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Geospatial dynamics of cropping pattern and agricultural efficiency in Kashmir Valley-A Northwestern Himalayan region, India.

Dinámica geoespacial del patrón de cultivo y la eficiencia agrícola en el valle de Cachemira, una región del Himalaya noroccidental, India

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ABSTRACT

Food (in)security and agricultural efficiency is a major challenge in many of the world's mountain ranges. The particular physical characteristics of mountains and associated socioeconomic factors, mountain regions all over the world face challenges in terms of food security and cropping pattern, although at different levels. Mountains in developing countries are sites of poverty. About 40 percent of the mountain population or nearly 300 million people are estimated to be vulnerable to food insecurity, of these, nearly 90 percent live in rural areas and almost half of those are likely to be chronically hungry. The present study also focuses on the regional disparities in agricultural efficiency and cropping pattern across different tehsils of Kashmir Valley-A north-western part of Himalayas. The study was carried out across thirty-nine spatial units (Tehsils) among different districts of Kashmir valley in GIS and remote sensing environment. Both primary and secondary data was employed. The study shows that the productivity of paddy, maize, and wheat is showing an increasing trend among all tehsils of Kashmir valley from 2011 to 2017 but the area under these crops is decreasing at an alarming rate leading a food deficit of 21.70 percent. So, agriculture planning is badly needed to curb this grave problem and impose restrictions to land conversion a burning issue nowadays

Keywords: Geospatial, Food security, Tehsil, Kashmir valley, agriculture, Efficiency

RESUMEN

La (in) seguridad alimentaria y la eficiencia agrícola es un desafío importante en muchas de las cadenas montañosas del mundo. Las características físicas particulares de las montañas y los factores socioeconómicos asociados, las regiones montañosas de todo el mundo enfrentan desafíos en términos de seguridad alimentaria y patrón de cultivo, aunque a diferentes niveles. Las montañas de los países en desarrollo son lugares de pobreza. Se estima que alrededor del 40 por ciento de la población de las montañas o casi 300 millones de personas son vulnerables a la inseguridad alimentaria; de estos, casi el 90 por ciento vive en áreas rurales y casi la mitad de ellos es probable que padezcan hambre crónica. El presente estudio también se centra en las disparidades regionales en la eficiencia agrícola y el patrón de cultivo en diferentes tehsils del Valle de Cachemira, una parte noroeste del Himalaya. El estudio se llevó a cabo en treinta y nueve unidades espaciales (Tehsils) entre diferentes distritos del valle de Cachemira en SIG y entorno de teledetección. Se emplearon datos tanto primarios como secundarios. El estudio muestra que la productividad del arroz, el maíz y el trigo muestra una tendencia creciente entre todos los tehsils del valle de Cachemira de 2011 a 2017, pero el área bajo estos cultivos está disminuyendo a un ritmo alarmante, lo que lleva a un déficit de alimentos del 21,70 por ciento. Por lo tanto, la planificación agrícola es muy necesaria para frenar este grave problema e imponer restricciones a la conversión de tierras, un problema candente en la actualidad.

Palabras clave: geoespacial, seguridad alimentaria, Tehsil, valle de Cachemira, agricultura, eficiencia

INTRODUCTION

The method of mapping agricultural efficiency regions provides a rational base for future agricultural planning and to cope with food insecurity, a burning issue nowadays (Jasbir 2004). Today the foremost challenge facing the world in general and developing countries, in particular, is the appalling increase in population and a corresponding upsurge in food demands. Food shortage is primarily due to insufficient production of food grains (Singh and Dhillon 2004, Lone 2018). Agriculture is the primary source of calories, essential nutrients and is also a major source of income for 80 percent of the world's poor (IFPRI and ILRI 2010) however, the output from it is not sufficient to feed the growing population (FAO 2015), yet trend of crop growth is not uniform across the regions. Recent discourses on agriculture in the Himalayas have repeatedly highlighted the ongoing agrarian distress in the region, manifested in deteriorating land productivity and declining yield (Nichols 2015). The social, economic, and environmental conditions for practicing agriculture are becoming progressively

challenging. As a result, rural livelihoods in the Himalayas are becoming increasingly delinked with agriculture, leading to widespread de-agrarianisation and agricultural land abandonment (Tiwari and Joshi 2015; Paudel et al., 2016). The Indian Western Himalaya shows considerable variation in climatic and topographic conditions, where agriculture forms the main livelihood source for 70 percent of the population and has been a significant contributor to the household food security of local communities (Lutz *et al*., 2013). However, farmers in the region have suffered agro-climate, socio-economy, culture, history, government policies and innovation, influence cropping pattern of a region (Hussain 1996) and unexpected natural disaster events (such as floods and earthquake) (Kala, 2014), social and physical marginalisation (Satyal*et al.,* 2017) and increased marketisation (Rigg *et al*., 2016). Cropping pattern is a dynamic concept which denotes the proportion of area under various crops at a given point of time (Misra and Puri 2011) and is influenced by socioeconomic conditions, food security compulsions, policy support and market demand (Velayuthum and Planniappan 2003). While estimates show that there is currently enough food produced globally per capita, around one in eight people in the world suffers from chronic hunger (FAO *et al.* 2013). Globally, the total number of undernourished people is decreasing, down from approximately 19 percent of the world's population in 1990 to 12 percent in 2011-2013 (FAO *et al.* 2013). But in the Himalayan regions, undernourishment remains stubbornly high (Lone et al., 2018). In 1990, there were over 535 million undernourished people living in China, India, Nepal, and Pakistan, about 53% of the world's undernourished people (FAO *et al.* 2013). Today, 48 percent of the global undernourished population (408 million people) are still found in these same four countries (FAO *et al.* 2013). The mountain areas of these countries show the highest degree of food insufficiency and persistent undernourishment remains an urgent situation (Chappel and Lavallen 2011; Rerkasem*et al.* 2002). In the Himalayas, production of traditional crops has declined drastically in the last decades (Sharma 2009; Srinivasa 2006). Subba (2006) also observed that the area and production of subsistence farming have decreased and it is under severe threat.

