ANALYSIS OF THE APMC MARKET AGRICULTURE REVENUE IN KARNATAKA

Abstract

Agriculture revenue is the primary economic source for farmers, but rural livelihoods are influenced by climate and market price changes. Farmers aim to increase output and revenue through various practices to the regional disparities. Since 2011, crop revenue has increased more than previous for paddy, maize, groundnut, ragi, and jowar crops, while groundnut revenue decreased from 2013. Paddy revenue is highly volatile, while ragi crop revenue is the least volatile. At the district level Yadgiri, Bengaluru Rural are most volatile and Vijayapura, Bidar are the least volatile. The study found higher revenue since 2009 across all regions and crops, with positive Pearson's correlation coefficients indicating a linear trend of revenue growth. Tunga-Bhadra River basin districts such as Raichur, Koppal, followed by Haveri, Davanagere, Shivamogga and Ballari received higher revenue.

Keywords: Regional disparities, Climate change, Volatility in quantity arrival and prices.

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I. INTRODUCTION

Agriculture revenue is a significant economic source for rural and farmer-dependent Karnataka. Regional disparities in climate, seasonal volatility, soil types, fertility, irrigation sources, water availability, price variations, and market quantity impact on crop output and price changes also affect crop revenue. Reforms in the agriculture sector can improve crop productivity through modern infrastructure, aggregation of scale, and market access. The output of the crop is different across the district and State due to different practices to the agro-climatic regions. Price variations and quantity arrivals to the market are significant reasons to the changes and variability in revenue over time. The revenue of crops varies based on the regional climatic pattern in different seasons across the State. Difference in the crop seeds quality, duration of cultivation, methods of cultivation and knowledge (ancient or modern methods of cultivation), usage of technology, expenditure on crop production, distance to the market and traveling costs affecting revenue.

Farmers sell their crop production in local markets for higher prices and income, often selling to other markets across the state. District revenue is derived from crop quantity sold in the district, which may not always come from the local farmer's own production. Economic factors like consumer demands, imports, exports, inflation rates, market conditions, marketing knowledge, and infrastructure facilities also influence revenue. The study uses the quantity arrival and price of crop sold in the APMC market to calculate revenue. The district level revenue has been estimated for the major crops of Karnataka such as Jowar, Paddy, Ragi, and Maize from cereals, and Groundnut from oilseed crops.

According to Directorate of Economics and Statistics the agricultural area and production data spans over 20 years from 1998-99 to 2017-18, Karnataka mainly produces paddy, maize, jowar, ragi, tur, and gram, groundnut in oilseeds, and cotton, sugarcane, coffee as cash crops, chilli and tomato from vegetables, and horticulture crops. And the Economic Survey Report (2015-16) explains that maize, ragi, jowar, groundnut, bajra, and cotton are the substitute crops to paddy cultivation. Dakshina Kannada district produces predominantly paddy crop, Udupi grows paddy besides groundnut and Yadgir producing paddy, groundnut, and jowar crops.

II. REVIEW OF LITERATURE

Improving farmer’s income has been of great focus for the government recently. Due to the crop loss in the different seasons, weather conditions are volatile over the period across the State and Nation to stop the farmers' indebtedness, migration of labors, crop diversification, hunger, and poverty. According to Lama (2019), crop diversification activities come to the mainstream to double the farmers' income, such as cultivating fruit crops, cash crops, floriculture, fishery, and mixed cropping patterns. These diversification activities are interlinked with agriculture revenue. Farmers’ income growth is purely dependent upon the crop output and price of crop sold, but profit depends on production costs.

Satyasai's (2016) A report offers government ways to increase farmers' income and slow the growth of agriculture costs. Bhalla and Singh (2009) and Vaidyanathan (2010) explain, Farmers are increasing non-farming activities in the State to generate extra income as a result of weather affects. Kannan (2011) explains Crop loss as a result of seasonal

weather and climatic pattern fluctuations, as well as a lack of production and marketing skills are the main causes of the differences in farmers' income. Changes in production, marketing, and agricultural practices will all contribute to increased profitability. Deshpande (2004) and Venkatachalam (2003) shows that the revenue of farmers can increase with greater infrastructure amenities, including roads and transportation, markets, irrigation systems, industrial operations related to agriculture, and other resources. If crop losses consistently lower the farmer's income and profit, they stop working in agriculture. So, according to Satyasai and Nirupam (2016), the growth in crop revenue than production cost can boost the farmers and stop them from diversifications and migrations. Bhattacharyya (2008), Chand and Raju (2009) observed that mainly with the aid of technology, machinery, fertilizers, and pesticides, small farmers are greatly expanding their product lines. Due to marginal and small farmers using 85% of the land.

Salvatore et al. (2011) examined the large fluctuation in climate variables and higher/extreme changes in weather are responsible for qualitative changes in agricultural production and revenue, which are only positively impacted by adaptation measures. Ringler and You (2010) noted that rainfall had a major influence on the changes in crop yield and income. The increase in log-run rainfall of 100 mm will have a negative impact on the 106kg of yield. Additionally, the same increase has observed the yield by 111 kg in the short term. According to research by Dinar et al. (2008), farmers who use adaptation strategies to combat climate change produce more food and earn more money than those who don't. Deressa et al. (2008) found that farmers' behavior in adapting to fertilizer was negatively correlated with farm revenue and production over the long term because of high application. According to Schlenker et al. (2005), the climate change-related variability also affects the availability of irrigated regions. Nguyen et al. (2020) discovered a nonlinear and inverted U-shaped link between the income of agricultural households and weather variability. As temperatures and rainfall rise during the dry season, farmers' net income declines. According to Bantilan et al. (2013), climate factors including temperature and rainfall had a non-linear impact on rice produced and sold.

As per the sample survey analysis of Situation Assessment Survey (SAS) conducted by the National Sample Survey Office (NSSO) in 2002-03 and 2012-13, the increase in farmers' income 5.24% has taken 14 years to marginal farmers in actual term. And 11.75% of income growth was observed from the ten years of 2002-03 to 2012-13 mainly by the large farmers than marginal farmers. Weber et al. (2014) has mentioned that increased crop prices and productive land drove this growth rate in agriculture revenue. USDA-ERS (2012) found an increase in corn prices up to 74% and soybean price 65% within 2006-2010 are providing higher income even the crop mix, higher fertilizer usage, HYV’s, and others.

Additionally, the revenue from agriculture has been calculated in numerous researches. However, our research has not turned up any literature on revenue calculation utilizing agricultural market arrivals data. The true revenue cannot be determined by calculating agricultural production revenue. Due to the fact that the government's instructions on the CC cut out in designated acreages of revenue villages, rather than individual farmer's agricultural production or output, are used to determine the agriculture production data. The whole crop output is not brought to market to determine pricing before being taken into account for computing revenue. Therefore, utilizing the MSP price and market price to calculate the revenue from crop production is incorrect. Seasonally produced crops are not

sold at the same price, ignoring inflation and deflation. APMC data reveals that commodity prices vary across states, affecting market prices by importing the goods in higher prices and farmers will store their production in lesser price. Only the commodity sold to the price generates revenue, not produced. In total production some amount of quantity will reduce in the harvesting period, self- family consumption, loss in storage and travelling will not generate income to the farmers. Therefore, the study calculated the revenue to the APMC data of crop arrival and prices of quantity on the day of market. So, the study assumes that there is no gap between Production and Market arrivals. Because farmers are unable to store the food production at long-run period due to the perishability and need of income.

