Spatial distribution of agricultural resources and food security: A case of Punjab Pakistan

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Abstract: Agriculture is Pakistan’s most vital sector and backbone of the economy, whose productivity depends upon several agricultural and natural resources. 19.8% of GDP of Pakistan’s economy is come from the agriculture sector and it employs 42.3% of the total work force. There are several agricultural resources which enhance the food production and helps in efficient production. Different regions of Pakistan have different type and amount of resources, these agricultural resources include land, water, livestock, agricultural credit, agricultural machinery, fertilizers and farm workers. The purpose of this study is to provide geographical intensity, district wise mapping of Punjab province of Pakistan. These maps illustrated the spatial distribution of districts in terms of crucial agricultural stocks which are important for higher food security. Then further econometric analysis is used to see the impact of various agricultural resources on food security. The study concluded that in overall availability of agricultural resources, Muzzafargarh, Sahiwal and Vehari districts are having abundance agricultural resources. With the increase in agricultural resources, more food will be produced which leads to increase the level of food security. Empirical investigation shows that Gini of Operational Farm Holding, Irrigated Area and Agricultural Machinery (Tractors) are significantly affecting the food security. The regression coefficients will direct the policy makers about what is the optimal combination of resources in terms of their importance for the food security, commercial importance of these input variables and assist them to prioritize their district wise spending using the geographical representations.

Subjects: Social Sciences; Development Studies; Economics, Finance, Business & Industry

Keywords: agriculture; food security; resources distribution; geographical; empirical

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PUBLIC INTEREST STATEMENT
Food security is a situation when all people at all times have physical and economic access towards sufficient, safe and nutritious food to meet their dietary needs for an active and healthy life. Food security is divided into three components; which are food availability, food access and food absorption. For better production and more availability of food, improvement and efficiency in agricultural production is required. The essential elements which involves in the agricultural production are land, water, livestock, agricultural credit, tractors, farm workers etc. This study examine and explains the availability of agricultural resources among districts of Punjab Pakistan, in order to investigate and cope with the problem of food insecurity.
1. Introduction
Agricultural resources play a very important role to promote the food security. There are several agricultural resources which helps efficiency in production and enhance the food production. Lack of agricultural resource availability and their distorted distribution lead to food shortage. Sustainable growth in food is possible only with the efficiency of agricultural growth and agricultural resource distribution (Mansoor, 2011). Pakistan’s agriculture is the backbone of the economy. 19.8% of GDP is come from the agriculture sector and it employs 42.3% of the total work force. It is the main source of livelihood for 66% of the country’s population. The agriculture sector has fairly large potential for growth (Government of Pakistan, 2015-16). The total geographical area in Pakistan is 79.6 million hectares, about which 27% area is under cultivation and 86% area is the irrigated area. 8.3 million hectares is the cropped production amount (SDPI, SDC & WFP, 2009).

Empirical and theoretical studies revealed that increase in expenditures on agriculture leads to higher agricultural output growth and poverty alleviation (Mellor, 1976). Lipton (2005) presented the historical trend that with the increase in the small farmers’ productivity in England, India and China; there had been considerable decline in poverty levels. For Pakistan to consistently increase its agricultural product, it is required from the government to insure adequate public funding to infrastructure and agricultural institutions. Government should focus on small farmers for high productivity, with wider net of support services coverage so that rural development can be achieved. Food security is a very complex concept which involves economic, social, cultural, environmental and political aspects. In order to really understand the food situation and the causes of food insecurity, it is important to understand the basic concept of food security. Food security has three main elements which are food availability, food access and food absorption (The World Food Summit, 1996).

Food production is the most ancient occupation where people started barter of wheat for meat or other goods. From that time up till now people are fighting to the scarcity of food that was first highlighted by Malthus. Between 1950s and 1970s, per capita food production and per capita agricultural production including food as well as non-edible agricultural products like cotton, sisal wool, and rubber all of them increased less than 1% per year in the developing countries as a whole, whereas the population growth was quite opposite. The unending hunger kills more people every day than disasters, disease or war. But this is when there is enough food to feed the entire population of the world twice. The reduction of poverty, hunger and food insecurity are an essential part of the Millennium Development Goals (MDGs) and are preconditions for economic development (United Nation, 2009).

The literature remains silent about the spatial distribution of the agricultural resources at districts level. Estimating and analyzing the spatial distribution of agricultural resources at districts level of Punjab province is important for several reasons; for example (Belcher, Nolan, & Phillips, 2005; Parker & Munroe, 2007) indicated the benefits of spatial externalities/distribution for agriculture such that it has great potential in efficient utilization of land, and hence ensuring environmental sustainability and welfare. Spatial externalities ensure increase in the returns of the farmer and can help in terms of organic farming, bio diversified crops, genetically and non-genetically modified crops. As food security is directly depend of agricultural production, more production means more food and these rural resources are the main component of agriculture. So in this paper we are trying to see the situation of all possible agricultural resources distribution through spatial distribution/mapping. As illustrated, the proper scope and combinations of policy depends on the particulars of the spatial externality and welfare concerns associated with the outcomes. This study will also be helpful for commercial purpose of the agriculture.