The 2013 Global Hunger Index (GHI) produced by the International Food Policy Research Institute (IFPRI) ranks India as 63rd out of 78 countries, and rates the severity of India's food insecurity as "alarming"7 (von Grebmer*et al.,* 2013). Agriculture and its allied activities are the predominant sectors of the economy of Jammu and Kashmir (Hussain 2006). The state economy is a high-cost mountain economy and has a number of characteristics that pose special development challenges (Singh, 2011). Agriculture is the mainstay of the state economy as more than sixty percent of the population derives their income directly or indirectly from the agriculture sector. Agriculture is a vital component of the primary sector.

The Jammu and Kashmir state is basically agrarian in nature. As per census 2011, 19.74 lakh persons comprising 17.12 lakh as cultivators and 2.62 lakh as agricultural labourers depend directly on agriculture for their livelihood forming 47 percent of the total working force (42.12 lakh persons). The Agriculture and allied sectors contributed about 27 percent to the GSDP while as Agriculture sector, specifically contributed 8 to 9 percent to the GSDP during 2007-07 (Ganaie and Bhat 2016). The agriculture sector in the state shows profound changes in cropping land use, agriculture workforce and food deficit (Lone *et al.* 2018). On the basis of above litterature ,the present study focuses on the regional disparities in agricultural efficiency and cropping pattern across different tehsils of Kashmir Valley-A north-western part of Himalayas.

MATERIAL AND METHODS

Study Area: The Kashmir Valley, also known as the Vale of Kashmir, is a valley in Northwestern Himalayas (Fig.1). The valley is bounded on the southwest by the Pirpanjal and on the northeast by the main Himalayas (Qazi, 2005). It is approximately 135 km long and 32 km wide and drained by the Jhelum river. Indian Western Himalaya consists of three mountainous states, Jammu and Kashmir, Himachal Pradesh and Uttarakhand which cover 67.1 percent, 16.77 percent, and 16.13 percent of the total area, respectively (Shukla *et al,* 2018).

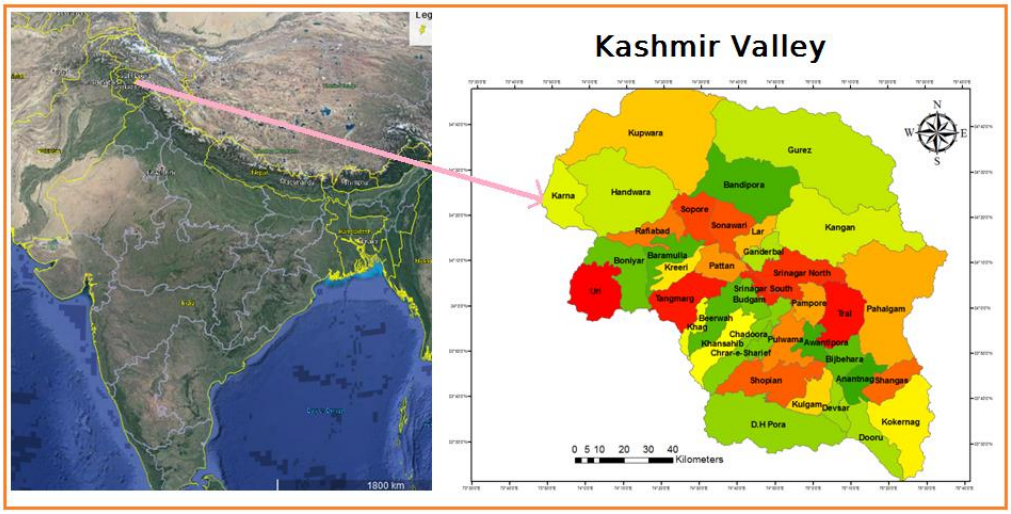

Fig.1. Map of studied site

Levels of agricultural efficiency: There are number of scholars who have contributed different ideas, methods, and techniques to measure the agricultural productivity, like Kendall (1939), Shafi (1960), Bhatia (1967), Khusro (1964), Jasbir Singh (1979) and Sapre and

Despanday (1964). The areas which experience high land productivity may always have been leading agricultural regions, as witnessed by the development of irrigation facilities (Dayal, 1984). The present study is based on both primary and secondary sources collected from various concerned departments and from many other literature and research papers. In this purpose to measure the agricultural efficiency, methods proposed by S.S. Bhatia (1967) have been used. The weights as suggested by Bhatia are the proportions of the area under each crop to the total cropped area.