However, According to EMPRI (2011) and TERI (2013) reports the projection of Bengaluru Climate Change Initiative – Karnataka (BCCI-K) under International Panel on Climate Change (IPCC) A1B scenario rainfall in Karnataka State decreased from 1204 mm in 1901–1950 to 1140 mm in 1950–2008 before increasing to 1343 mm in 2009–2010, which was 17% above the average (1151 mm). Since 1951, the State has had 1% of negative precipitation, and the northern and coastal districts have lost 6% of yearly precipitation. The world's warmest years over the last 120 years, according to IMD (2020), happened from 2005 to 2020. The supply of water for drinking and agriculture may decrease as a result of increased evaporation, especially during the summer and in desert areas. In comparison to the southern districts of Karnataka, the northern region has seen an incremental temperature change of more than 0.6oC. It has observed the warming level in Karnataka State could rise by as much as 1.8 to 2.2 oC by 2030. The northern areas may have a greater rise than the southern ones. Regional climate variations are caused by a variety of factors, including geographic location, environmental variation, socioeconomic and political conditions, and others, such as the variability of natural resources.

III. THEORETICAL MODEL

On the economic side, the study uses the production possibility frontier to assess the advantage of multi crop production happening by diversification because of climate change effects. This mathematical expression of production function explain/examine and summarize the relationship between quantities of inputs combined to produce the maximum output from every possible combination of two or more crops by full and efficient usage of resources in an economy. And every other crop combination is considered 'technically inefficient'.

CEI represents the production possibility frontier to determine the major crop in multi crop production. The production possibility curve derived from the tangency of each point between isoquants at any point of contract curve, defines the maximum output combination from each crops production.

The slope of the production possibility curve or production-transformation curve is

$$-\frac{\partial y}{\partial x} = \frac{MP_{L,y}}{MP_{L,x}} = \frac{MP_{K,y}}{MP_{K,x}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The optimal combinations of crop output are pairs to the one will give highest revenue, observed from the given production possibility curve derived based on the total quantities of the curve. And additionally, we need the iso-revenue tool to find the equilibrium.

The iso-revenue curve of the multiproduct firm; is the locus of various combinations of quantities of y and x, whose sale yields same revenue of the crop. The slope of the iso-revenue curve is equal to the ratio of the price of the crop on time at district.

$$Slope\ of\ Revenue = \frac{0A}{0B} = \frac{P_x}{P_y} \quad \text{.. (2)}$$

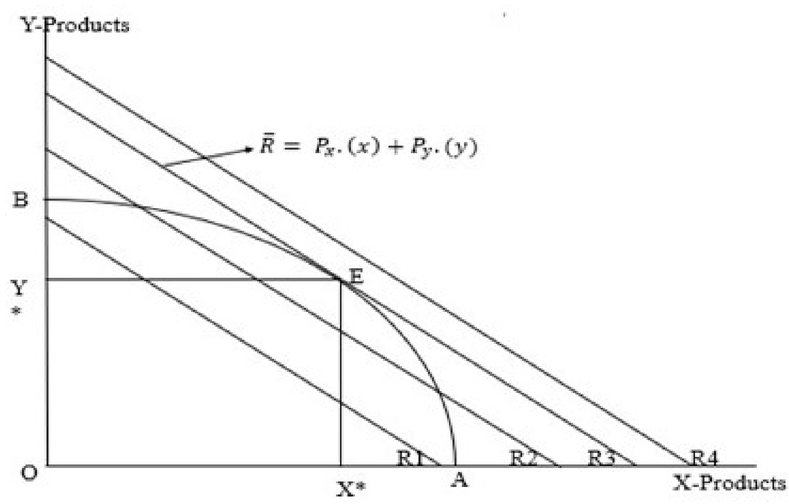
It assumes that we want an iso-revenue curve depicting $\bar{R}$ represents total revenue, may obtained from the bellow equation:

$$\bar{R} = P_x.(x) + P_y.(y) \quad \text{.. (3)}$$

Solving for $'y'$ we obtain

$$\frac{Y}{\partial x}$$

Given the prices of two or more crops and any value of $\bar{R}$, points are computed by assessing the values of (x = 0,1,2, … … , n). And the origin of iso-revenue curve is the larger revenue among the crops will be.



In the equilibrium of multi-product crops; the farmer wants to maximize his revenue given

The constraints set by the factors of production (w, r), and (ii) prices of the crops (,

Py , … . Pn) those price and quantity of the crop are given to maximize the revenue, R. Graphically, above diagram explains, at the tangency of points defines the (conditions for) equilibrium is slope of (highest) iso-revenue of crop in given production possibility or transformation curves are equal.

$$\frac{\partial y}{\partial x} = \frac{MP_{L,y}}{MP_{L,x}} = \frac{MP_{K,y}}{MP_{K,x}} = \frac{P_x}{P_y} \quad \text{..... (5)}$$

1. **Material and Methods:** Across the 30 districts from 162 APMCs, the study consists of 955 excel sheets of 5 crops contain the data set of 23, 22,860 observations. The study has taken daily data of crops sold such as paddy, maize, groundnut, jowar, and ragi. These five crops are chosen, given they occupy major share in total production and acreage in Karnataka has observed from the data over 1998-99 to 2017-18.

   Based on that, the work has gathered 16 years of daily panel data of quantity and price over 2002- 03 to 2017-18 from each APMC market across all the districts of Karnataka State.

2. **Estimation of the Model:** The revenue of crop calculated by using daily data of price and quantity with the help of the revenue function is mentioned below:

$$TR_{ijt} = \sum_{i=1}^{n} Q_{ijt} * P_{ijt} \quad \text{.....(6.1)}$$

   Where TR represents Total revenue, P indicates crop Price, Q shows the Quantity arrival, and i = crop – paddy, maize, groundnut, jowar and ragi, j represents Markets in district, and t indicates the Time. The revenue is taken as the product of i each crop quantity (arrival) and its price in the market.

$$TR = Q_J * P_J + Q_P * P_P + Q_R * P_R + Q_M * P_M + Q_G * P_G \quad \text{..... (6.2)}$$

   The second equation calculates crop revenue of Jowar, Paddy, Ragi, Maize, and Groundnut by multiplying daily quantity with price, and adding overtime to the total revenue. The study uses graphical analysis, line charts, and Q-GIS maps to explain income trends and patterns across the districts of the State. Panel data from 2002-03 to 2017-18 is used for trend estimation. Data obtained from the Department of Agricultural Marketing and State Agriculture Marketing Board (Krishi Marata Vahini website) accredited by the Government of Karnataka.

   Over time, there is a variation among the district revenue due to the changes in climate and its pattern, availability of irrigational facilities, different types of soil and its fertility rate, multinational and marketing knowledge of farmers, usage of technology, and adaptations to the crop production, etc...

IV. RESULTS

The rural economic growth is strongly influenced by the agriculture output and its market prices. But revenue of crop is product of quantity and prevailing market price. There is a difference in crop output and quantity arrival, as farmers can save a small part of their production for consumption purpose. Low income is evident in the highly populous APMC markets of Bengaluru Urban (258.71 crores), Belagavi (535.8 crores), Mysuru (1521.43 crores), Tumakuru (1244.1 crores), and Kalburgi (171.13 crores) compared to less populated districts. Highest revenue could be observed from districts such as Raichur (9718.881 crores), Koppal (6584.09 crores), Haveri (4321.02 crores), Davanagere (3541.62 crores), Shivamogga (3375.89 crores), and Ballari (2729.61 crores), respectively.

Higher revenue observed from the cultivation in Kharif, than Rabi, and summer seasons respectively. It could be to the higher area of cultivation and more production in Kharif season due to the irrigational sources or water availability.

The study estimated descriptive statistics of revenue (Table 1) to the total output of each crop such as paddy, maize, groundnut, ragi, and jowar at the State level. In the selected crops maximum revenue of 9143.34 crore come from paddy, maize, groundnut, and less revenue from jowar, ragi, respectively. The mean revenue of paddy crop (403.59 crores), maize (228.55 crores), groundnut (100.27 crores), ragi (17.89 crores), and jowar gets 14.32 crores. Jowar, ragi, maize, groundnut, and paddy are in the descending order of volatility.

