Volume 9, Issue 3, March – 2024 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR525

An Assessment of the Weather and Technological Change on Agriculture Revenue of Maize Crop in Karnataka

Jagadeesh[1*]; Ponnaluru Srinivasa Sasdhar[2*] (Assistant Professor)
Faculty Department of Economics, Vijayanagara Sri Krishnadevaraya University, Ballari, Karnataka, India-583105

Corresponding Author:- Jagadeesh[1*]; Ponnaluru Srinivasa Sasdhar[2*]

Abstract:- Presently the agriculture economy influenced by the weather and technological implication. In state maize has occupied top fourth place (10.79%) in total area of cultivation, is highly sowing in rainfed area (65.94%). Study estimates the revenues over a period form 2002-2018 and estimated moving average of revenue to the capital-intensive technology and labor-intensive technology based on the market arrivals data. The implication of capital-intensive technology in agriculture production brings higher output than labor intensive technology even a change in weather, but not more than 2010. The study found that changes in production to the weather and technology has direct relation, but weather negatively impacts on maize crop. Due to the weather extreme events, the prices have positive relation with drought and inverse relation to quantity arrival and rainfall helps to maintain economic stability by the consumer and producer surplus with higher income. To fulfill the loss of agriculture output and to reduce the risks from weather extreme events Maize was converting commercially as a food crop, it greatly caused to increase the amount of cultivation and revenue to the farmers across the State.

Keywords:- *Labour-Intensive and Capital-Intensive Technology, Weather Extreme Events, Market Arrivals, Prices, and Revenue.*

I. INTRODUCTION

Agriculture is the main source to the rural economy; people almost earns from the agriculture and allied activities. The agricultural production is causally link to the climate, and other inputs. The agriculture production and its movement to the market will decides the prices, and directly influence on rural or farmers income, savings, standard of living, health, and children education. The rural economic development is strongly bonded by the agriculture output and minimum support prices (MSP) or market prices, but less dependent upon the investment and intervention of government. Above optimum level changes in climate cause to shifts in the days of cultivation, crop growing, and harvesting periods. It directly impacts on the further physical process of agriculture crops. To analyze that, the quantity of maize crop production and crop prices are taken to estimate the revenues in the year. The revenue has been fluctuated as changes in the production process due to the weather change are causes to change in the price of commodity. That increase in production or prices will cope the farmers economically.

The area of cultivation for the maize crop has covered 4.99 percent (6.617 lakh hectares) in 2002. It has continued to increase 11.22 percent (91.38 lakh hectares) in 2014, and 130.70 lakh hectares in 2018-19. In that, irrigated area is 2.55 lakh hectare in 2002, it increased to 5.193 lakh hectares in 2011, and 3.895 lakh hectares in 2017. And un-irrigated area covers 3.20 lakh hectares in 2002, it increased to 9.542 lakh hectares in 2015, and 9.175 lakh hectares in 2018-19. In the beginning rainfed area is closer to the irrigated but later gap between irrigated and un-irrigated is widening due to as increase in drought level. Presently, 65.94 percent area of maize crop cultivation was depending on rainfed. In the state total area of cultivation, maize crop has sowed annually in 10.79 percent of area (top fourth crop in highest area of cultivated).

The un-irrigated area recharged from the wells and bore-wells are considered as irrigated area due to the increase in ground water level and as fall in ground water level cause to increase arid area. So, farmers can choose to grow lucrative crops that consume less water and harvest more quickly, because those crops help farmers can easily escape from the climatic fluctuations. For that Maize is a best crop for the farmers. This is because farmers can choose substitute selling opportunities to sell their crops (to the food vendors such as street vendors, and hoteliers) when the crop is intermittently damaged by extreme weather events. Even the farmers' negotiations and agreements, or decision of hedging or tie-up with substitute selling opportunities such as hotel management and street venders, will reduce the number of days in crop production and helps to get crop output early as need. However, it may give more income in early period to the farmers as compare to the existing prices by reducing the risks from hedging. And Maize green cane can also be used as feed for cattle. So, it may fulfill the expected profit of farmers. Even to fulfill the need of demand of the popcorn companies, and agricultural allied activities with the hedging creates marketing opportunities are caused to sown more will bring higher profit. Because even the maize crop has capacity to grow in less water and early-bird crop cutting reduces the risks of

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR525

weather pattern. It will positively impact to increase the area of production.

The farmers are making an agriculture management to get a higher production, but the negative effect has been found in both the seasons due to climatic factors (Amjath, et al. 2017) and weather extreme events (Seetharam, et al. 2017). The economic loss of maize yield in irrigated area (12.2 percent) is more than the rainfed agriculture (6.5 percent). Annually, the Sri Lanka and Bhutan are loosed 6.5-6.6 percent, India, Bangladesh, and Nepal are from 8.7-9.9 percent, and Maldives 12.6 percent loss has faced (Lee, et al. 2017). Because that change in climate shifts the sowing day's as reduction or widening the length of seasonality (Yoon and Choi, 2019) year by year causes to crop loss and effects on the food availability. Even the crop productivity will decrease with delay or early-bird crop cultivation (Sandhu, 2019) due to, longer summer and unseasonal rainfall. And each crop has their own weather conditions and seasonality in each step of growth such as germination, flowering, fruit, and nut. The unseasonal rainfall confuses the farmer in the selection of suitable weather for crop cultivation. Even, heavy rainfall rotten and destroys the crops by keeping continues wetness. This vulnerable rainfall and frost level can bring risks of early flowering in many trees will damage. The earlier breeding highly impact by increasing pests and diseases due to mild winters (Conservation in a Changing Climate). These unseasonal effects are caused to keep longer dry season will adversely impact on agriculture output. That may push the crop price but not the income of farmers. Due to, as farmers are trying to reduce the risks of crops by adaptations the costs of crop production are increasing.