Agricultural efficiency regions has been developed as"

$$Ij = \frac{\sum Yij\ Cij}{\sum Cij}$$

where Ij= composite index of tehsil j

Cij=Proportion of the area under ith crop to the total cropped area in the jth tehsil

$$Yij = \frac{Eij}{Ei}$$

Eij = per acre yield of the ith crop in jth tehsil

Ei= per acre yield of the ith crop in the region

The composite index for each tehsil has been worked out and three agricultural efficiency regions (High, Medium and Low) has been worked out. For this purpose main crops, viz., paddy, maize, and wheat have been considered. The production of these three crops (paddy, maize, and wheat) has been determined by multiplying the total area under these crops in different years by their productivity in the corresponding years. The formula used for this purpose is given below:

$$PC1y = AC1y \times P1y$$

Where 'PC_1y' = total production of a crop C_1 in a year 'y',

'AC_{1y}' = area under this crop in year 'y' and

'P1y'= productivity of the crop C_1 in the year 'y'

Change:

The change has been depicted by making use of bar graphs of two different time periods. The formula used is

$$\text{Change } (V_1) = \frac{St1-St2}{St1} \times 100$$

Where,

V_1 = Change in any variable,

St_1= Status at time t_1,

St_2 = Status at time t_2

RESULTS AND DISCUSSION

Productivity and area under Paddy: Agricultural productivity is directly related to the nutritional status of the people. It is a functional interplay of physical, cultural and socioeconomic variables and is expressed as per hectare productivity and volume of production (Agnihotri 2005).

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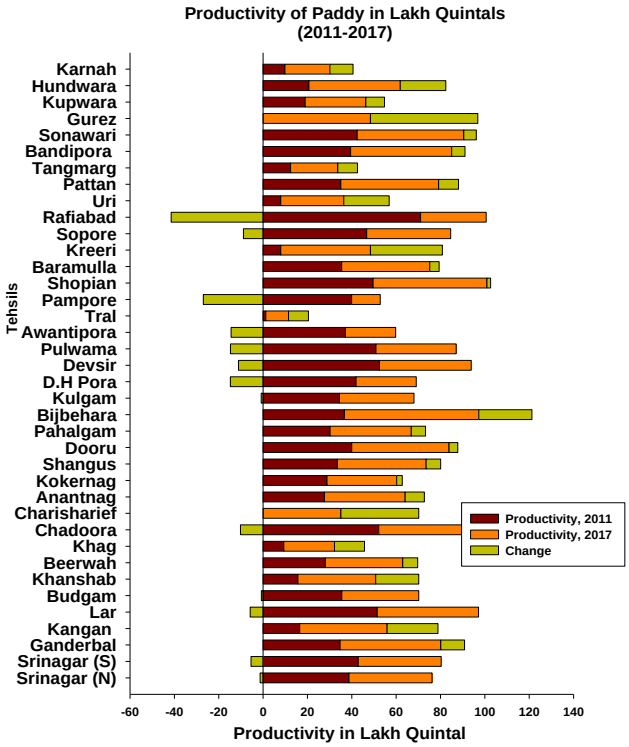
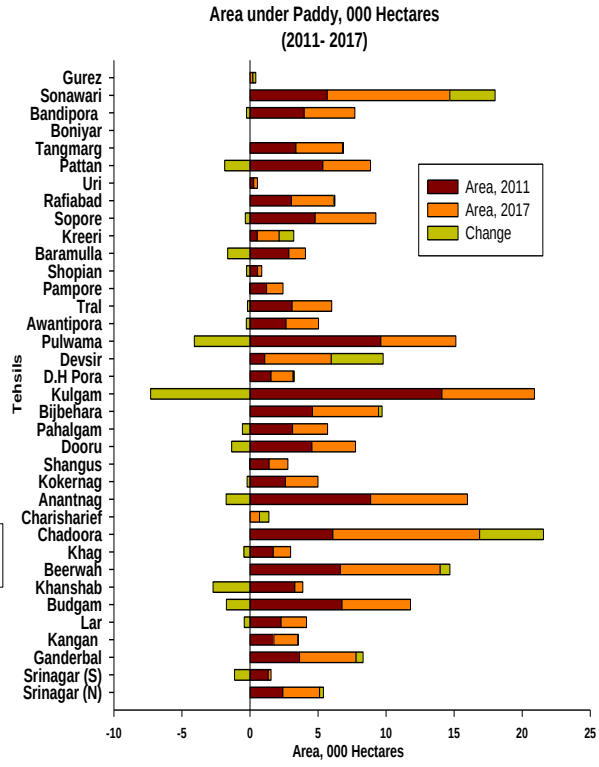
Paddy is the dominant crop grown in the Kashmir valley, as it is the staple food of more than sixty percent of the population of the state. It is a tropical crop and requires high temperature and moisture conditions (24°C to 35°C and 150-250cm). Paddy cultivation is an age-old practice, hence its productivity has increased in maximum number (24) of tehsils, with an average increase of 3.23 quintals/hectare from 34.19 quintals/hectare in 2011 to 37.42 quintals/hectare in 2017. Highest productivity was found in tehsils of Rafiabad(71.01 quintals/hectare) and Bijbehara (60.6 quintals/hectare) in 2011 and 2017 respectively (Fig. 2). However, the area under the same crop is showing a diminishing picture in which most of the tehsils (Fig.3, 4) have lost their share to other land use classes. The maximum change was found in tehsil Kulgam (-7 thousand hectares) followed by Pulwama tehsil (-4 thousand hectares).