Crops in Yadgiri, Bengaluru Rural, Udupi followed by Dakshina Kannada, and Uttara Kannada are highly volatile compared to less volatile districts of Vijayapura, Bidar, Dharwad, Bagalkot, and Ballari. The distribution of each crop revenue across the State is different. This may be due to changes in the production of crop quantity arrival and price of the market.

1. **Paddy:** The district of Bidar earned the least paddy revenue throughout the period and across the State's in 2016, with only 8000 rupees. And other districts of Kalburgi received 26,250 rupees in 2007, Gadag was 32,905 rupees in 2014, followed by Dharwad, Bengaluru Urban and most of the northern districts get significantly less income. Over a period, the most income is from the districts of Raichur gets 9143.34 crores in 2017and Koppal was 6402.45 crores in 2015, followed by the districts of Ballari, Davanagere, Shivamogga (land area surrounded by the Tunga – Bhadra rivers basins) and Mysuru district.

   The study has observed (see Figure 2) higher revenue of paddy crop in 2002 at Raichur was 791.063 crore rupees, followed by Koppal (198.44 crores), Davanagere, and Mysuru district. And lower revenue has been seen in Kalburgi (2.68 lakhs), Belagavi (6.31 lakhs), and Bengaluru Rural (8.64 lakhs). And in 2017 Raichur (9143.34 crores), Koppal (5925.12 crores), Ballari (2081.97 crores), and Davanagere, respectively due river basins. Lower income received from Bengaluru Urban (26.99 Lakhs) due to less dependency, and Chitradurga (1.08 crores) is a dry region. The change of farmers higher concentration on paddy crop have seen in 2017 than 2002 at Ballari, Kalburgi, Uttara Kannada, Haveri, and Tumakuru district but less concentration has been seen in Mysuru, Dharwad, Chitradurga, Chikkamagaluru, and Chikkaballapura. Also, they are received

higher the income than before due to the higher prices of MSP, increase in irrigation facilities, and usage of inputs & adaptations.

2. **Maize:** The minimum amount of maize crop revenue comes from the markets of Kolara district in 2008 was 56,000 rupees and from Bidar was 60,000 rupees in 2002. Lower income of maize is obtained from Ramanagara, Chitradurga, Chamarajanagara, Uttara Kannada, Kalburgi, and Mandya districts. The Haveri district has mainly gotten the highest revenue of 3900.16 crore rupees from almost the year across all the districts of the State, followed by the districts of Shivamogga (2074.98 crores in 2012), Hassan (1891.2 crores in 2014), and Davanagere (1775.32 crores in 2010).

   In 2002, the study observed higher revenue of maize crop (see Figure 3) from Haveri (235.42 crores), Davanagere (117.52 crores), followed by Shivamogga, Koppal, Chikkaballapura district and less income from the districts of Bidar (60000 rupees), Chamarajanagara (4.75 lakhs), followed by Tumakuru, Mandya, and Kolara, respectively. That changed slightly in 2017, has received higher revenue from Haveri (3900.2 crores), Shivamogga (1591.45 crores), and followed by Davanagere, Hassan, Chitradurga and lower revenue of maize has come from Kalburgi (6.05 lakhs), Bidar (2.38 crores) followed by Mandya and Raichur districts. Farmers are increasingly dependent on maize crop in almost of the districts across the State, mainly in Uttara Kannada, Chitradurga, Ballari, Hassan, Bengaluru Urban, Kolara, Raichur, Kalburgi, and Bidar districts (have faced diversification to the maize production) in 2017 than 2002.

3. **Groundnut:** From the groundnut cultivation across the districts, the study observed the lowest amount of revenue, 9,750 rupees from Kalburgi district in 2013, and Ramanagara district (36,000 rupees), followed by the districts of Bengaluru Rural, Chikkamagaluru, Bidar, and Davanagere. Higher income received by Yadgir district from 2011 (824.11 crores) to 2017 (1401.68 crores). In 2013 the highest revenue, 2174.06 crores approximately could be observed and Gadag (749.23 crores in 2011 and 575.12 in 2016), Raichur (567.2 crores in 2013), Bagalkot, Dharwad, and Chitradurga occupies the next place in revenue earning.

   In 2002, the districts revenue (see Figure 4) of Gadag (123.73 crores), Dharwad (63.04 crores), Bagalkot (61.38 crores), Belagavi, and Chitradurga are received higher revenue from groundnut, and lower from Chikkamagaluru (10.73 lakhs), Mandya (12.98 lakhs), Davanagere, Kolara, and Raichur districts. In 2017, Yadgir is turned into major producer (1401.69 crores) of groundnut. Raichur (473.02 crores), Gadag (285.26 crores) and followed by Chitradurga, Ballari shows higher revenue. Minimum revenue of groundnut crop in 2017 found from Bidar (7.61 lakhs), Ramanagara (22.31 lakhs), Chikkamagaluru, Shivamogga, and Uttara Kannada districts, orderly. Even the change of interests in cultivation of groundnut have observed highly in Yadgir, Raichur, Ballari, Chitradurga, Bidar, Udupi, Mysuru, and Chamarajanagara districts from 2002 to 2017.

4. **Ragi:** The ragi crop is a dry region crop, almost sown in Kharif, Rabi and the summer period based on the availability of water level. Ragi had received significantly less revenue of 6,500 rupees from Gadag in 2017. Less revenue is also observed from the Dharwad (up to 13,260 rupees in 2016), Belagavi (up to 32,700 rupees in 2014), followed by Ramanagara, Kodagu, Koppal, Uttara Kannada, and from Chitradurga districts. The

highest revenue of ragi crop was 324.884 crore rupees received from Mandya district, followed by Davanagere (168.54 crores), Mysuru (162.55 crores), Hassan, Bengaluru Urban, Tumakuru, and Chikkaballapura.

Ragi cultivation in 2002 has received highest revenue (see Figure 5) from the districts of Davanagere (16.74 crores), Mandya (7.89 crores), followed by Tumakuru, Hassan, and Mysuru. Lower values have seen in Dharwad (61,050 rupees), Ramanagara (76,500 rupees), and followed by Kodagu, Ballari, and Chitradurga districts. In 2017, higher revenues could be observed in Mandya (290.62 crores), Mysuru (162.55 crores), and followed by Hassan, Bengaluru Urban, Tumakuru district markets. Less revenue come from Gadag (6,500 rupees), Dharwad (41,760 rupees), and shadow districts of Belagavi, Raichur, Chamarajanagar. Farmers diversified to high yielding and revenue generation crops in Bengaluru Urban and Rural, Chitradurga, Ramanagara, Gadag, Belagavi, and Raichur districts.

5. **Jowar:** The revenue of the jowar crop is significantly less in the amount of minimum income was 9,000 on 2013 in Yadgir due to less price, less quantity arrival, almost of the area has used to cultivate groundnut. Followed by the district of Kolara (10,000 rupees), Yadgir (21,400 rupees), Tumakuru, Bengaluru Rural, Hassan, Ramanagara, and Mandya show less income. Highest income of jowar crop was 167.49 crore rupees comes from the Kalburgi district in 2012. Other than that, more revenue districts of jowar are Davanagere gets 140.73 crores in 2013, Raichur in 2016 was 131.58 crores followed by Bidar, Bengaluru Urban, and Gadag.