1.1. Problem statement
Punjab province is considered as the bread basket of Pakistan, it has fertile lands and vibrant irrigation system and is the backbone of the Pakistan’s agriculture. 38% of the Punjab’s Province population is at borderline while only 12% of the population is food secured (SDPI, SDC & WFP, 2009). Keeping in view the depth of this study has never been addressed in earlier research. Therefore there
is a great research gap to observe the impact of agricultural resources like land utilization, irrigation, fertilizer, literacy rate etc. on the food security of Punjab Pakistan.

1.2. Objectives of the study
Following are the proposed objectives:

• To analyze how the distribution of agricultural resources across the districts can affect the food security of Punjab.
• To map the agricultural resource distribution both at individual and overall level across the districts of Punjab.
• To examine the relationship among food security and agricultural resources in the district of Punjab province.

2. Methodology
This part of the paper exhibits the brief description of the target study area, data, data sources and analytical tools rendered to achieve the objectives of the study.

2.1. Study area, rationale and data description
Punjab is the largest province of Pakistan, Punjab produces lions’ share of staple food and cash crops like wheat (76%), rice (70%), sugarcane (68%) and cotton (69%) respectively (SDPI, SDC & WFP, 2009). Therefore, population of the country mainly depends upon Punjab for its food needs. The province has been stratified into 35 administrative units called districts. In most of the cases Chaniot and Nankana Sahib shown as not available in data due to the fact that these districts are newly formed and did not exist at the time of the data collection. But territories of these districts are included in the parent districts (i.e. Faisalabad and Toba Tek Singh, respectively) from which they were separated. As per best of our knowledge, distribution of resources like land, water/irrigation, livestock, agricultural credit, agricultural machinery, labor farmer’s etc. amongst the districts has yet not been empirically explored. In this regard, cross-sectional data is attained from various secondary data sources i.e. Multiple Indicator Cluster Survey (Government of Punjab, 2009), Punjab Agricultural Census Report 2010 (Government of Pakistan, 2012) and Food Insecurity in Pakistan 2009 (SDPI, SDC & WFP, 2009).

2.2. Data analytical tools
In this section the proposed analytical tools are explained which includes Gini Coefficient, Spatial distribution and Econometric modeling.

2.2.1. Gini coefficient
Gini Coefficient is a World Bank recommended tool to measure inequality. It is a mathematical measure to find out the extent of inequality of the assets, wealth etc. Its values lie between two extremes i.e. zero to one. First of all, we measured the inequality of the operational and ownership land holdings, and water availability by employing Gini coefficient. Land and Water are the most important resources in agricultural production; therefore, we explored the distribution (i.e. inequality/equality) of these resources by using aforesaid tool in the districts of the Punjab province of Pakistan.

To calculate the Gini coefficient of operational farm holding, two variables farm area by size of farm and number of farms by size of farm are used. Firstly we calculate the cumulative value and proportion of both variables, then calculate the polygon based on the proportion values of both variables, then take the sum of polygon values, then Gini value is calculated by $1 - (2 \times \text{sum of polygon})$. Variables used for Gini coefficient of ownership farm holding are owner farm total area and number of farms by size of farm. For Gini coefficient of irrigated area, total cultivated area by mode of irrigation and total actually irrigated variables are used. Data is taken from Agriculture Census Report 2010. Nine observations are used against each district and each variables which includes three categories of farms sizes (small, medium and large). Distribution of operational & ownership land
holdings and irrigated area were determined by employing the following mathematical expression of Gini Coefficient,

\[ \text{Gini coefficient} = \frac{\sum [X_i Y_i]}{\sum [X_i Y_i]} \]

where \( X_i \) = Cumulative percentage of frequency with respect to number of farms corresponding to the size of class \( (X_i = 1, 2, 3, \ldots, n) \); \( Y_i \) = Cumulative percentage of frequency with respect to farm area corresponding to the size of class \( (Y_i = 1, 2, 3, \ldots, n) \); \( X_{i+1} \) and \( Y_{i+1} \) = Preceding observation of \( X_i \) and \( Y_i \).

2.2.2. Spatial distribution/mapping
Spatial distribution/mapping is rendered to observe the geographical distribution of the target indicators being used in the study. In this regard, this particular endeavor is undertaken by using Adobe Photoshop Software. Numerical values of each variable are divided into five groups equally weighted, started from rich to poor availability of each particular agricultural resource. Then make boundaries around each district on the map using Adobe Photoshop Software. Furthermore, filled with different colors, starting from “Red” indicating adverse conditions and ending at “Green” showing highly promising condition for that particular district by filling different colors in the map to the concerned districts of the province with relevant resources bestowed in them and their distribution. Variables used to show the spatial distribution of agricultural resources are; Gini of operational land holding, Gini of ownership land holding, Land use intensity, Cropping intensity, Agricultural land ownership titles, Gini of irrigated area, Ratio of irrigated area to total cultivated area, Ratio of canal irrigation to total cultivated area, Ratio of tubewell irrigation to total cultivated area, Ratio of canal & tubewell irrigation to total cultivated area, overall agricultural credit Institutional agricultural credit, Non-Institutional agricultural credit, agricultural machinery, Farm work animals percentage, Livestock population per acre, Milk & meat animals per hectare, Farmer’s literacy rate, Ratio of male farm’s workers to total farm workers and Ratio of female farm’s workers to total farm workers. All the aspects that effect food security are highlighted in the Figure 1.