But the Indian states are filled with 82 percent of small and marginal farmers has less capacity of adoption to the weather through the capital inputs. The weather volatility reduces the production, it will increase the price of crop and higher productions in lessor price are may increase in total amount of revenue but subtraction of costs in revenue even small and marginal farmers will not meet the production costs (Kannan, 2014). So, the producer gets less hope to produce same crop at next season as decrease in profit and savings. Even, government discrimination in the program implementation such as Green revolution is only limited to irrigated area except dryland, it will create income disparities between the areas (Singh and Bhalla, 2009). That income and revenues disparities from the place to place and crop to crop are found as changes in the farmer's knowledge about the crop production and managements, usage of inputs and technology, climate, market prices, and cost of production. Based on that, as increase in 1-dollar price of commodity can increase the personal income of farmers, workers, and farm owners. But in consumption side, it is weakly effects on the non-farmers (Weber et. al. 2014). That increasing trend of income has observed from the crops of arhar, sugarcane, and BT cotton production (Kannan, 2014). However, the diversified crop sowing farmers are also having the chances of stabilizing their income level by the adaptations but currently it fails due to the influence of market prices (Christina et al. 2018).

II. MATERIAL AND METHODS

A. Materials:

The study uses secondary data of time series over 16 years from 2002 to 2018 (Krushimaratavahini, Government of Karnataka). The maize is top 4th major crop in area of cultivation after the jowar, rice, and ragi are placed at first three in crop production of Karnataka. The study also uses crop wise area of production and irrigated area data from the Directorate of Economics and Statistics (DES) over 1997-2019, to compare with the area of production and market arrivals.

The climate data of 1901 to 2017 is obtained from the Indian Meteorological Department, spans over one hundred eighteen years. That was available by the district level from 1901-2002 and for up-to 2017 study has calculated the 30years moving average. The drought data has taken from the Karnataka State Natural Disaster Management Center (KSNDMC) from 2001 to 2018. That amount of drought area is not in the hectares, but it is in the number of taluks because those rainfed regions hit by the existing weather pattern. That amount of arid region are declared or considered as drought hit area by the government of Karnataka.

The data of technological implication in the state has collected from 1998-2017 in the Ministry of Statistics and Program Implementation (MOSPI), Government of India website. It has been used to analyze the sudden change in arrival rate or production.

B. Methods:

The market data has used to evaluate the impact of market expansion by standard deviations, coefficient of variations. The revenue calculation has been done using the equation is as follows

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

Where R represents revenue, P represents Price, and Q represents Quantity.

In this study, the data flow of crop arrivals to the markets have diversified trend from 2009-10. So, the year 2009-10 is considered has the beginning year of capital-intensive technology and the technological adoption continued highly in the year 2010. So, based on the amount of change in market arrivals, study has considered to divide two parts, such as from 2002-2009 (labor-intensive technology) and 2010-2018 (capital-intensive technology). In the calculation of base year also observed the 2010 is considered as an over producing year and a zero-drought year with a stable weather pattern and technological adoption. Therefore, it has received highest output over a period and created a new path in the production.

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Before and after 2010, It is important to know the change in climate and technology how much it can make a difference in crop production and income of farmers. So, the study assumed, if, the state's labor-intensive technology proceeds upto 2010 to 2018, its effects are captured by the estimation of forward Moving Average (FMA). And by the estimation of backward Moving Average (BMA) the state capital-intensive technology adoption effects are estimated to the 2002 to 2009.

Heteroskedasticity and Autocorrelation are to be expected given the nature of data. Heteroskedasticity and Autocorrelation Consistent (HAC), or Newey West estimator for the variance-covariance matrix was estimated dependent variable's, $\boldsymbol{y}$ is the total revenue of the Maize crop in the State. That total revenue was regressed using the equation (8.1). The PROC AUTO REG from the SAS system accounts for heteroskedasticity standard errors and consistent autocorrelation errors.

$$Y_{ijt} = \alpha + X_{ijt}\beta_i + \varepsilon_{ijt} \quad (2)$$

The vector of an independent variable is X, represent the climatic factors and other inputs, i is Crop, j represents Markets in district, and t indicates the Time. The parameter vector is β, the ε indicates the error term, which is used to analyze the dependent variable - Y.

$$MR_{ijt} = \alpha + \beta_1 AFsq_{ijt} + \beta_2 MAICW_{ijt} + \beta_3 MAUICW_{ijt} + \beta_4 FCsq_{ijt} + \beta_5 PCI_{ijt} + \beta_6 CCO_{sqijt} + \beta_6 GFF_{ijt} + \beta_7 lnPE_{ijt} + \beta_8 TEMPsq_{ijt} + \beta_9 lnRAIN_{ijt} + \beta_9 WDFsq_{ijt} + \beta_{10} WDsq_{ijt} + \beta_{10} fRAIN_{ijt} + \varepsilon_{ijt} \quad (3)$$

Heteroscedasticity is a systematic deviation of predicted variables over the range, which monitors different independent factors over time values are nonconstant.

