Districts)	No. of Districts
Buffalo	Islamabad, Gujranwala, Hafizabad, Gujrat, Mandi, Sialkot, Narowal, Lahore, Kasur, Okara, Sheikhupura, Nankana, Faisalabad, Jhang, Sargodha, Sahiwal, Pakpattan	17
Cattle	Layyah, Muzzafargar, Chohlistan	3
Sheep	De. Ex. Area of Rajanpur	1
Goat	Rawalpindi, Attock, Jhelum, Chakwal, Toba Tek Singh, Khushab, Mianwali, Bhakkar, Multan, Lodhran, Vehari, Khanewal, D G Khan, De. Ex. Area of D. G. Khan, Rajanpur, Bahawalnagar, Bahawalpur, Rahim Yar Khan	18

Source: Authors calculation, Biodiversity

According to Livestock census 2006, cattle, buffalo, sheep and goat found in Pakistan were 29.55, 27.33, 26.48 and 53.78 million heads respectively. Out of this 49% of cattle, 65% of buffalo, 24% of sheep

in each district and significantly aggregated in each district (Table 5). Each of specie of livestock is aggregated in each district of Punjab.

Bray-Curtis Cluster Analysis (Single Link)

and 37% of goat were found in Punjab. Buffalo is more concentrated in Punjab, so dominate mainly irrigated districts.

Bray Curtis cluster analysis indicate that in terms of livestock wealth of Punjab, about 80% similarity exist in Punjab based on 2006 census actual data among various administrative units. Sialkot and Gujranwala has highest similarity Index in Punjab (96.23%) with a minimum distance of 3.76. These districts are further clustering with Shiekhupuara (94.03%), Mandi Bahuddin (93.23%) and Pakpattan (88.84%) which belong to central Punjab. The results indicated that livestock diversity mostly follow geographical pattern on the basis of results of similarity index and make similarity matrix accordingly. Bakhar has livestock population biodiversity similarity index of 94.26% with Layyah, followed by Rajanpur (90.45%) and Narowal (89%) (Fig. 1).

Livestock Species Distribution in Punjab
Individual livestock species distribution
Cattle population is in each district of Punjab was found to be 0.369 million heads which are significantly aggregated in each district. The buffalo population in was found to be 0.455 million heads in each district and was also significantly aggregated. The sheep and goat population in each district was 0.163 and 0.508 million heads respectively and was also significantly aggregated. The camel, horses, mules and asses were 0.005, 0.004, 0.0016 and 0.057 million heads respectively

Table 5: Individual species dispersion/aggregation in each districts of Punjab

Species	Variance	Mean	Chi-sq	d.f.	P	Aggregation
Cattle	4.93E+10	369546.8	5068491	38	0	Aggregated
Buffalo	9.42E+10	455063.5	7869950	38	0	Aggregated
Sheep	2.59E+10	163122.2	6035587	38	0	Aggregated
Goat	1.06E+11	508488.2	7941145	38	0	Aggregated
Camel	25935650	5101.641	193183.9	38	0	Aggregated
Horse	9808397	4182.231	89119.68	38	0	Aggregated
Mule	2032087	1623.077	47575.87	38	0	Aggregated
Ass	1.34E+09	57224.41	889601	38	0	Aggregated

Source: Authors own calculation- Biodiversity Pro. V 2.

Table 6: Results of Chi square test on whole community of livestock in Punjab

Chi - Square	Value	D.F.	Probability	Dispersion
Total	28134652	312	0	Aggregated
Pooled	14440899	38	0	Aggregated
Heterogeneity	**13693753**	**274**	**0**	**Discordant**

Livestock Distribution in Punjab
The results of chi square test suggested that livestock population in Punjab province of Pakistan is aggregated. The results are highly significant. So livestock population in Punjab is highly aggregated during 2006 (Table No. 6). Different species of livestock are aggregated in Punjab for coexistence.

The aggregation of livestock in Punjab is highly significant (p= < 0.000) Table 7. Almost all species are present in all geographical boundaries.

Conclusions

Major dominant livestock species in Punjab are buffalo, cattle, goat and sheep on the basis of overall population in each district. Only buffalo population density is above 2heads per hectare in few districts of Punjab. Livestock population diversity showed geographical pattern on the basis of Bray Curtis similarity index and form clusters in geographical pattern. The livestock diversity index in Punjab is decreasing which needs special attention of the policymakers and planners.

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