In the beginning year of 2002 (see Figure 6), Bengaluru Rural farmers are received 66,500 rupees of revenue, followed by Chikkaballapura, Mandya, and Koppal districts. Its higher income is just 20.03 crore obtained by Vijayapura, followed by Kalburgi, Gadag, and Raichur districts. But the lower revenue of 2017 has received from Chikkaballapura (5.08 lakhs), Ramanagara (5.6 lakhs), followed by Chikkamagaluru (15.72 lakhs), Shivamogga, Tumakuru, and higher income taken from Raichur (94.69 crores), Bidar (90.37 crores), followed by Kalburgi, Bengaluru Urban, and Ballari districts. Jowar has also faced diversification in Bengaluru Rural, Chitradurga, Mandya, Ramanagara, Shivamogga, Tumakuru, and Yadgir but Uttara Kannada, Udupi, Dakshina Kannada, Kodagu, and Kolara districts farmers are not dependent on jowar cultivation.

Overall, in the trend line, the study found an unmeaning order of variability from jowar, ragi, maize, groundnut, and paddy over a period from 2002–03 to 2017–18 (see Figure 1).

V. DISCUSSION

The study has observed an increasing trend of revenue. Quantity production is dependent upon availability of water, weather conditions, farmers adaptations. Revenue was higher from irrigation lands than dry lands in case of paddy, maize, and groundnut. In the dry land farmers' income predominantly comes from groundnut, maize, jowar, and ragi.

Higher variability in revenue (Table 2) observed from paddy, groundnut, maize and least from jowar, and ragi crops. Crops in Yadgiri, Bengaluru Rural, Udupi followed by

Dakshina Kannada, and Uttara Kannada are highly volatile and Vijayapura, Bidar, Dharwad, Bagalkot, and Ballari are less volatile in revenue. State has received higher revenue from the Tunga-Bhadra River basin districts such as Raichur (9718.881 crores), Koppal (6584.09 crores), Haveri (4321.02 crores), Davanagere (3541.62 crores), Shivamogga (3375.89 crores), and Ballari (2729.61 crores), respectively. This could be due to availability of irrigation sources, adaptations, knowledge in crop production and marketing. And study has observed higher revenue since 2009 across the entire region and from all the crops due to an increase in 17% rainfall (1343mm) more than normal (1151mm) rainfall.

The study found positive correlation coefficient of Pearson's (Table 3) among selected crops of paddy, maize, groundnut, ragi and jowar. The linear trend is increasing. High Yielding Variety seeds (HYVs) positively correlated to each crop revenue. The fertilizer consumption was positively associated with all selected crops except jowar. Cloud Cover (CCO) negatively correlated with total revenue and groundnut, jowar, maize, paddy except for ragi revenue. Because clouds can reduce photosynthesis levels by stopping the sunlight, photosynthesis is essential to crop growth, germination, flowering, and fruiting on time. And for some crops, it positively affects by preventing evaporation and maintaining the cropland's water level. The Ground Frost Frequency (GFF) was positively associated with total revenue but negatively correlated with jowar, ragi, and paddy crops. Those frosts could harm the stem of crop plants. Vapor pressure (VP) and Wet Day Frequency (WDF) negatively affect the total revenue of selected crops.

Higher Temperature (TEMP) causes Reference Crop Evaporation (RCE) at the ground level helps increase the revenue by reducing the higher wetness and keeps the required amount of water to the crop roots. Even the rainfall pattern has variations across the State over monsoons such as heavy rainfall, less rainfall, and unseasonal rainfall are also adversely affects. In this case, the water condition makes to suffer the region or crop. The Water Deficit (WD) negatively affects maize and ragi revenue; also, others are positively correlated.

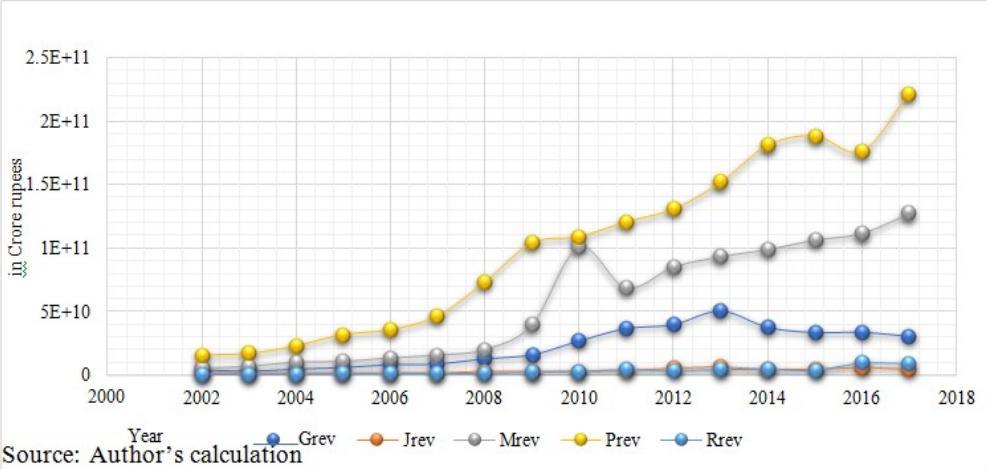
Water scarcities exist mainly in Rabi and summer periods, mainly in the less rainy regions and years. In the summer, the area of cultivation declines due to less water and in the monsoon period, crops rott or get destroyed due to excess or untimely rainfall. An increasing water storage capacity and water management may augment the monsoon's cultivated area or rained region, even in summer. That may increase agriculture output annually. The State requires a water management system because the cultivation area drastically declines in post-monsoon and summer due to drought and unseasonal effects.

To reduce these risks, farmers have to adjust cultivating dates properly. Land management actions such as creating sloping on flat surface and using natural fertilizers to increase productivity are also required. After that, the farmers should use best quality seeds. Which are must be suitable to the seasonality, the region's environment, the availability of water, and the soil system for sowing also plays a vital role in revenue maximization.

Conflict of Interests: There is no conflict of Interest to be declared.

VI. APPENDIX

Figure 1: Trends in total revenue for the major crops in Karnataka.



Source: Author's calculation

Figure 2: Distribution of Paddy crop revenue over time across the Karnataka State.