III. RESULTS AND DISCUSSION

The farmers are adjusting to the weather conditions with the necessary managements in different seasons. Because in three seasons weather is flowing constantly (within the period of seasonality) day by day with slightly changes. For that farmers are adjusting with the taking care of crop by the usage of inputs, implementation of technology and machinery, adopting modern cropping system, sowing adjustable crops, land, and water management, etc. so, the crops are also automatically adjusting to the existing weather pattern in the season. Even these adjustments and farmers carenes on crop, the production is volatile to the existing weather because of pests, diseases, and extreme events.

In the production pattern, the markets of the state have received approximately 21.14 lakh quintals of maize - *ActualArrival* (see Figure 1) in 2002. The upward trend of crop arrival has been continued over a period. In that sudden positive changes of 42.736 lakh quintals (76.96 percent higher than 2008) of arrivals has increased in 2009 due to normal weather pattern (from 55.53 lakh to 98.266 lakh quintals of maize arrived at the market in 2008 and 2009). Again, rapid increase of crop arrival found in 2010 (234.25 lakh quintals of state highest arrival from 12.03 lakh hectares, which is less than the area under 2011-2018) due to the zero-drought year, normal rainfall in 2009 and 2010 (stabilized weather pattern) and increasing MSP. Compared over 2009 and 2010, the higher area (13.246 lakh hectares) is used in 2011 for agriculture, and over a period, highest amount of agriculture land (13.738 lakh hectares) has used for the cultivation in 2014 although it did not meet (-69.01lakh quintals) the amount of 2010 crop arrivals to the market due to the climate volatility even the inputs usage, managements, technological implementation, and knowledge change. Finally, markets of state have received 187 lakh quintals in 2018, is 8.846 times higher than 2002 and doubled than 2009.

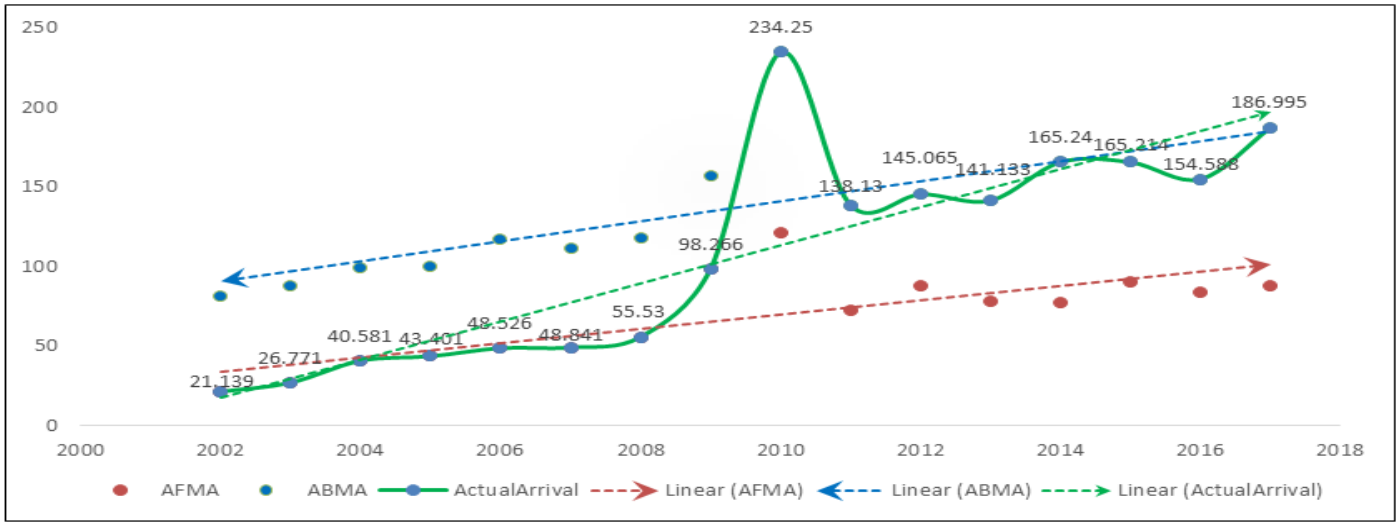

Fig 1 Amount of Quantity Arrival to the Market

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR525

After the fall of crop arrival in 2011 as maintained a small fluctuation with an increasing trend. It proved that only normal weather pattern could yield more than 2010, because even farmer caring increases day-by-day, proper management of agriculture, usage of mechanization, fertilizers and pesticides, adaptation of technology and knowledge change but these are does not mattered in weather volatility in 2002-2008 and 2011-2017. The 2010 crop arrivals were 135.984 lakh quintals over 2009 and 11.08 times higher than 2002 arrivals. Since then, the arrival of crops has dropped (96.12 lakh quintals) dramatically in 2011 (138.13), 69.01 lakh quintals in 2014, and 47.26 lakh quintals in 2017. But the arrivals continued increasing more than labor intensive technology of 2002-2009 with normal fluctuations.