2.2.3. Econometric models
Multiple Linear Regression model is used by employing ordinary Least Square (OLS) method of estimation, to observe the changes in dependent variable in response to the fluctuations in independent variables under study. Food insecure population (%) is taken as dependent variable in the model, while Gini Coefficient of Operational Farm Holding (OPFH) and Ratio of Canal & Tubewell Irrigation to Total Cultivated Area (CTI), Ratio of Institutional Agricultural Credit to number of Farms (IAC), Agricultural Machinery- Tractors (TRAC), Milk and Meat Animals/Hect (MMA), Livestock Population/Acre (LP), Ratio of rural population to total population (RP), Fertilizers, Pesticides and Herbicides (CHEM), Farmer’s Literacy Rate (FLR), Male Farm’s and Workers per Acre (MW) are used as independent variables.

\[ \text{Food security} = \alpha + \beta_1 \text{OPFH} + \beta_2 \text{CTI} + \beta_3 \text{IAC} + \beta_4 \text{TRAC} + \beta_5 \text{MMA} + \beta_6 \text{LP} + \beta_7 \text{RP} + \beta_8 \text{CHEM} + \beta_9 \text{FLR} + \beta_{10} \text{MW} + e \]
3. Results and discussion

3.1. Spatial distribution of agricultural resources

In the following section, intensity map illustration is shown for each variable, to show what the district wise scenario. It will help us to identify how they are distributed and how they are affecting the main issue of food security which is under focus. In each section of agricultural resources, we are also demonstrate their literature review in the context of food security with the particular resource area.

3.1.1. Distribution of land

Land is one of the input in food production which has its limitations. It is for sure that same land is require for the agriculture production, food processing factories, recreational parks, offices and last but not least for our homes. So the use of land available for production is expected to play its role in the amount of food output. The variables used in case of land distributions are Gini of operational land holding, Gini of ownership land holding, Land use intensity, Cropping intensity and Agricultural land ownership titles. Following are some studies which shed some light on the role of land/farm in the food security.

Kiani (2008) examined the farm size and productivity in Pakistan. She used Cobb-douglas production function to find the relationship between different farm size and productivity. The following variable were used; value of output as dependent variable and total cultivated area, irrigated area, fertilizer, labor, tractors, and seed, cropping intensity and farm size as independent variables. She finds out that there is a negative but insignificant coefficient between output per cultivated acre and farm size, consequently it can be said that small farmers can be more productive. Ibrahim and Bello (2009) analyzed the food security and resource allocation status of farming households in Nigeria. They collected data about labor input, capital input, output and prices of inputs and outputs, farmer socio-economic characteristic such as age, farming experience in crop production, level of education, household size and credit use, income, farm size, age of household head, membership of cooperative society, educational status, access to consumption credit, quality of food from own production and household size. They observed that majority of the farming households are food insecure (58.9%). Food insecure household should be encouraged to increase the production of cassava, Yam and maize to enhance their food security status. Family planning technique should be introduced among farming households for food security purpose. Broek, Newman, Tarp, Quang, and Khai (2011) observed the distribution of land use rights/property rights in Vietnam, they select 12 provinces of Vietnam. They find out that the land with exclusive title have the positive effect on yield. They also observed that Male headed households with positive effect are inefficient while the female headed household’s exclusive title land have greater positive effect of efficiency on yield. They suggest that there should be an approach to help those minorities and poor people who do not have formal land title. Abbasi (2012) analyzed that the conditions of agriculture farm activities were very poor because technology and policy intervention were not strong for them. He concluded that the relationship between corporate farming and food security is not good enough. Rockson, Bennett, and Groenendijk (2013) examined that land administration provide secure land tenure, support for implementation of agricultural policies, access to credit, less litigation, easier land dealings, land taxation, land inventories, and land transaction controls. Moreover, they concluded that how land administration support the food security at conceptual, strategic and operational level. They analyzed that the relationship between land administration and food security appears to be conceptually agreed upon; however, at operational levels the link is less evident. In summary, it can be said that the efficient use of land by providing land reforms or better agricultural techniques can be the source of increase in the food security for the people.

In order to find out the situation of land distribution we use Gini coefficient of operational farm holding, Gini of ownership holdings, land use intensities, agricultural land ownership title (%) and ratios of fragmented farms to cultivated area.
In case of spatial distribution of equality of operational land holding and ownership holding all the districts of Punjab province are facing severe inequality in the distribution, as red color indicate the severe condition of the particular resource distribution. The values of Gini coefficients, given in the figures above from 0.663 and culminate in 0.881 which is a serious matter of concern.

Bahawalnagar, Layyah and Bhakhar are the districts where the land use intensity is very low, Okara, Sargodha and Hafizabad are also having low land use intensity. While Rawalpindi, Jhelum, Gujrat, Sialkot, Mianwali and Vehari are having very high level of land distribution.

In case of cropping intensity most of the districts are on the safe side, having high level of cropping intensity. Only Layyah is found in the dangerous situation. Sargodha, Bhakhar, Hafizabad and Bahawalnagar are found in the category of low cropping intensity. In medium category of the distribution of cropping intensity, R.Y. Khan, D. G. Khan, Okara, Bhakhar and Attock are established. Except these low and medium categories all other variables are found in the high category of cropping intensity in the distribution.