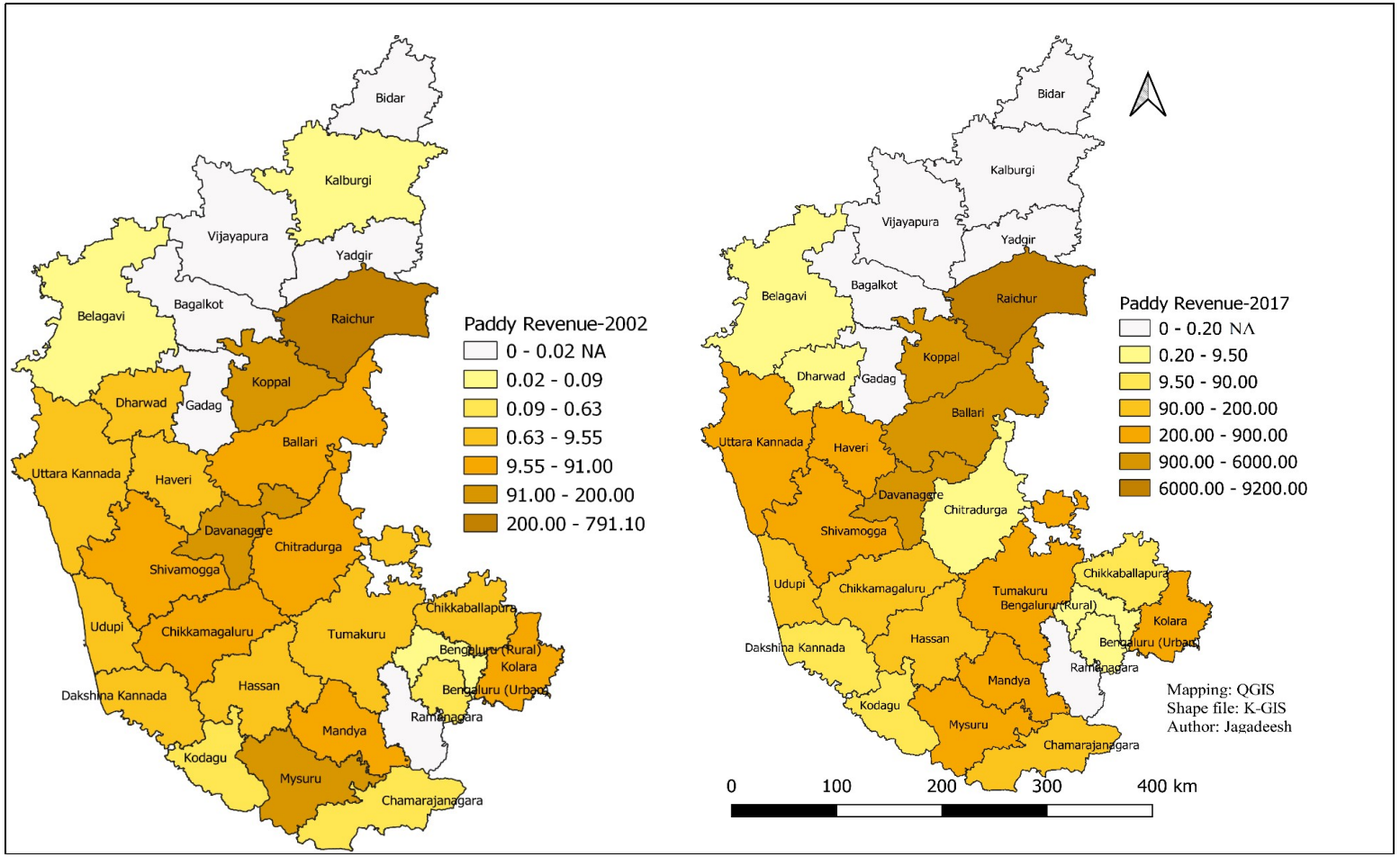


Figure 3: Distribution of Maize crop revenue over time across the Karnataka State.

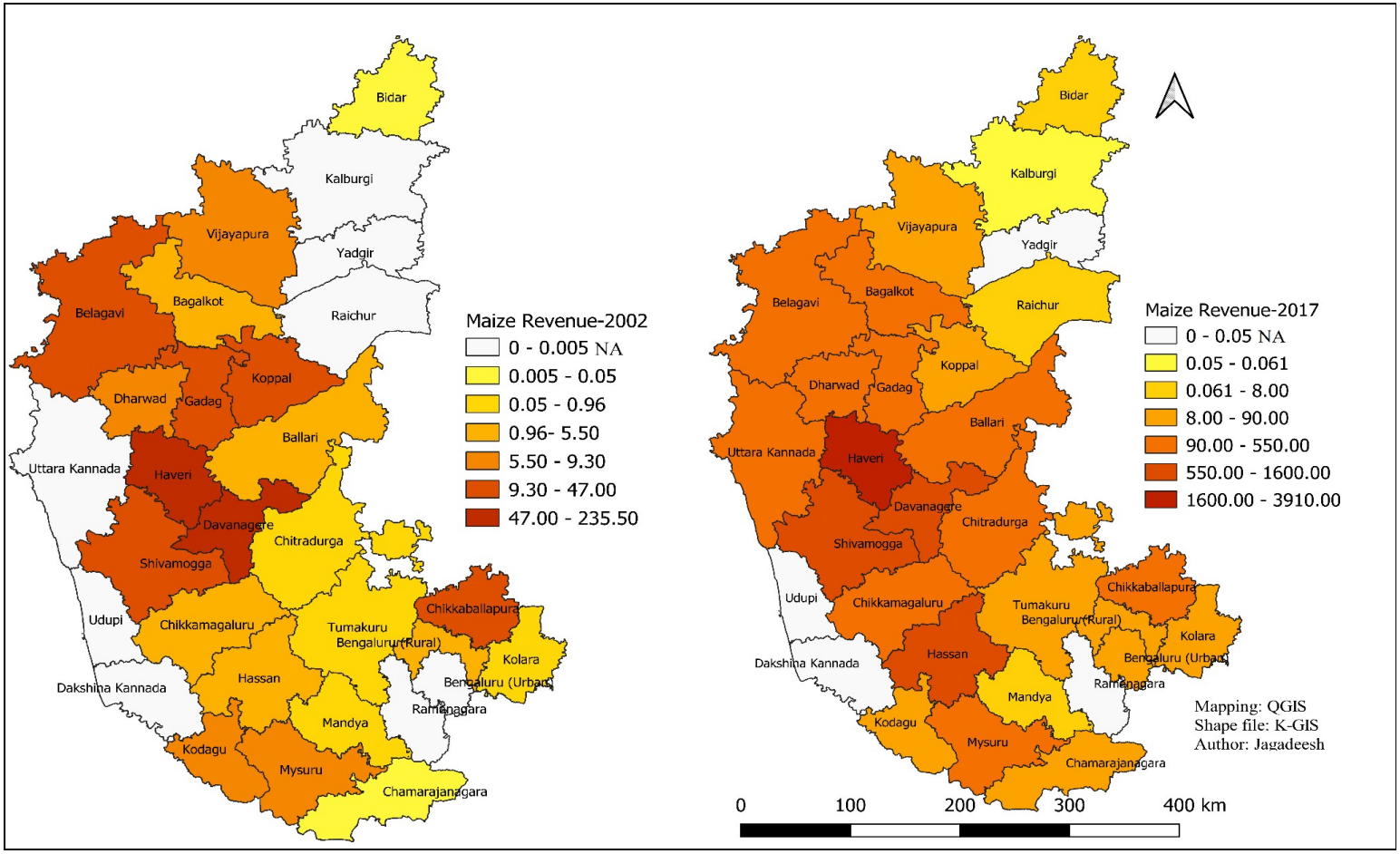


Figure 4: Distribution of Groundnut crop revenue over time across the Karnataka State.