If study assumes there is a same or constant flow of labor-intensive technology after the 2009, the crop arrival may increase from 2010-2017 (the forward dot line flow - calculated the three years forward Moving Average to the arrivals) - *AFMA*. That *AFMA* trend is assumed to be the crop output from the labor-intensive technology and regular input usage with the farmers learning by doing. From that fluctuating weather pattern state has received 113 lakh quintals less than the actual arrivals in 2010, 87.8 lakh quintals in 2014, and 99.4 lakh quintals in 2017. It is the gap between *ActualArrival and AFMA* or adaptation and non-adaptation of technology and knowledge even the higher prices. The flow of crop arrival is widening as maize quantity arrival (*ActualArrival)* has increasing year by year over a period due to the as increase in area of cultivation, demand to the crop, and extension of markets in the substitute selling opportunities.

Again, if we assume the farmers of state are if aware, adopted, and used the technology and knowledge of 2010-2017th from the beginning of 2002-2009 in crop production to mitigate the fluctuations of weather and to earn higher income. The farmers/state may receive market arrivals of backward dot line flow - *ABMA*. It explains the difference or gap between the production of labor-intensive technology and capital-intensive technology and knowledge are adopted from the beginning year. The maize crop will receive 80.74 lakh quintals in 2002, and 117.48 lakh quintals in 2008, 156.25 lakh quintals in 2009, and 186.99 lakh quintals in 2017. Without technological adaptation land's higher productivity level or farmers may also loose crop output 59.61 lakh in 2002, 67.98 lakh quintals in 2006, and 58 lakh quintals in 2009. However, the impact of capital-intensive technology and knowledge of the *ActualArrivals* from 2010 forecasted values – *ABMA* (the three years backward moving average to the arrivals) from before 2009 are gives more output comparing to the labor-intensive technology.

So, as compared between 2002 to the maximum output of 2010 crop arrival farmers/state may loosed 213.11 lakh quintals but the gap has declining year by year, rapidly from the 2011 this is because the usage of technology, knowledge about crops, usage of inputs, and agriculture managements farmers are trying to meet the maximum output to get higher profit even a lesser price.