Figure 5 referred that Lahore is at very poor condition in case of agricultural land ownership titles. Sialkot, Gujranwala, Sheikhupura and Multan are found in the low category distribution of agricultural land ownership titles. Rajanpur and Layyah are better in this contribution. While Attock, Rawalpindi, Gujrat, Sargodha, Hafizabad, Sahiwal, Vehari and Pakpattan are the medium category districts. Rest of the districts showing in the dark and light green colors are the highly categorized districts in the distribution of agricultural land ownership.

There might be multiple reasons of best land distribution in Rawalpindi district due to the fact that this city is neighboring to the country's capital Islamabad and head quarter of armed forces. Therefore, there might be more/lucrative job opportunities in civil as well as in armed forces in the...
said district which would have reduced farming business charms for the population. Moreover, the district belong to arid zone with least surface irrigation facilities due to its hilly terrain which is not much fit for the agricultural production. Overall land holding size is small in the district and perhaps that is why small farmers prefer to lease out their lands and like to work in twin city of Islamabad and Rawalpindi. District Pakpattan represent area with leased land distribution disparities. Pakpattan district is located in cotton–Wheat zone of the Punjab province. Cotton, being one of the major cash crops of the area, may have motivated land markets in the area which have created natural balance of operational land holdings. But this argument could be further probed to confirm the reality in some future research endeavors.

Figure 3 exhibits results of Gini Coefficient of land ownership holdings along with its district ranking in the province. It is very interesting to explore that Rawalpindi district lies at the extreme top position with its smallest Gini Coefficient value of land ownership holdings. As far as district wise ranking of land use intensities are concerned, the results in Figure 4 shows that Rawalpindi district has the least while district Khushab is at the top with highest level of land use intensity amongst all of the districts of the Punjab province. The results of Figures 3–5 are absolutely in-line with each other in case of ranking of Rawalpindi district whether it is operational/ownership land holdings or land use intensity. The districts having large number of small farmers, have tilled more intensively as compared to others and have proven decade’s old famous concept of inverse relationship in agricultural sector (Unal, 2008). It is evident that most of the districts with highest percentage of land ownership title belong to southern part of the province where ratio of rural population is considerably greater than the civic ones. In addition, more rural population means greater dependence on agriculture sector and, consequently, larger percentage of land ownership titles. More urban population means less dependence on agriculture and, consequently, small percentage of land ownership titles (Figure 5).
Figure 4. Land use intensity.

Source: Prepared by author using software.

Figure 5. Agricultural land ownership (%).

Source: Prepared by author using software.
3.1.2. Distribution of water

For better food production, availability of water and quality of water is very important. In this section the role of irrigation and mode of irrigation on food security will be analyzed. In case on mode of irrigation/water distribution we used Gini of irrigated area, Ratio of irrigated area to Total Cultivated Area, Ratio of canal irrigation to Total Cultivated Area, Ratio of Tubewell irrigation to Total Cultivated Area and Ratio of canal & tubewell irrigation to Total Cultivated Area.

Hussain and Hanjra (2004) reviewed the empirical research in Asia to study the linkages both direct and indirect between irrigation and poverty, role of irrigation in alleviating poverty. There were strong linkages between irrigation and poverty. Direct linkages operate by localized and household-level effects, and indirect linkages operate by aggregate and national level impacts. They also concluded that Irrigation is helpful for smallholders in more and efficient production; advance technologies like micro-irrigation have strong impact on alleviating poverty. Haq (2007) examined level of overall and provincial land inequality by mode of irrigation across two periods 1990 and 2000. She also examined the relative performance in achieving equity in land distribution by irrigation facilities. She used cross sectional data from two Agricultural census Reports of Pakistan. Theil’s entropy measure was used for analysis. Results showed that there is a significant level of increase in inequality in cultivated area irrigated by canal except in the NWFP whereas inequality in irrigated area by tubewell has increased in all provinces in 2000. Equity index of irrigated area was less in 1990 and it was increasing in 2000.

Hira (2009) analyzed the water management and food security in Northern States of India. Punjab, Haryana and Western Uttar Pardesh are the highly irrigated areas particularly in rice production. Punjab has 97% area under irrigation. Amount of balance of withdraw of ground water depends upon the rise and fall of the ground water in any region. There is a negative withdrawal in Punjab due
to many reasons which are Early Transplantation of Rice, Less Canal Irrigation and Plowing of Watercourses, Shift in Cropping Pattern, Large Area under Rice and Early Regular Supply of Subsidized Electric Power for Tube wells. Efficient mechanism is required for better performance of the irrigation system and there should be subsidies provided to the farmer's. Munir and Qureshi (2010) studied the scenario of global water crisis and future food security. Moreover, they also analyzed the impact of climate change, water scarcity, energy crisis and credit crisis on the food security. They concluded that the water for food security situation is complicated and might become scary if no action is taken. Investments to deal with climate change, preserving land and conserving water, reducing the energy footprint in food systems is necessary.