Productivity and area under Maize: Maize is also one of the prime crops grown in the state of Jammu and Kashmir as it is the staple food of the Gujjars and Bakerwlas living in and around the Himalayas (pirpanjal range) consisting of more than ten to fifteen percent of the population of the state. It is a coarse grain and requires moderate temperature and less water (10°C to 25°C and 50-120cm). Though maize is cultivated in all the tehsils of the state, but it is a dominant crop in the hilly districts having more low lying mountainous area (*Kandi belt*) than the tehsils which have relatively more plain area. The productivity of maize in all the tehsils of the Kashmir valley has increased from 11.73 quintals/hectare in 2011 to 14.23 quintals/hectare in 2017, thus implies a total increase of 2.5 quintals/hectare. The highest growth is recorded in Uri, Baramullah, followed by Anantnag and Khanshb (9.16 percent), while the negative is observed in tehsil Pulwama and kreeri (Fig.5).

Like paddy, the productivity of maize is increasing almost among all the tehsils of Kashmir valley but the main concern is that the land under these staple food crops is decreasing at an alarming rate to other land use land cover classes (Fig.6,7). The study shows that only in a period of seven years from 2011 to 2017 our valley lost 17.78 thousand hectares land area under this crop. Among tehsils, the maximum change was observed in Hundwara and Baramullah.





Source: Financial commissioner's office, Srinagar 2011 and 2017

Fig.2 Fig.3

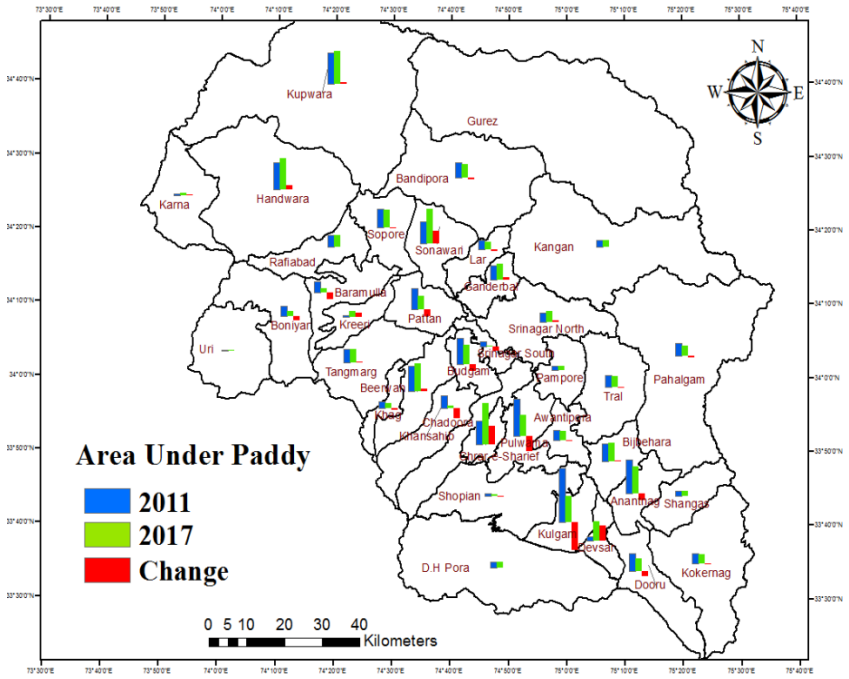


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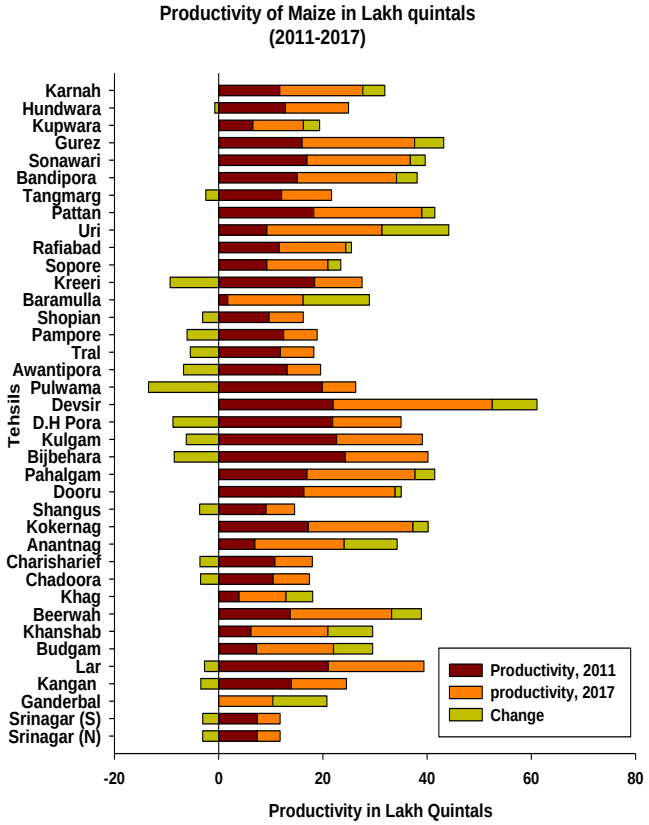
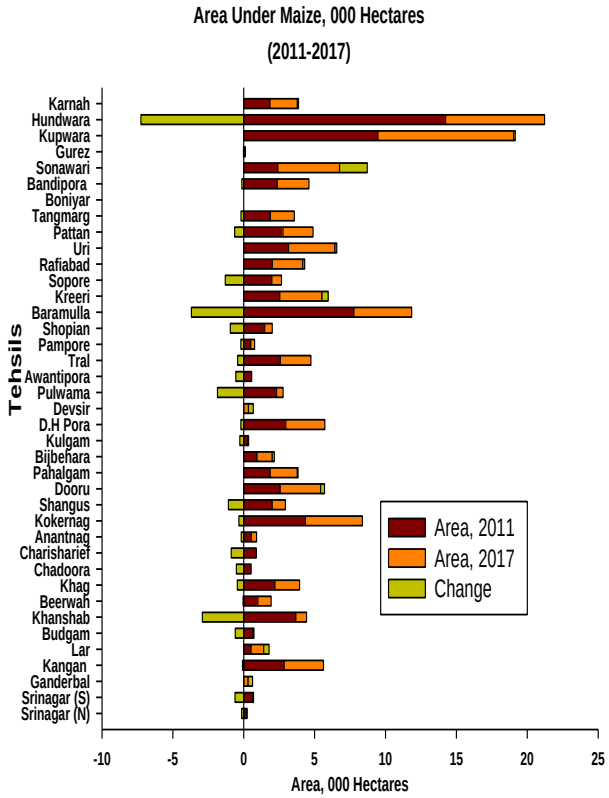
Fig.4