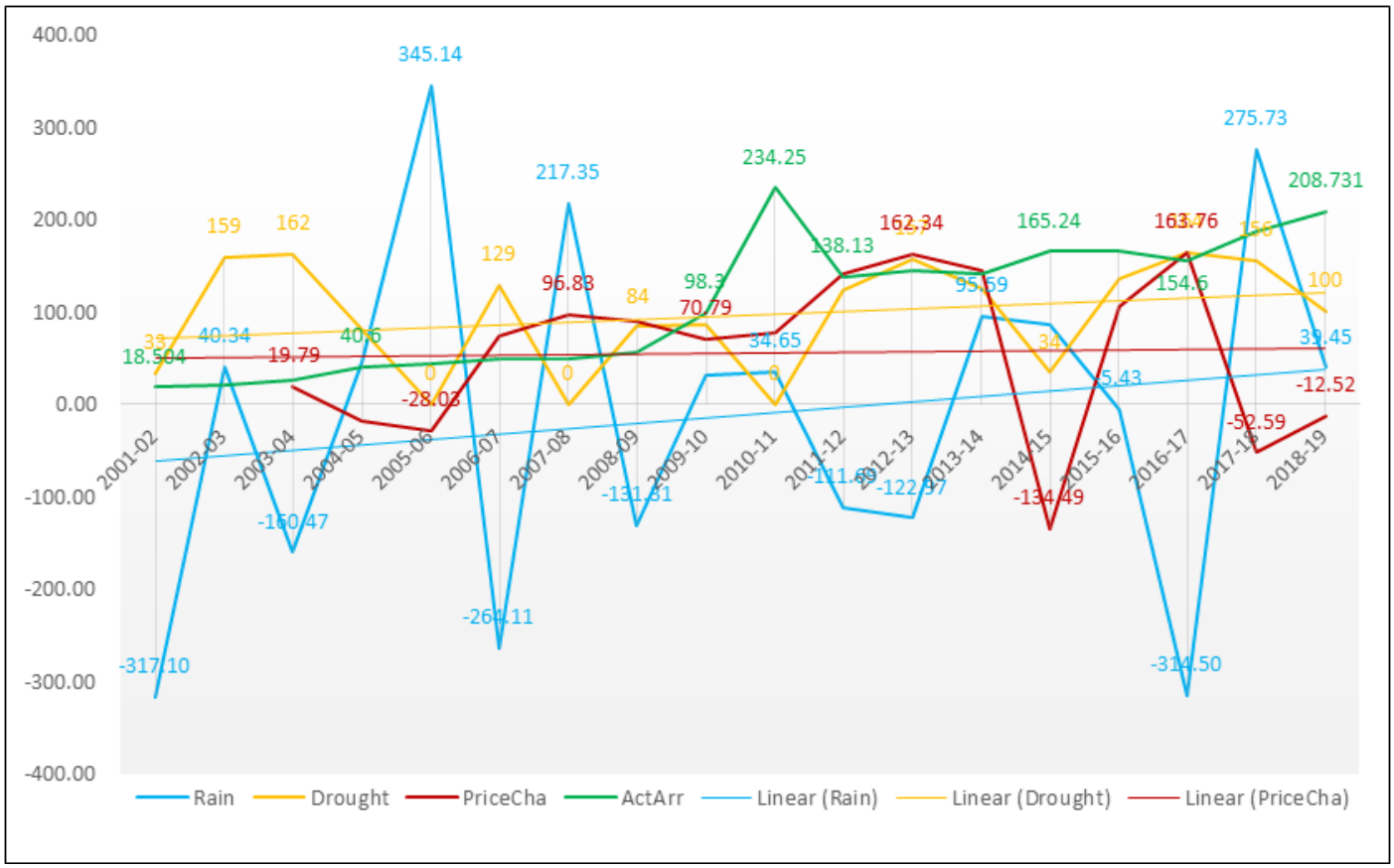

Fig 2 Amount of Changes in Price to the Weather Pattern and Crop Arrivals

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR525

The Figure 2 explaining a change in the price over time comparatively to the climate (such as drought and rainfall) and crop output. In which, as drought increase due to the higher temperature, evaporation, and less precipitation are reduce the quantity of production or quintals of production arrives to the market will decides the higher price rate. But as increase in rainfall will cause to decline the drought level brings higher quantity of output results lower price. Even, sometime the higher rainfall will not bring more output due to the extreme events of un-seasonal effects, heavy rainfall, floods, storms, etc. also cause to increase the amount of price rate. That was happened in 2007-08 even a zero-drought year and higher rainfall (more than 217.35mm of positive rainfall) period crop has received 638 rupees of price shows 96.83 rupees of positive change due to stabilized growth of maize crop arrivals to the markets. So, the study found, the drought and changes in price has directly interlinked but both has inverse relation to the rainfall and crop quantity arrivals to the market except 2007.