Hussain et al. (2012) analyzed the threats to rain fed and canal irrigated agro-ecosystem of the Punjab, Pakistan. They examined that Chakwal, Jehlum and Rawalpindi are the wheat growing districts in rain fed area and Chakwal is very rich in weed diversity. Sahiwal, Kasoor and Gujrat districts are the canal irrigated area. They concluded that the districts like Sahiwal and Kasoor are well educated about the use and importance of the weeds which help to maintain a level of food security. Pradhan (2012) motivating the irrigation and food security, there approaches and vision in the Nepal. He examined that the Water Resources Strategy outputs will contribute. For this purpose he analyzed the short, medium and long-term implementation of water strategies and irrigation system. He concluded that for the improvement in irrigation system, increasing agricultural production is mainly important. There are great possibilities of increasing agriculture production through right combination of good water management system and agriculture improvement technologies. Hence above review can conclude that to avoid food insecurity, agricultural production must rise as for this instance it is the availability of water in lower cost is necessary and rain water is not the safest source (Figure 7).

Figure 7. Ratio of irrigated area to total cultivated area.
Source: Prepared by author using software.
Irrigated area per acre is very low in Rawalpindi, Aottok, Chakwal and Sargodha. While the distribution in Bhakhar, Layyah and Jhang lies in medium category. In rest of the districts distribution of irrigated area per acre is high. The Figure 8 shows the equal/unequal distribution of irrigated area, like operational and ownership land holding, irrigated are also facing high level of unequal distribution (high level of inequality in the distribution of irrigated area) (Figure 9).

The situation of distribution of canal irrigation per acre is quite different as compared to overall irrigated area. Rawalpindi district is under the very low category of resource distribution of canal irrigation along with Attock, Chakwal, Jhelum, Gujrat, Gujranwala and Sialkot. Lahore and Kasur, these both districts are found in the rich resource of canal irrigation. Sargodha, Mianwali, Bhakhar and D. G. Khan are also lies in the high category of canal irrigation per acre. While Bahawalpur and Rajanpur lies in the medium category (Figure 10).

Tubewell Irrigation per acre is very alarming condition among the almost all districts of Punjab. Only three districts are having high distribution of tubewell/Acre which are Okara, Nankana Sahib and Sialkot. While Jhang, Hafizabad, Gujranwala and Gujrat are with medium level of distribution. Rest of all the districts of Punjab province are at worst situation of this distribution.

Figure 11 represents the distribution scenario of both canal and tubewell irrigation per acre together. Mix results have been found in all of the districts regarding the target indicators here. However, in most of the cases districts belonging to Barani region of the province are found in low category.
Figure 9. Ratio of canal irrigation to total cultivated area.
Source: Prepared by author using software.

Figure 10. Ratio of tubewell irrigation to total cultivated area.
Source: Prepared by author using software.
3.1.3. Distribution of agricultural credit
In order to equip farmer with state of the art production mechanism, farmers face a hindrance of cost, easy availability of technology can allow the farmers to adopt to new more efficient production mechanisms. Here below the role of Government in providing easy access of technology to farmers and its impact on food security is discussed. There are two type of agricultural credit are used i.e. Institutional Agricultural credit and Non-Institutional agricultural credit including overall agricultural credit.

Ninno, Dorosh, and Subbarao (2007) examined the food aid and food security of four countries of two regions i.e. India & Bangladesh from South Asia and Ethiopia and Zambia from sub-Saharan Africa in the context of food production, trade and markets. They concluded that food aid has positive effect in reducing food insecurity and enhancing food security among households. Hema, Rodrigo, and Findeis (2010) examined the impact of gender access to credit on labor allocation in Malawi. They found that access to credit both formal and informal depends upon both genders. They also concluded that formal credit programs aimed to provide credit to women for their self-employment in household or farm production which contributes to enhance their income and improve welfare and better living status of households. Miller, Tsoka, and Reichert (2011) analyzed the impact of the cash transfer scheme on food security in Malawi. For analysis data collected from three round of survey of Social Cash Transfer Scheme (SCTS) in Malawi from March 2007, September 2007 and April 2008. The SCTS proved to be an effective tool for improving food security of the poor households in the country. Social Cash Transfer Scheme benefited more to female headed households as compared to male headed households because female are economically more poor than male (Figures 12 and 13).

The above results of spatial distribution of total agricultural credit and institutional agriculture credit are almost same. Rawalpindi, Chakwal, Gujrat, Lahore and Jhang are the districts having low
Figure 12. Ratio of total farmer's agricultural credit to number of farms.

Source: Prepared by author using software.

Figure 13. Institutional agricultural credit to number of farms.

Source: Prepared by author using software.
distribution of agricultural credit per farm. Hafizabad is found rich in resource of agricultural credit both in total and institutional type of credit. Bahawalpur is also at top in case of institutional agricultural credit in spatial distribution. Farms and households if have higher agricultural credit, then the access to better technology and productivity techniques will be easier, and can lead to increase in the agricultural output. Institutional credit help farmers to buy tractors and new machinery that can help in fast harvesting of crops. This credit is surely beneficial for the reduction in the food insecurity. In Total agricultural credit and Institutional agricultural credit, Jehlum and Rawalpindi districts are at the highest rank.

There might be multiple reasons of best land distribution in Rawalpindi district due to the fact that this city is neighboring to the country’s capital Islamabad and head quarter of armed forces. Therefore, there might be more/lucrative job opportunities in civil as well as in armed forces in the said district which would have reduced farming business charms for the population. Moreover, the district belong to arid zone with least surface irrigation facilities due to its hilly terrain which is not much fit for the agricultural production. Overall land holding size is small in the district and perhaps that is why small farmers prefer to lease out their lands and like to work in twin city of Islamabad and Rawalpindi. Hafizabad district is at the lowest rank which means that Hafizabad is getting more agricultural credit per farms. Hafizabad is cash crop district of the Punjab Pakistan and it is the top rice producer in Pakistan. While R. Y. Khan, Sheikhpura and Bhakhar districts are at middle rank in Punjab Province (Figure 14).