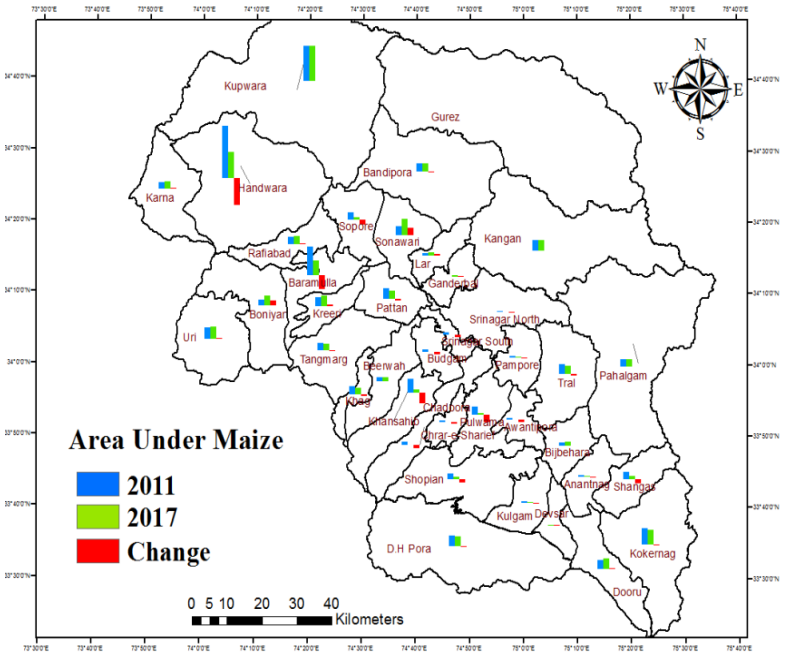


Source: Financial commissioner's office, Srinagar, 2011 and 2017

Source: Financial commissioner's office, Srinagar 2011 and 2017

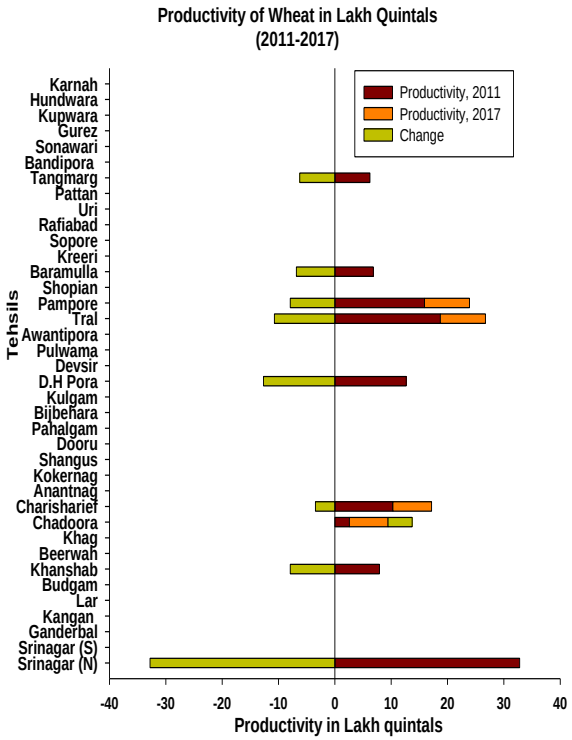
Fig.5

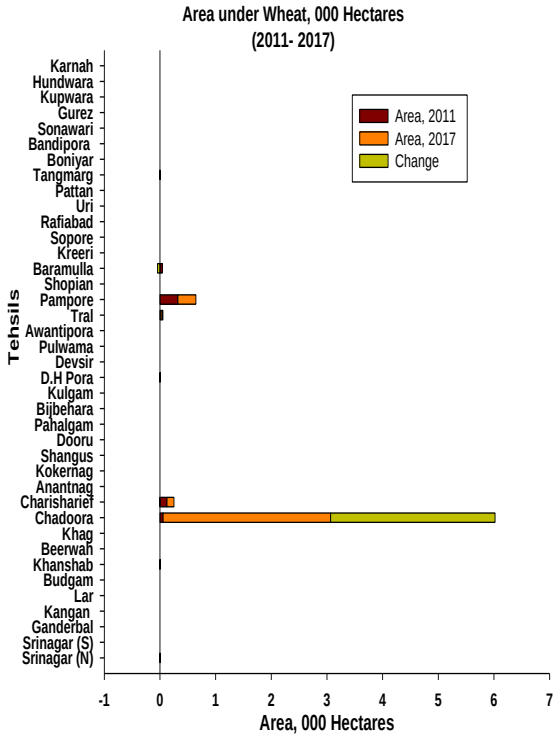
Fig.6



Source: Financial commissioner's office, Srinagar, 2011 and 2017