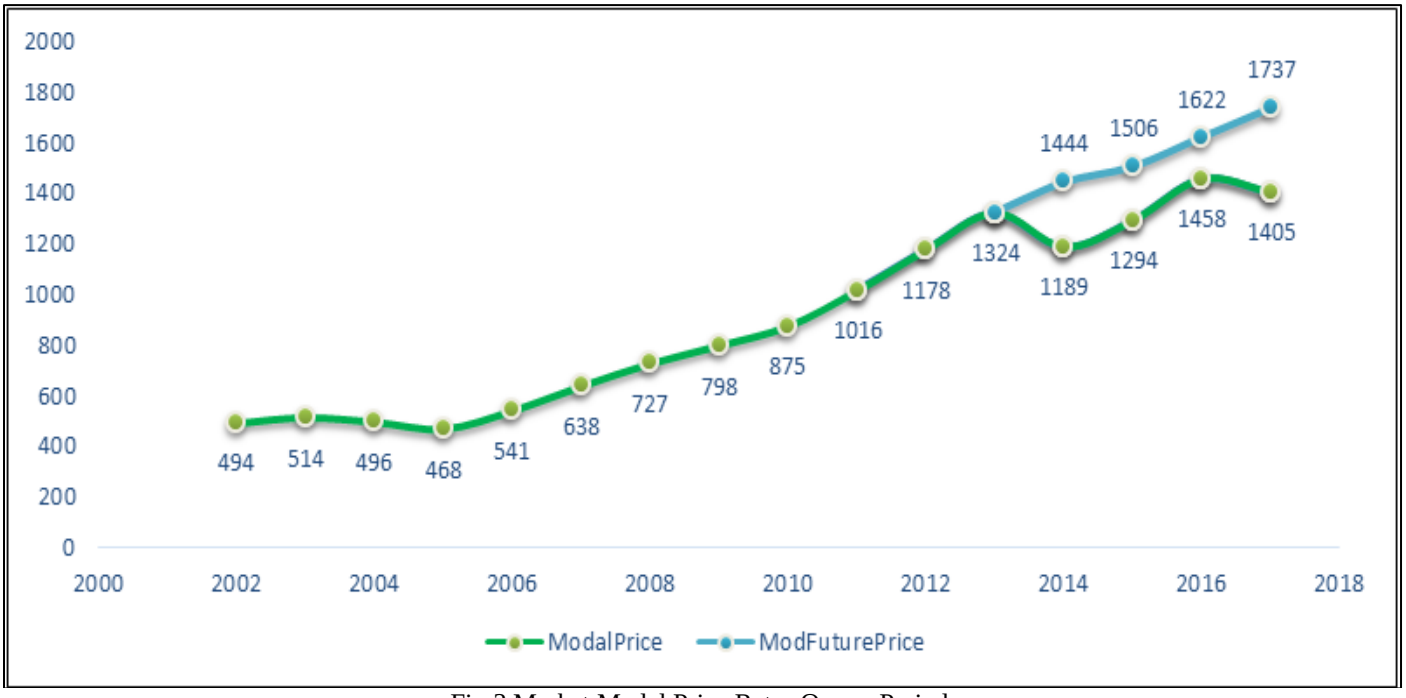

Fig 3 Market Modal Price Rates Over a Period

The study has found decreasing market prices (see Figure 3) from 514 to 468 rupees in 2003 to 2005. Because of higher quantity arrivals started than before from 2004 and continued increasing. After that market price has increasing due to the amount of quantity supply chain moved constantly till 2008. From 2009, state has started to receive higher quantity of arrival (98.267 lakh quintals arrived from 10.454 lakh hectares in 2009, is more than 55.53 lakh quintals from 10.844 lakh hectares in 2008) of 42.73 lakh quintals than before, it is reached peak level in the year of 2010 even received more price of 77 rupees than 2009. It may contribute more income to the farmers and agriculture GDP. After that production has fell-down suddenly in 2011 has caused to increase in the price rate on an average 1016 rupees, even a quantity of arrivals to the market is more than the 2009 due to area of production (is 1.58 lakh hectare) is more than 2010. As fluctuations seen continuously in the crop quantity arrivals, price is also moved upward. When 165.24 lakh quintals arrived at the market in 2014, the government has decided to cut-down the price rate due to highest area of cultivation (13.74 lakh hectares) and concern on public or consumption side effects. It has observed more than 24.107 lakh quintals in last three years, but it has failed to bring higher output than 2010 even higher area of cultivation. Even prices are maintained an increasing trend at the decreasing quantity arrival to the market due to weather extreme events adverse effect on crop production. Over a period, total market price rates of maize are maintained an increasing year by year at the decreasing rate of quantity arrival to the market compare to the area of cultivation due to weather extreme events adverse effect on crop production. But totally we can observe upward trend of crop arrivals to the market, that higher amount of crop arrival than last year is caused to decline the price rate (Figure 3).

After the peak level of quantity arrivals in 2010, study observes fall in crop arrivals has caused to increase the price rate from 875 to 1016 in 2011. After that small fluctuations in the crop arrivals due to the changes in weather has maintained on an average above 142 rupees of change in crop market prices up-to 2013 (1324 rupees) and the price suddenly fell to 1189 (-134) rupees in 2014. If new trend line is not started from 2014 (*ModalPrice*) the peak of 1458 rupees in 2016 may be reaches 1444 rupees (in 2014) in single step of continues change in the price (*ModFutPrice*). That predicted price line - *ModFutPrice* continues increase up-to 2017 reaches 1737 rupees, it may increase the income of maize cultivators with the producer surplus, but it will cause to consumer deficit and creates inflation in retail

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market. So, to control the inflation rate in the agriculture commodities and to bring the stability in the economy government has taken the right chance to cut-down the price rate in 2014. So, study has observed new trend line of price from 2014 as fall in price rate. It kept moving upward and reached peak of new trend line in 2016 (1458 rupees) and again declined in 2017 (1405 rupees).

That amount of price change (positive or negative change) has three steps. Firstly, from 2002-2005 has seen 22 rupees of change in price annually, in next step it reched between 71-97 rupees, it is on an average of 81 rupees from 2006-2010. After 2011 we can see third trend of an amount of price change is increased in between 105-162 rupees, it is on an average 120 rupees. But recently price rate are fell down (-134 ruppes) from 1324 - 1189 rupees in 2013 - 2014, and -53 rupees has declined in 2017 from last year (1458 rupees).

D. Ricardo observed, in the pattern of crop arrival, price, and revenue were increasing trend at decreasing rate over a period. Even, it is not possible to see (see Figure 4) increasing trend in the land production or quantity due to declining land productivity year by year as cultivation continues. But in the year 2009 and 2010 has proven there is a chance to grow higher than before, but also it will fell from next year even a higher area of cultivation because of sudden disasters such as weather prone extreme events will adversely affect on farmers (observed in 2002-2008 and 2011-2017). Those changes in climatic conditions can affect on crop growth, production, and its revenue. Climatic changes inducing a change in cropping pattern may shift crop sowing period (it is highly suitable for sensitive crops), changes the choice of crop seed for cultivation, crop mix, or may be agriculture area is also used for allied activities of agriculture, and it may also give a chance to convert the land as arid or for urbanization.