In case of spatial distribution of Non-Institutional Agricultural Credit/Total Cultivated Area, Jehlum and Sahiwal Districts are at the highest position while Mandi Bahauddin and Attock are at lowest. Multan, Kasur and R.Y. Khan are at middle in Punjab Province.

Figure 14. Non-institutional agricultural credit.

Source: Prepared by author using software.
3.1.4. Distribution of agricultural machinery

Tractors are the main source of agricultural machinery and known as agricultural inputs. Meanwhile, Fertilizers, Pesticides and Herbicides also play an important role. In order to find out the distribution of agricultural machinery/agricultural inputs percentage of Tractors are used (Figure 15).

Spatial distribution of Agricultural Machinery explored that most of the districts are having the facility of agricultural machinery (tractors). Vehari, Attock, Gujrat, Hafizabad and Narowal are highest at the distribution of this resource. Layyah, Lodhran, Faisalabad, Lahore and Sargodha are the worse in the availability of agricultural machinery. While in the context of middle category D. G. Khan, Bhakkar, Okara, khushab, Jhelum, T. T. Singh and Mandi Bahauddin come forward. Rests of the districts are also facing the high availability and distribution of resource.

3.1.5. Distribution of livestock and farm work animals

Most of the farmers use livestock as a supplement source of income, food or assist in farm. Variables used for spatial distribution are farm work animal's percentage, livestock population per acre and milk & meat animals per hectare.

Following studies has been selected to observe the role of livestock in food security. Livestock's has significant impact on achieving food security of households. With the increase in the small & large livestock it leads to increase in the food security level. Hence it can be seen that livestock especially female livestock help the household in terms of their nutrition, financial health as well as their male offspring's can be used to increase food supply (Bashir, Schilizzi, & Pandit, 2012). Adams (1996) explained that total income decompose into five following sources which are agricultural, nonfarm, livestock, rental and transfer. They concluded that the income from male/female animals have different effect on income distribution while livestock income from male animals have negative
effect on income distribution and female animals have positive effect on income distribution. Randolph et al. (2007) and Alary, Corniaux, and Gautier (2011) found positive link between livestock and human nutrition & health. Moreover, they concluded that increase in the livestock population leads to reducing poverty and improving human’s health. Therefore, they suggest that government must intervene to promote livestock contribution in alleviating poverty (Figure 16).

The situation of spatial distribution of farm animal is worse among the district of the Punjab province. Few districts are rich in farm work animals. Sheikhpura is the district which is having high availability of farm work animals. While Muzafargarh and Nankana Sahib lies in the middle category. Except these all other districts are facing very low level of distribution/availability of farm work animals.

There is a mix situation among distribution of livestock population per acre in Punjab province. Lahore, Lodhran, Multan, Muzafargarh and D. G. Khan are the districts having high availability of livestock population per acre. Gujranwala, Hafizabad and Mandi Bahauddin are the districts with very low contribution of livestock population per acre. Rajanpur, Bahawalpur, Vehari, Layyah, Sargodha and Khushab lies in the middle category. Rests of the maximum districts are facing low availability of livestock resource (Figure 17).

Figure 18 shows the spatial distribution of Milk and Meat animals, where Lahore, D. G Khan and Muzafargarh are found in the high level distribution/availability of this resource. R. Y. Khan, Bahawalpur, Multan, Jhang, Sahiwal, Pakpattan and Rawalpindi are the middle category in milk and meat animals’ availability.
Figure 17. Livestock population per acre.

Source: Prepared by author using software.

Figure 18. Milk and meat animals per hectare.

Source: Prepared by author using software.
3.1.6. Distribution of infrastructure for human capital

Labor and capital are two major factors in production, so in terms of agricultural food production the role and interaction of labor and capital are playing vital role. Nutrition plays a role in enhancing educational outcomes. Education has a direct effect on the weight dependent anthropometric measures and an indirect effect on the long-term measure of nutritional status. Female education had a direct effect on the food intake measure. Following are studies which intend to shed light on the role of human capital on food security. Mukudi (2003) and Cook et al. (2004) observed the association between food security and the adverse health outcomes among human infant and toddlers with the age of less than 36 months. The food-insecure children had chances of “fair or poor” health nearly twice as great, and chances of being hospitalized since birth almost a third larger than food-secure children. A dose-response relation found between poor health status and food insecurity. Bhattacharyaa, Currieeb, and Haider (2004) find out that among school going children both poverty and food insecurity are not related to nutritional outcomes while the adults are associated with nutritional outcomes both in poverty and food insecurity. Burchi (2006) analyzed that in both theoretically and empirically education promotes development and food security. Both the Human Capital Approach and the Human Development Approach stress the importance of investments in education. Moreover, they also concluded that an increase of children's school attendance rate basic education by 100% can decrease food insecurity by 22%. Rehman and Khan (2012) examine the human capital regional disparities and analyze the level of human capital in different regions of Pakistan particularly rural-urban comparison in descriptive analysis. They divided human development into three different categories of the four provinces of Pakistan. Statistics on human capital for Pakistan showed this significant difference, where mean human capital for rural areas is 0.46 and for the urban areas it is 0.64. They suggested that through investment in human capital we can enhance the skills of workforce and there is a dire need to collect more funds for this purpose so that they can be used to reduce food insecurity. Verwimp (2012) examined that how violent conflict and human capital affects the food of the average farm households. He analyzed that income source of the farm households effect the food intake. He concluded that there is long time period required to improve the human capital and create mechanisms which maintain the level of food intake. Ahmad and Heng (2012) examined that the human capital is the second important agriculture productivity growth in Pakistan. Agriculture credit also playing significant role but the area under crop is statistically insignificant. To enhance the agriculture productivity growth government should intervene by providing skill training workshops. According to the (Stephen, 2012) there is positive correlation between demand for education and the level of economic growth in Nigeria. It is visible from the above studies that increase in the ability of humans using better nutrition or learning better skills, does cause better performance in the farm, hence human capital as a whole can assist in rise in food security (Figure 19).