Fig.7

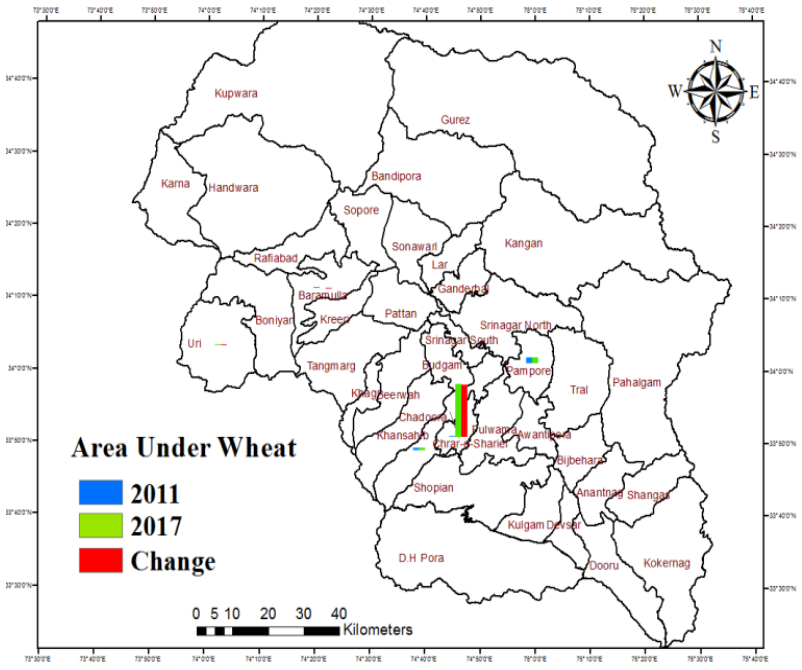




Source: Financial commissioner's office, Srinagar 2011 and 2017

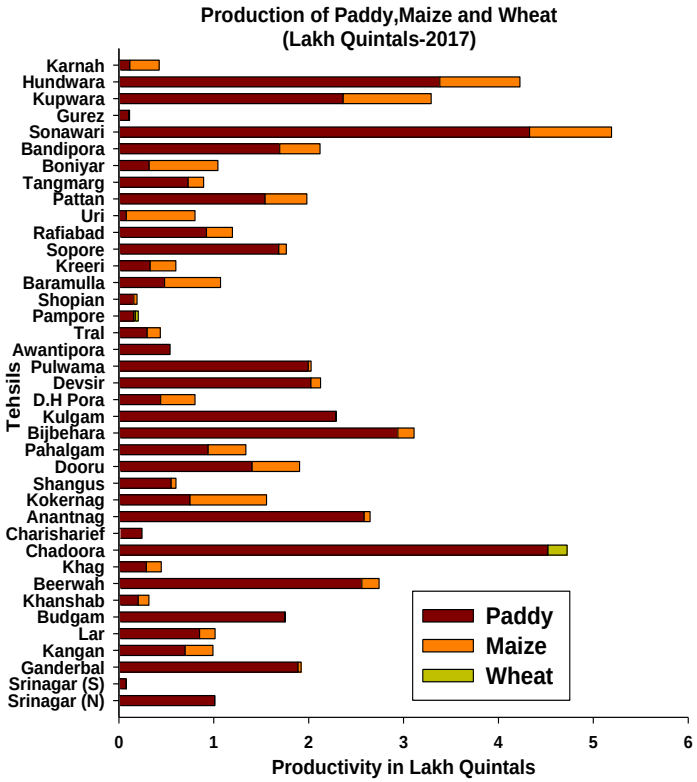
Fig.8

Fig. 9



Source: Financial commissioner's office, Srinagar, 2011 and 2017

Fig.10



Source: Financial commissioner's office, Srinagar 2011 and 2017

Fig.11.