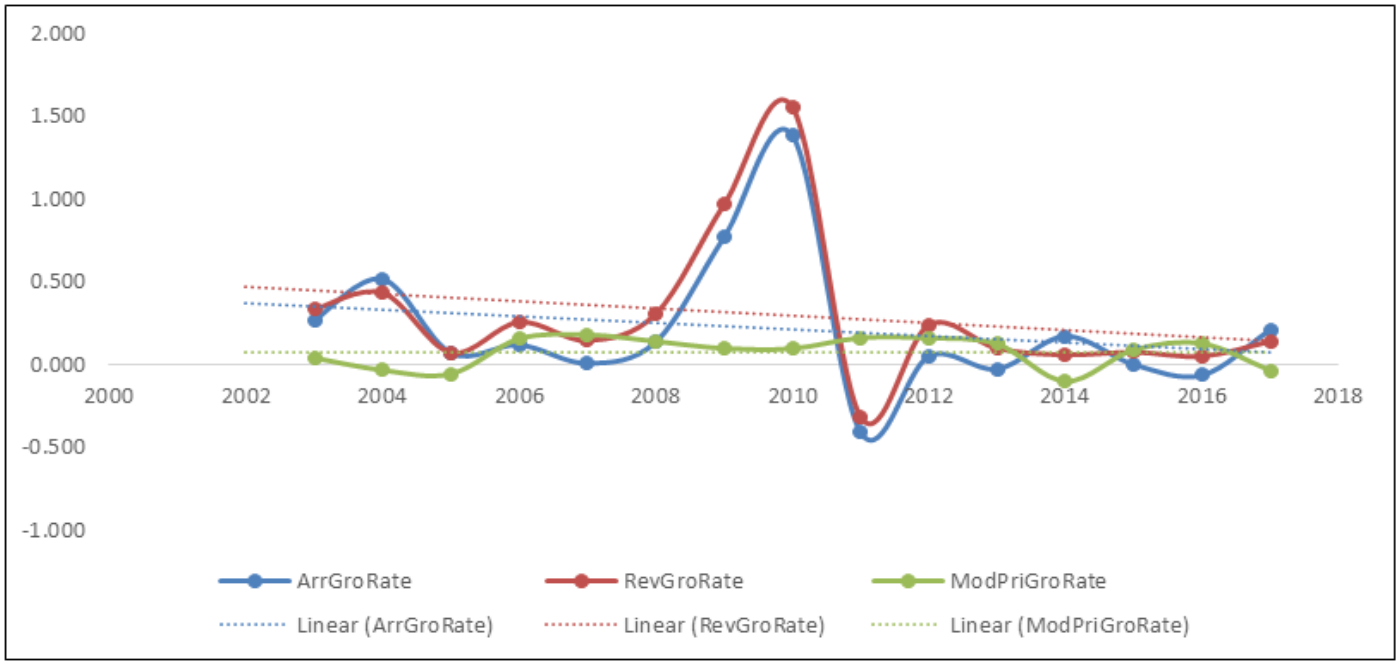

Fig 4 The Growth Rate of Quantity Arrival, Price, and Revenue

The daily amount of crop quantity arrival in the market and the commodity sold at the prices of markets (see Figure 3) are multiplied to get crop revenues (Figure 5). The future predicted revenues (*RevFMA*) from 2010-2017 are taken from the 2002-2009 labor-intensive technological crop output - *AFMA* and prices. And from the 2010-20017 technological change (*ABMA*) applied to the year from 2002-2009 has received the revenue line of *RevBMA*. The curve of Revenue flows as same to the actual *Arrival* (figure 1) explains, in 2002 state has earned 104.01 crore rupees and loosed 294.9 crore rupees due to non-adaptation of technology as compare to the technological usage (*RevBMA* curve). It has continued incresingly, 460.94 crore rupees has losed in 2009. But, the 234.25 lakh quintals of crop arrives to the market in 2010 with an average modal price of 875 rupees has generated 2008.352 crore rupees of revenue. That revenue has earned due to the adjustable weather pattern, highest maize quantity arrival over a period and positive change (77 ruppes) in price. But 2014, Maize producers has earned 1976.5 crore rupees even from less amount of crop arrival (165.24 lakh quintals) from highest area of 13.74 lakh hectares with 1189 rupees of market price (compared to the 2013 price of 1324, the price of -134 rupees has declined due to increase in area of cultivation, production, and market arrivals the price rate shift downward). And 2010 revenue has crossed in 2015 (has received 2123.88 crore rupees) from 165.21 lakh quintals of crop arrival even it is lessor than 2010 due to the 1294 rupees of price. The highest revenue (of 2541.19 crore rupees) has earned in 2017 with the price of 1405 rupees and 187 lakh quintal of arrivals (is second highest after 2010). These capital-intensive technological revenues of agriculture has received more than labor-intensive technology. In the same prices, if the labor-intensive technology exist from 2010-2017 - *AFMA*, it has chances to loses 949.59 crore in 2010, 105.57 crore in 2014, and 131 crore in 2017 due to the technological lapse.