Spatial distribution of farmer's literacy rate shows that Lahore, Faisalabad, Gujranwala, Gujrat, Jhang, Attock, Rawalpindi districts are having highly literate farmers. About half of the province has rich resource of educated farmers. Rajanpur, R. Y. Khan, Lodhran, Pakpattan, Layyah and Bhakkar are the districts where the contribution of the educated farmers is very poor. Figure shows that Bahawalpur, D. G. Khan, Muzafargarh and Multan are the middle category of farmer's literacy rate. It has been witnessed that most of the southern Punjab districts are deprived in the context of farmer's literacy rates while central and northern districts are well-endowed and bestowed with famer's literacy rate. This might be due to the fact that southern Punjab districts have to just rely on public sector schools and those areas do not have available this facility by private sector. Moreover, the population of these areas mostly belongs to rural regions which is characterized as backwards and laggards. Moreover, governments need to focus on southern Punjab districts to cater up to the mark educational facilities if they intend to bring them at par to the central and northern Punjab population (Figure 20).

In case of distribution of male farm works (family worker and hired worker), mostly districts are with low availability of labor resource. Only Hafizabad and Sheikhpura, Lahore, Gujrat and Gujranwala are the districts on secure side of this distribution. Few districts are found in the medium availability
Figure 19. Farmer’s literacy rate (%).
Source: Prepared by author using software.

Figure 20. Ratio of male farm’s workers to total farm workers.
Source: Prepared by author using software.
Figure 21. Ratio of female farm’s workers to total farm workers.

Source: Prepared by author using software.

Figure 22. Scenario of overall availability of agricultural resources.

Source: Prepared by author using software.
neither high nor low those districts includes Bhawalnagar, Sahiwal, Pakpattan, Kasur, Bhakhar and Faisalabad. The situation in both southern and northern area is very poor in male labor availability. Figure 21 represent the distribution of the female workers, the situation of distribution of female worker is opposite to the male workers. Hafizabad and Sheikhpura are the districts with very low availability of female workers.

3.1.7. Cumulative distribution of all agricultural resources

The cumulative is sum of all the variables related to agriculture resources and food security. Hence all the districts are now comparable with each other in terms of their agricultural performance. If we see number wise, Muzaffargarh, Vehari, Sahiwal, Gujrat and Khanewal are rich in availability of agricultural resource distribution because these districts are found in southern region in Punjab province. Multan, Jhehlum, Rawalpindi, Faisalabad and Mandi Bahauddin are the districts with medium level of availability of agricultural resources. Layyah, Sargodha, Bahwalnagar, Hafizabad and Bhakhar are the districts with worse situation of availability of rural resources. Bhakhar are the region of dunes that’s why rural resources are very low there. These numbers shows that there is a majority of districts in Punjab who are performing satisfactorily in terms of food security but if concentration given to this overall scenario can be improved considerably (Figure 22).

3.2. Econometric model

Following are the results of the regression model, determining the Food Insecure Population with the help of indicators of agricultural resources (Table 1).

IA and TRAC are significantly affecting the FIP; increase in one unit of OPFH will reduce the FIP by 62 units. The reason behind that Pakistan has highest percentage of small farmers and the highest concentration of the population living in the rural areas. All of them are dependent on Agricultural sector while the food production reduces day by day and there is shortage of surplus in rice export. Our finding is similar to the (Kiani, 2008) which concluded negative but insignificant correlation between output per cultivated acre and farm size. There is not enough good relationship between corporate farming and food security (Abbasi, 2012). one percentage increase in IA leads to 74 units decrease in the inequality in water distribution and increase. There is a significant level of increase in cultivated area irrigated by canal except in the NWFP whereas inequality in irrigated area by tube-well has increased in all provinces in 2000 (Haq, 2007). Livestock population has positive relationship with food security.