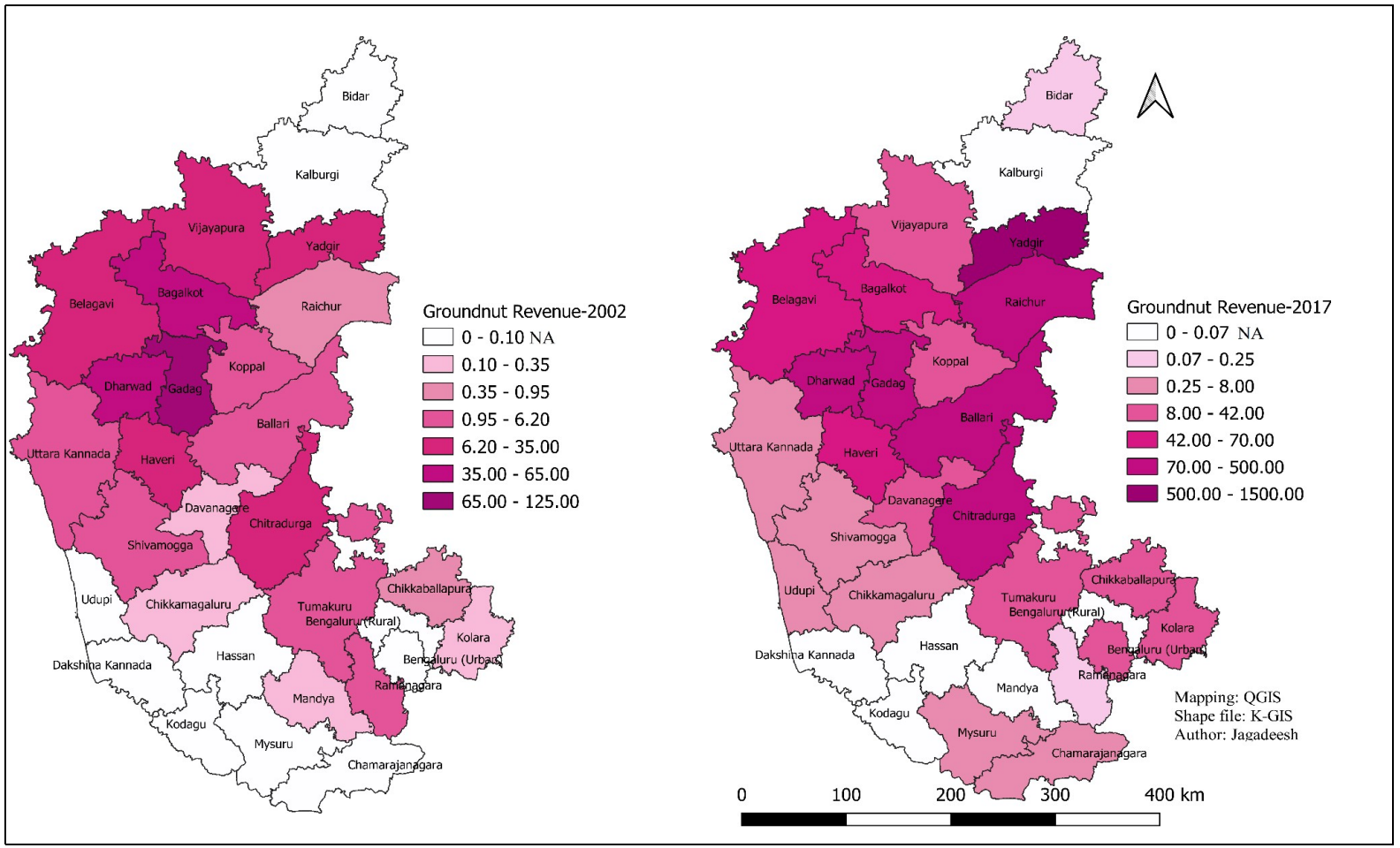


Figure 5: Distribution of Ragi crop revenue over time across the Karnataka State.

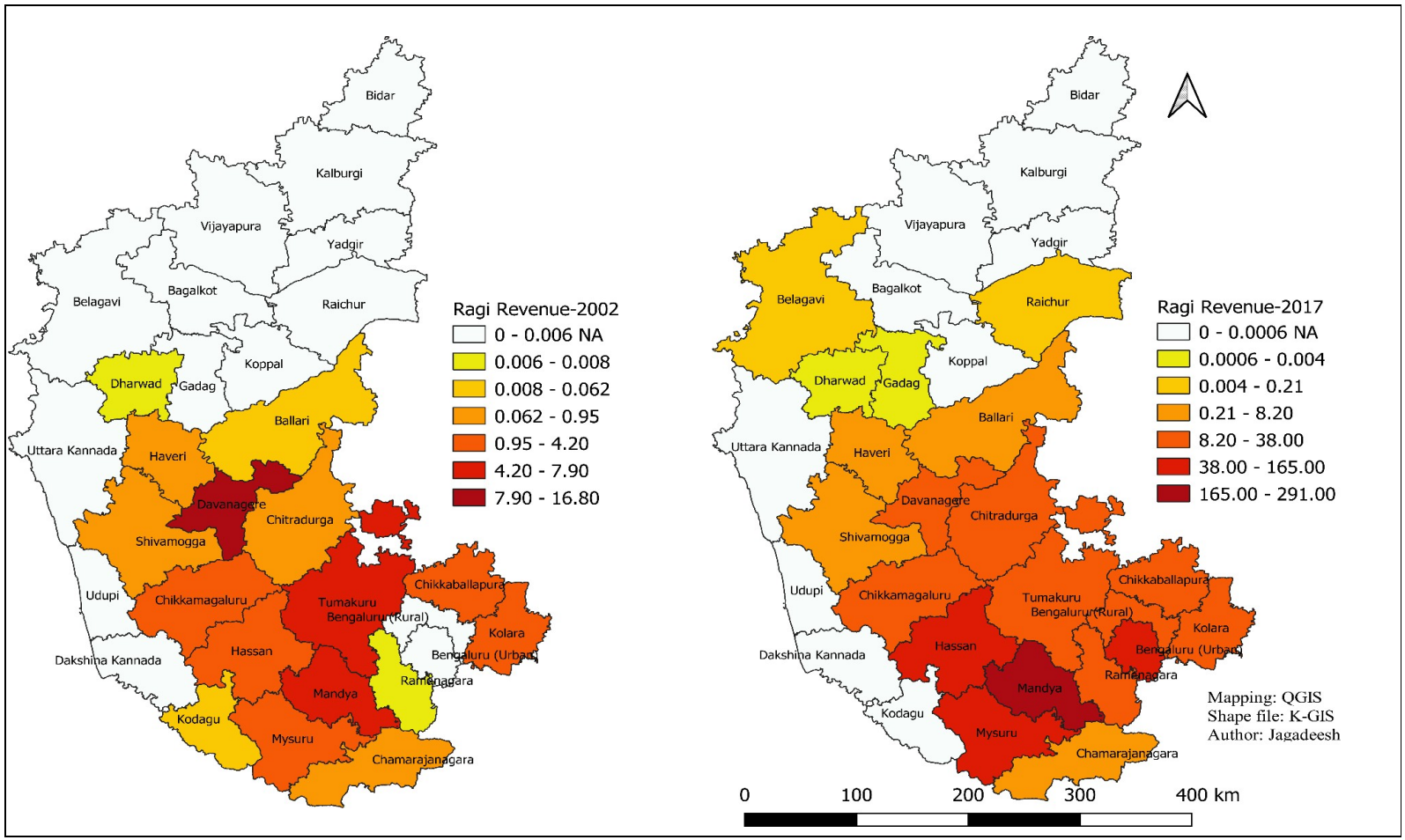


Figure 6: Distribution of Jowar crop revenue over time across the Karnataka State.