Productivity and area under Wheat: Wheat is also one of the important crops grown in the state of Jammu and Kashmir as it is a staple food for the people of Jammu and Ladakh province consisting of more than forty percent of the population of the state. This is a rabi crop in the state; i.e. it is grown in October-November and harvested in March-April and requires moderate temperature and less water (150C to 250C and 50-120cm) (Hussain 1996). This crop is mainly cultivated in Jammu and Ladakh division and less area is under this crop in the Kashmir valley (Fig.8). In Kashmir valley wheat is grown only in Budgam tehsil, Charisharief, and Kulgam. The average productivity of wheat in the Kashmir valley has been decreased to 5.68 quintals/hectare from12.65 quintals/hectare to 6.97 quintals/hectare in 2017. Although the area under this crop is showing an increasing trend, still the area under this crop is very low (Fig. 9, 10).

Levels of agricultural Efficiency: Levels of agricultural efficiency of paddy, maize, and wheat has been determined by multiplying the total area under these crops in different years by their productivity in the corresponding years. The formula used for this purpose is given below:

$$PC_{1y} = AC_{1y} \times P_{1y}$$

Where '$PC_{1}y$' stands for a total production of a crop C_1 in a year 'y', 'AC_{1y}' is the area under this crop in year 'y' and '$P_{1}y$' for the productivity of the crop C_1 in the year 'y'

The production has increased over the period of time not because of an increase in area under these crops, but on account of the increase in productivity. The production of paddy, maize and wheat was not uniform across the tehsils of Kashmir valley and exhibited wide variations (Table 1 and Fig.11). The production of paddy was found highest in chadoora and Sonawari tehsils and lowest in Srinagar 'S' and Gurez. Maize is mostly cultivated in higher altitudes. The production of maize found highest in Kupwara, Hundwara, Sonawari, and Kokernag tehsils and lowest production was found in Awantipora, Chadoora, Srinagar 'N' and Srinagar 'S' tehsils.

The ranking coefficient method of Kendal and Bhatia was used to classify the Tehsils into three agricultural efficiency regions (High, Medium and Low) on the basis of productivity per hectare and area under each crop in each spatial unit. Highest productivity regions were assigned the highest rank i,e 1 and vice-versa (Table 1and Fig. 11).

On the basis of the above index values, the study area was divided into the following three agricultural efficiency regions:

Table 1: Production and Ranking of Paddy, Maize, and Wheat(Lakh quintals)

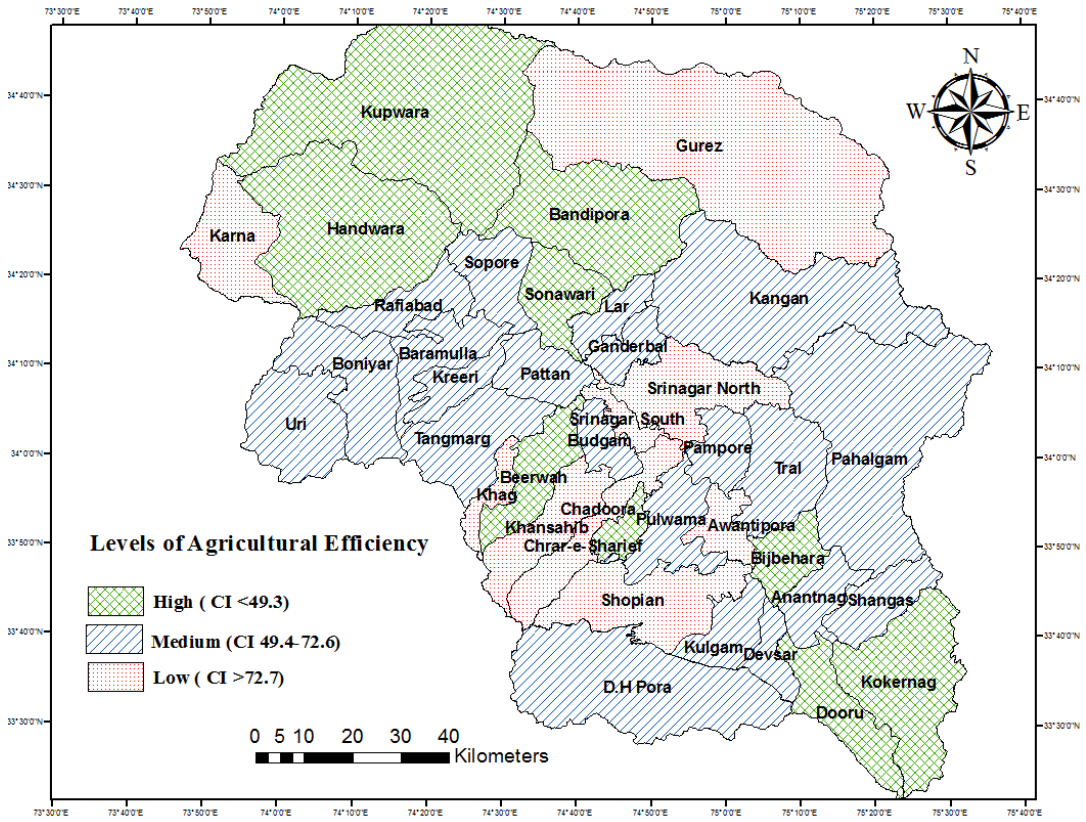
Tehsils	Production Paddy (Lakh Quintals)	Ranks of Paddy	Production Maize (Lakh Quintals)	Ranks of Maize	Production wheat Lakh Quintals	Ranks of Wheat	Total (CI)
Srinagar (N)	1.009	17	0.002	35	0	22	74
Srinagar (S)	0.077	39	0.002	35	0	22	96
Ganderbal	1.888	11	0.032	28	0	22	61
Kangan	0.699	23	0.292	13	0	22	58
Lar	0.85	20	0.164	18	0	22	60
Budgam	1.746	12	0.009	32	0	22	66
Khanshab	0.205	33	0.112	22	0	22	77
Beerwah	2.56	6	0.183	16	0	22	44
Khag	0.29	31	0.157	20	0	22	73
Chadoora	4.523	1	0	37	0.2	1	39
Charisharief	0.244	32	0	37	0	4	73
Anantnag	2.586	5	0.062	25	0	22	52
Kokernag	0.75	21	0.806	4	0	22	47
Shangus	0.551	24	0.051	26	0	22	72
Dooru	1.405	16	0.499	7	0	22	45
Pahalgam	0.941	19	0.397	10	0	22	51