| Table 1. Regression analysis                                                                 |
|---------------------------------------------------------------------------------------------|
| Dependent variable = Food insecure population (%) Co-linearity statistics                     |
| Coefficient | p-value | Tolerance | VIF |
| (Constant)  | −14.43  | 0.756     |     |
| Gini of operational farm holding (OPFH)          | −62.513 | 0.097*** | 0.534 | 1.87 |
| Irrigated area (IA)                              | 74.512  | 0.058**  | 0.512 | 1.96 |
| Livestock population/acre (LP)                   | 15.204  | 0.101     | 0.502 | 1.97 |
| Milk & meat animals/hect (MMA)                   | 1.688   | 0.171     | 0.689 | 1.45 |
| Male farm workers (MFW)                          | −0.054  | 0.824     | 0.395 | 2.53 |
| Institutional agricultural credit (IAC)          | −3.492  | 0.197     | 0.410 | 2.44 |
| Farmer’s literacy rate (FLR)                     | −0.140  | 0.227     | 0.408 | 2.45 |
| Rural population (RP)                            | 10.126  | 0.260     | 0.509 | 1.96 |
| Chemicals–fertilizers (CHEM)                     | 0.0142  | 0.573     | 0.468 | 2.14 |
| Tractors-agricultural machinery (TRAC)            | 0.435   | 0.058**   | 0.502 | 1.99 |

Notes: $R^2 = 0.601$; $F$-stat = 3.32; $p$-value of model = 0.009.
*Significant at 1% level of significance.
**Significant at 5% level of significance.
***Significant at 10% level of significance.
4. Conclusion and policy implications

Food insecurity being major cause of concern for the high population countries, this study is constricted to highlight what is the scenario of food related indicators for the districts of one of the most economically active province of Pakistan. So that we will be able to see what is the scenario of the poorest performing district as compared to the average performing district in terms of the dispersion of the agricultural resources. This paper intended to show the geographical scenarios of several economic indicators (Gini coefficients and ratios) related to food security and it reveals that most of the cases it is the southern and western Punjab which shows deprivation of economic resources. The study could be instrumental for the policy makers to target certain areas as in this study cumulative availability of resources for each district in terms of all of its resources are constructed, which advocated that Muzafargarh ranked highest as per amount of aggregate resources, whereas Bhakhar ranked lowest. Moreover in order to tackle the food insecurity, individuals and government have to focus on many fronts as with the increase in population, the current 40% food insecure population of Punjab will be facing higher degree of problems for their survival. Agricultural departments of each district should urge the farmers to learn and adopt latest techniques, and the commercial banks should ensure that credit should only be provided to the neediest districts like Rajanpur which is most poor.

The regression analysis shows the importance of the efficient use of fertilizers and the literacy of the district, which directs on the importance of education as it surely increases the awareness among farmers for timely use of fertilizers. Many farmers in Pakistan are stuck with the norms and they are reluctant toward acquiring agricultural credit and machinery for higher productivity and adopting, increase in literacy rate can help in countering this problem. In order to increase food production, proper utilization of land is one of the most important variables. Just like land utilization, irrigation proved to be crucial for food security too. Empirical results shows that Irrigation is casing food security, employment to rise and poverty to fall. Surprisingly, increase in the livestock population and female family workers showed negative proportional effect on food security which reasoned that per unit production of livestock is not as productive as crop output per unit area. Female farm workers are not primary workers in the field because of their physical nature and they are less efficient.

The analysis on agricultural resources and food security in this study reveals that there are some policy related factors which are root determinants for the higher agricultural production and hence higher food security. The policy related factors are land availability for cultivation, water availability for irrigation, education level of farmers and credit availability on time, along with all these factors agricultural output is very sensitive. Disturbing them will lead to less agricultural production, less availability of food and hence undernourishment. The regression coefficients will direct the policy makers about what is the optimal combination of resources in terms of their importance for the food security, commercial importance of these input variables and assist them to prioritize their district wise spending using the geographical representations.

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References
Abbasi, Z. F. (2012). Corporate agriculture farming the role of corporate sector. Islamabad. Retrieved from www.impactconsulting.com.pk
Adams, Jr., R. H. (1996). Livestock income, male/female animals and inequalities in rural Pakistan (Discussion Paper No. 21).
Ahmad, K., & Heng, T. (2012). Determinants of agriculture productivity growth in Pakistan. International Research Journal of Finance and Economics, 95, 163–173.
Alary, V., Corniaux, C., & Gautier, D. (2011). Livestock’s contribution to poverty alleviation: How to measure it? World Development, 39, 1638–1648. https://doi.org/10.1016/j.worlddev.2011.02.008
Appendix 1. Overall scenario of the availability of rural resources in the districts of Punjab.

| District         | Rank | District   | Rank | District   | Rank |
|------------------|------|------------|------|------------|------|
| Muzaffargarh     | 1    | Narowal    | 13   | Okara      | 25   |
| Sahiwal          | 2    | Kasur      | 14   | Gujranwala | 26   |
| Vehari           | 3    | Jhang      | 15   | Attock     | 27   |
| Gujrat           | 4    | TSingh     | 16   | Mianwali   | 28   |
| Khanewal         | 5    | Multan     | 17   | RY Khan    | 29   |
| Sialkot          | 6    | Jehlum     | 18   | Khushab    | 30   |
| Rajanpur         | 7    | Rawalpindi | 19   | Sargodha   | 31   |
| Balawalpur       | 8    | Faisalabad | 20   | Layyah     | 32   |
| Nankana Sahib    | 9    | Mandi Bahauddin | 21 | Bahawalnagar | 33 |
| Lodhran          | 10   | Chakwal    | 22   | Hafizabad  | 34   |
| Lahore           | 11   | Pakpattan  | 23   | Bhakhar    | 35   |
| DG Khan          | 12   | Sheikhpura | 24   |            |      |

Source: Author’s estimation