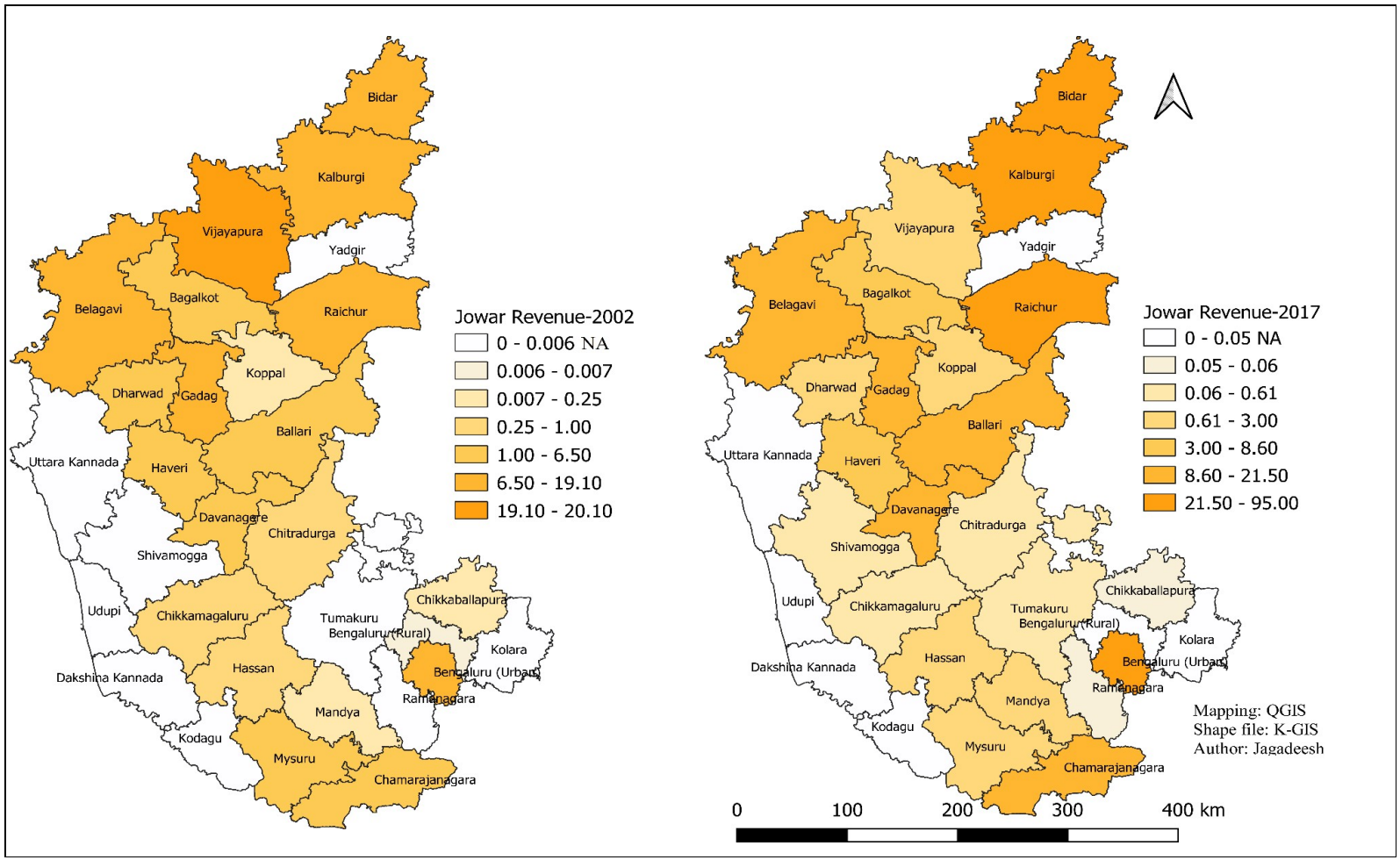


Table 1: Descriptive Statistics of Total Revenue from Selected Crops at Across the State Level during the Study Period (In Crores).

Districts	Minimum	Maximum	Mean	Std. Dev	Coef. Var
Bagalkot	73.204	987.75	424.95	267.042	62.84
Ballari	58.11	2729.61	1582.64	1069.62	67.58
Belagavi	53.83	535.795	272.286	192.3	70.62
Bengaluru Rural	2.375	393.96	87.32	99.30	113.72
Bengaluru Urban	11.354	258.71	129.02	88.49	68.58
Bidar	15.46	92.823	44.65	23.774	53.24
Chamarajanagara	0.82	326.07	122.94	114.44	93.08
Chikkaballapura	10.73	588.63	238.11	2179.54	91.54
Chikkamagaluru	10.26	428.8	198.46	157.92	79.57
Chitradurga	17.503	978.82	405.822	348.82	85.95
Dakshina Kannada	0.09	87.534	29.88	33.22	111.18
Davanagere	275.52	3541.61	1850.09	1299.58	70.24
Dharwad	53.64	738.18	402.61	246.41	61.20
Gadag	93.06	1102.52	531.21	373.175	70.25
Hassan	17.62	2161.7	675.94	657.57	97.28
Haveri	266.961	4321.02	1533.98	1299.57	84.72
Kalburgi	8.88	171.12	62.28	47.084	75.60
Kodagu	4.10	122.05	62.41	44.64	71.52
Kolara	9.995	433.06	184.1	151.97	82.55
Koppal	228.1	6584.09	2928.77	2110.3	72.05
Mandya	33.90	580.84	240.67	179.76	74.69
Mysuru	99.02	1521.43	715.145	497.67	69.59
Raichur	801.85	9718.88	3273.69	2505.97	76.55
Ramanagara	0.21	14.44	6.32	5.054	79.94
Shivamogga	109.65	3375.89	1302.32	1137.51	87.35
Tumakuru	10.51	1244.1	417.62	415.08	99.39
Udupi	0	124.61	36.38	40.54	111.43
Uttara Kannada	3.93	766.01	214.08	223.353	104.33
Vijayapura	27.90	213.473	88.2	44.05	49.95
Yadgir	0.964	2174.06	632.7	719.671	113.75
Groundnut	₹ 9750	2174.06	100.28	226.263	225.64
Jowar	₹ 9000	167.49	14.32	23.44	163.68
Maize	₹ 56000	3900.16	228.56	471.01	206.08
Ragi	₹ 6500	324.884	17.89	36.82	205.83
Paddy	₹ 8000	9143.34	403.6	1013.88	251.21
Total Revenue	₹ 908750	9718.88	623.15	1122.603	180.15

Source: Authors calculations

Table 2: Selected Crop Revenue at District Level across State in 2017 (In Crores).

SL. No	Districts	Paddy	Maize	Groundnut	Jowar	Ragi	Total Revenue
1	Bagalkot		251.69	52.49	6.81		310.99
2	Ballari	2081.96	461.26	161.45	21.43	3.53	2729.63
3	Belagavi	4.73	460.16	51.5	18.26	0.19	534.84
4	Bengaluru Rural	6.39	71.05			14.88	92.32
5	Bengaluru Urban	0.27	86.9	11.21	57.91	102.42	258.71
6	Bidar		2.38	0.08	90.37		92.83
7	Vijayapura		14.69	24.75	1.63		41.07
8	Chamarajanagara	165.44	39.94	2.35	10.15	1.23	219.11
9	Chikkaballapura	18.94	227.5	13.18	0.51	28.44	288.57
10	Chikkamagaluru	140.03	104.18	1.13	0.16	34.77	280.27
11	Chitradurga	1.08	545.34	246.32	0.6	15.97	809.31
12	Dakshina Kannada	86.31					86.31
13	Davanagere	1116.19	1570.95	28.79	11.57	30.26	2757.76
14	Dharwad	9.26	331.79	117.65	2.9	0.004	461.604
15	Gadag		408.26	285.24	17.65	0.006	711.156
16	Kalburgi		0.06		89		89.06
17	Hassan	108.35	1268.74		2.01	117.35	1496.45
18	Haveri	342.56	3900.16	68.46	8.6	1.24	4321.02
19	Kodagu	67.44	37.31				104.75
20	Kolara	237.36	30.43	23.79		16.09	307.67
21	Koppal	5925.12	226.66	36.4	1.61		6189.79
22	Mandya	285.2	3.75		1.27	290.62	580.84
23	Mysuru	837.73	511.73	7.91	1.5	162.55	1521.42
24	Raichur	9143.34	7.64	473.01	94.69	0.2	9718.88
25	Ramanagara			0.22	0.056	13.44	13.716
26	Shivamogga	822.05	1591.44	1.68	0.17	8.12	2423.46
27	Tumakuru	419.39	31.44	41.47	0.37	37.65	530.32
28	Udupi	121.15		3.46			124.61
29	Uttara Kannada	244.87	518.91	2.24			766.02
30	Yadgir			1401.681			1401.681
Karnataka		**39263.61**					

Source: Authors calculations

Table 3: Partial Correlation Coefficient of Variation between the Crop Revenue and Climatic Variables.