Bijbehara	2.94	4	0.171	17	0	22	43
Kulgam	2.285	8	0.006	33	0	22	63
D.H Pora	0.441	27	0.361	11	0	22	60
Devsir	2.024	9	0.102	23	0	22	54
Pulwama	1.996	10	0.03	29	0	22	61
Awantipora	0.54	25	0	37	0	22	84
Tral	0.298	30	0.138	21	0	3	54
Pampore	0.156	35	0.018	30	0.03	2	67
Shopian	0.157	34	0.035	27	0	22	83
Baramulla	0.482	26	0.59	6	0	22	54
Kreeri	0.33	28	0.271	15	0	22	65
Sopore	1.686	14	0.079	24	0	22	60
Rafiabad	0.923	18	0.274	14	0	22	54
Uri	0.078	38	0.724	5	0	22	65
Pattan	1.541	15	0.44	8	0	22	45
Tangmarg	0.731	22	0.162	19	0	22	63
Boniyar	0.32	29	0.724	5	0	22	56
Bandipora	1.695	13	0.425	9	0	22	44
Sonawari	4.328	2	0.864	2	0	22	26
Gurez	0.104	37	0.009	32	0	22	91
Kupwara	2.365	7	0.927	1	0	22	30
Hundwara	3.382	3	0.845	3	0	22	28
Karnah	0.116	36	0.308	12	0	22	73

Source*: Financial commissioner's office, Srinagar 2011 and 2017,*
Field survey, 2017

Table 2: Levels of Agricultural Efficiency Regions

Particulars	Levels of Agricultural Efficiency		
	High (< 49.3)	Medium (49.4-72.6)	Low (>72.7)
Name of Tehsils	Beerwah, chadoora, Doru, Bandipora, Sonawari, Kupwara, Hundwara Kokernag, Bijbehara	Ganderbal ,Kangan, Lar, Budgam, Anantnag, Shangus, Pahalgam, Kulgam, D.H Pora, Devsar, Tral, Pulwama, pampore, Baramullah, Kreeri, Sopore, Uri, Rafiabad, patten, Tangmarg, Boniyar,	Srinagar 'N', Srinagar 'S', Khag, Charisharief, Awantipora, Shopian, Gurez, Karnah , Khanshb
Total	09	21	09



Source: Generated from table 1and 2

Fig.12

High agricultural efficiency region: The first category area comprises tehsils of Berwah, Chadoora, Dooru, Sonawari, Kupwara, Bandipora, Hundwara, Kokernag, Bijbehara, Out of thirty-nine tehsils, nine were found in this category (Table 2 & Fig. 12). The composite index of these tehsils is < 49.3. It is due to factors like high agricultural productivity in paddy, maize, and wheat, more area under these crops, favorable geographical conditions. Similar research were carried out by number of researchers like Dutta 2012, Ganie 2016, Shafi1960

Medium agricultural efficiency region: Most of the tehsils of Kashmir valley in this category. The composite index of these tehsils ranges between 49.4-72.6.it includes tehsils like Ganderbal, Kangan, Lar etc. (Table 2 & Fig. 12).

Low agricultural efficiency region: The composite value of all these tehsils falling in this category ranges above 72.7. The reasons are attributed low productive soils, low irrigation facilities, and Socio-economic backwardness, traditional practices in place and low awareness regarding scientific methods and HYV seeds and most important the conversion of agricultural land into horticulture and built up.

As conclusions and suggestions, the fluctuation in the production, as well as productivity, is also realized along with the fluctuation in the area under cultivation. A change

in area under cultivation is always accompanied by a change in production and yield of the food grains. The study shows that the productivity of paddy, maize, and wheat is showing an increasing trend among all tehsils of Kashmir valley from 2011 to 2017but the area under these crops is decreasing at an alarming rate leading a food deficit. The study further shows the wide regional disparity in terms of agricultural efficiency and thus the study area was divided into three agricultural efficiency categories viz. high, Medium and low. Most of the tehsils of Kashmir valley fall under medium and low agricultural efficiency regions (30 tehsils), thus affecting the food security of Kashmir valley.So, agriculture planning is badly needed to curb this grave problem and impose restrictions to land conversion a burning issue nowadays. Rice promotion awareness programs by agricultural department need to be held at the lowest administrative level and HYV seeds and other allied requirements should be locally available at reasonable rates, besides legislation pertaining to the prohibition of encroachment of agricultural land must be implemented in letter and spirit to avoid the wanton conversion of productive agricultural land into another land use categories.

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