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0																
	Revenue	**GQ**	**JQ**	**MQ**	**RQ**	**PQ**	**AUHYV**	**FC**	**CCO**	**GFF**	**VP**	**WDF**	**RCE**	**TEMP**	**Rain**	**WD**
Revenue	1	0.1973 0.0002	0.2429 <.0001	0.4472 <.0001	-0.0199 0.7444	0.8671 <.0001	-0.0290 0.5258	0.2904 <.0001	-0.2594 <.0001	0.1029 0.0439	-0.1512 0.0030	-0.0246 0.6313	0.0250 0.6254	0.0391 0.3983	-0.1883 <.0001	0.2222 <.0001
GQ	0.1973 0.0002	1	0.1910 0.0011	-0.0139 0.8062	-0.1805 0.0092	0.2072 0.0004	0.0712 0.1835	0.1337 0.0122	-0.2682 <.0001	0.0759 0.2014	-0.1007 0.0896	-0.0257 0.6654	0.1312 0.0268	0.1842 0.0006	0.0440 0.4290	0.2205 <.0001
JQ	0.2429 <.0001	0.1910 0.0011	1	-0.0022 0.9684	-0.0876 0.1884	0.3717 <.0001	0.0093 0.8588	-0.0180 0.7320	-0.3814 <.0001	-0.0541 0.3210	-0.4570 <.0001	-0.3970 <.0001	0.5105 <.0001	0.3515 <.0001	-0.1908 0.0003	0.1838 0.0004
MQ	0.4472 <.0001	-0.0139 0.8062	-0.0022 0.9684	1	-0.0007 0.9907	0.0838 0.1203	0.0379 0.4503	0.2237 <.0001	-0.1516 0.0040	0.5205 <.0001	0.1778 0.0007	0.4228 <.0001	-0.3223 <.0001	-0.0140 0.7823	-0.1067 0.0359	-0.0828 0.0985
RQ	-0.0199 0.7444	-0.1805 0.0092	-0.0876 0.1884	-0.0007 0.9907	1	-0.0611 0.3322	0.0216 0.7235	0.2155 0.0004	0.3446 <.0001	-0.2222 0.0006	0.1641 0.0113	0.1030 0.1130	0.0050 0.9392	0.1245 0.0445	-0.0190 0.7633	-0.0253 0.6787
PQ	0.8671 <.0001	0.2072 0.0004	0.3717 <.0001	0.0838 0.1203	-0.0611 0.3322	1	0.0436 0.3831	0.1572 0.0015	-0.3447 <.0001	-0.0903 0.1030	-0.3662 <.0001	-0.2689 <.0001	0.2291 <.0001	0.0589 0.2412	-0.2086 <.0001	0.2731 <.0001
AUHYV	-0.0290 0.5258	0.0712 0.1835	0.0093 0.8588	0.0379 0.4503	0.0216 0.7235	0.0436 0.3831	1	0.3157 <.0001	0.0108 0.8327	0.0956 0.0612	-0.0125 0.8072	0.0500 0.3284	-0.0134 0.7933	-0.1157 0.0121	0.0796 0.0911	-0.2869 <.0001
FC	0.2904 <.0001	0.1337 0.0122	-0.0180 0.7320	0.2237 <.0001	0.2155 0.0004	0.1572 0.0015	0.3157 <.0001	1	0.0105 0.8377	-0.0391 0.4448	0.0006 0.9914	0.0416 0.4168	-0.0033 0.9491	0.1030 0.0256	0.0107 0.8213	-0.1771 <.0001

CCO	-0.2594 <.0001	-0.2682 <.0001	-0.3814 <.0001	-0.1516 0.0040	0.3446 <.0001	-0.3447 <.0001	0.0108 0.8327	0.0105 0.8377	1	-0.0662 0.1954	0.6208 <.0001	0.2365 <.0001	-0.2670 <.0001	-0.1694 0.0009	0.2337 <.0001	-0.1912 0.0002
GFF	0.1029 0.0439	0.0759 0.2014	-0.0541 0.3210	0.5205 <.0001	-0.2222 0.0006	-0.0903 0.1030	0.0956 0.0612	-0.0391 0.4448	-0.0662 0.1954	1	0.3191 <.0001	0.5096 <.0001	-0.3191 <.0001	-0.1136 0.0260	-0.1174 0.0214	-0.1018 0.0461
VP	-0.1512 0.0030	-0.1007 0.0896	-0.4570 <.0001	0.1778 0.0007	0.1641 0.0113	-0.3662 <.0001	-0.0125 0.8072	0.0006 0.9914	0.6208 <.0001	0.3191 <.0001	1	0.8449 <.0001	-0.7029 <.0001	-0.3000 <.0001	0.4619 <.0001	-0.5137 <.0001
WDF	-0.0246 0.6313	-0.0257 0.6654	-0.3970 <.0001	0.4228 <.0001	0.1030 0.1130	-0.2689 <.0001	0.0500 0.3284	0.0416 0.4168	0.2365 <.0001	0.5096 <.0001	0.8449 <.0001	1	-0.7984 <.0001	-0.3225 <.0001	0.3218 <.0001	-0.4850 <.0001
RCE	0.0250 0.6254	0.1312 0.0268	0.5105 <.0001	-0.3223 <.0001	0.0050 0.9392	0.2291 <.0001	-0.0134 0.7933	-0.0033 0.9491	-0.2670 <.0001	-0.3191 <.0001	-0.7029 <.0001	-0.7984 <.0001	1	0.5567 <.0001	-0.4166 <.0001	0.5587 <.0001
TEMP	0.0391 0.3983	0.1842 0.0006	0.3515 <.0001	-0.0140 0.7823	0.1245 0.0445	0.0589 0.2412	-0.1157 0.0121	0.1030 0.0256	-0.1694 0.0009	-0.1136 0.0260	-0.3000 <.0001	-0.3225 <.0001	0.5567 <.0001	1	0.1568 0.0008	0.0005 0.9918
Rain	-0.1883 <.0001	0.0440 0.4290	-0.1908 0.0003	-0.1067 0.0359	-0.0190 0.7633	-0.2086 <.0001	0.0796 0.0911	0.0107 0.8213	0.2337 <.0001	-0.1174 0.0214	0.4619 <.0001	0.3218 <.0001	-0.4166 <.0001	0.1568 0.0008	1	-0.6601 <.0001
WD	0.2222 <.0001	0.2205 <.0001	0.1838 0.0004	-0.0828 0.0985	-0.0253 0.6787	0.2731 <.0001	-0.2869 <.0001	-0.1771 <.0001	-0.1912 0.0002	-0.1018 0.0461	-0.5137 <.0001	-0.4850 <.0001	0.5587 <.0001	0.0005 0.9918	-0.6601 <.0001	1

VII. CONCLUSION

Agriculture revenue is the main economic source of the farmers. However, rural livelihoods are influenced by climate and economic factors such as consumer demands and market price changes. Farmers aim to increase output and revenue through various practices and regional disparities. To calculate the revenue from agriculture production at the district level the study used the market level daily panel data from APMC across all the districts from 2002-03 to 2017-18. The study observed significant differences in the price and quantity arrival and these differences vary across the district markets of State. Farmers may experience an increase in crop revenue as price hikes in-spite of reduction in quantity due to incidence of drought, mainly from 2011-17. The total revenue of paddy, maize, groundnut, ragi, and jowar crop were increasing over time, and groundnut revenue decreased from 2013, could be due to weather variability in rainfall pattern. The revenue of paddy was highly volatile, while ragi crop was least variable. At the district level Yadgiri, Bengaluru Rural are most volatile and Vijayapura, Bidar are least volatile. Tunga-Bhadra

River basin districts such as Raichur, Koppal, followed by Haveri, Davanagere, Shivamogga and Ballari received higher revenue, which could be due to the irrigation sources. Study has observed higher revenue since 2009 across the entire region and from all the crops. Positive values of Pearson's correlation coefficient indicate increasing linear trend of revenue over the study period and changed its growth path at a higher level from 2009-2017. Even BCCI-K an observed decline in the rainfall and increase in the temperature as increase in the government concentration to improve and doubling farmer's income. The study found in meaning order of variability from jowar, ragi, maize, groundnut, and paddy.

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