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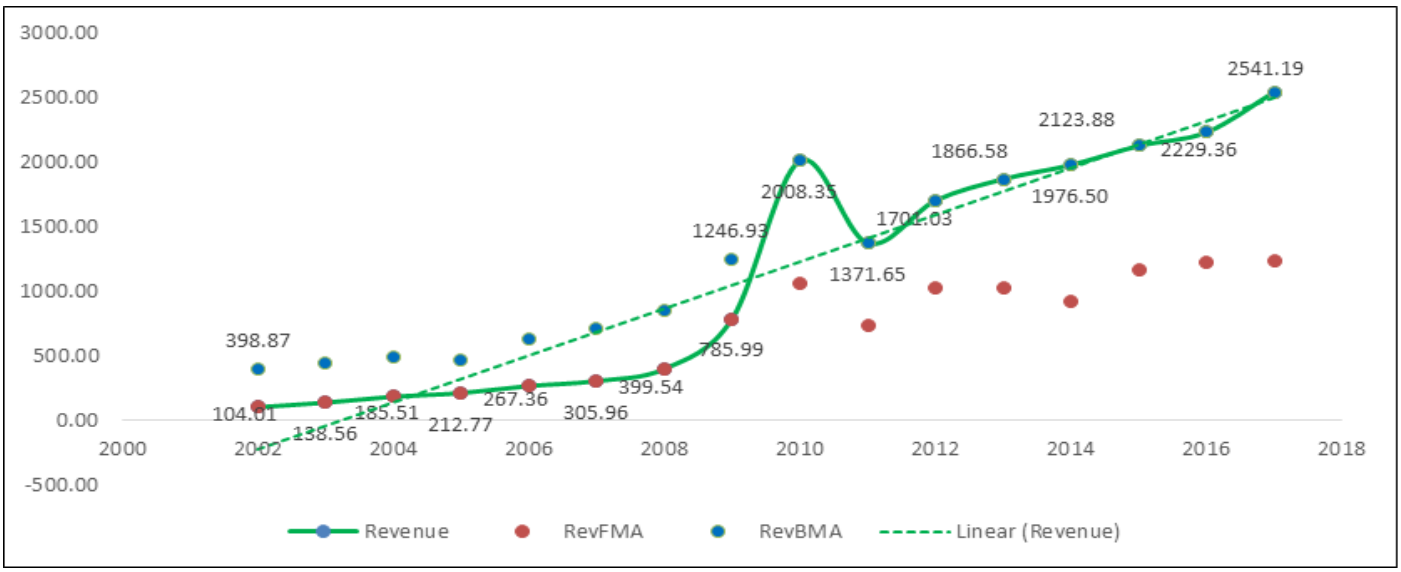

Fig 5 Revenue of the State from Maize Production Over a Period

The revenue has increasing year by year due to the incrimental changes in price (to meet the profit out of cost) and total quantity arrivals (the area of production may increased to meet the higher demand) will help the farmers to get more revenue. And the negative changes of price to the quantity arrival are making fall in total amount of revenue as compare to the positive growth of price and output. The market price of maize is increasing as amount of quantity arival decrease and as decrease in quantity arrival can increase the price shows a inverse relation. That inverse changes of price to the quantity arrival are made to stabilize the infalation in economy, by taking a both side decisions for producer surplus and consumer surplus.

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 7) 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.

Table 1 Estimated Variations to the Projected Changes in Annual Rainfall and Temperature (in Percentage)

Districts	Area (Ha)	Production (Qtl)	Yield	Revenue (Cr)	Rain (%)	Temp (°C)
Bagalakote	27.83	32.7	14.82	92.677	1.38	2.15
Ballari	46.19	53.26	15.96	75.019	0.52	2.08
Beedar	74.3	106.34	31.13	113.698	27.03	2.12
Belagavi	21.12	36.12	21.41	90.527	6.15	2.01
Bengaluru Rural	33.24	41.33	24.15	118.940	3.56	1.97
Bengaluru Urban	93.89	87.13	29.16	37.247	3.66	1.96
Chamarajanagara	35.37	49.81	29.48	90.815	-1.85	1.96
Chickballapura	24.41	42.51	30.78	93.762	0.97	1.98
Chikkamagaluru	107.63	111.65	24.23	94.334	3.62	1.86
Chitradurga	42.05	53.75	32.52	110.418	6.5	2
Dakshina Kannada	64.05	100.74	41.67	.	0.87	1.72
Davanagere	17.38	34.51	25.76	71.734	6.57	1.98
Dharwada	59.32	62.41	25.21	74.386	3.71	2
Gadaga	48.98	50.03	32.08	97.613	1.93	2.08

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Hasana	61.85	75.44	26.44	102.701	2.45	1.92
Haveri	31.25	39.91	28.58	85.653	5.8	1.97
Kalaburagi	51.35	48.54	28.46	149.393	4.26	2.19
Kodagu	31.21	47.35	25.19	55.561	2.53	1.79
Kolara	113.05	111.33	25.21	164.954	1.08	1.96
Koppala	60.3	71.27	30.53	92.049	-1.56	2.14
Mandya	64.74	79.86	32.08	129.546	1.4	1.99
Mysuru	34.94	35.12	18.57	110.624	-0.78	1.95
Raichuru	165.84	182.11	32.49	78.104	-6.79	2.2
Ramanagara	36.27	43.06	28.62	126.717	2.85	1.97
Shivamogga	38.1	47.46	19.6	98.584	5.27	1.88
Tumakuru	41.01	44.83	21.28	120.445	5.22	1.99
Udupi	57.15	59.06	12.85	.	4.07	1.71
Uttara Kannada	94.37	108.94	42.44	160.808	5.4	1.87
Vijayapura	55.99	68.22	21.05	92.520	0.6	2.2
Yadagiri	65.5	64.77	27.5	.	-4.07	2.21

Source: Authors Calculation and BCCI-K, under the IPCC A1B Scenario

Study has accounted amount of variations in the area of cultivation, crop production, yield, and revenue to the predicted changes in climatic pattern such as rainfall and temperature (Table 1). In the area of cultivation study has observed least varuiations from Davangere (17.38%), and Belagavi (21.12%) due to the highest positive chages in the rainy pattern eavn an 1.98 and 2.01 ^{o}C changes in temperature. The highest variation have seen from Raichuru was 165.84% due to the -6.79% negative fall of rainfall, and Kolara (113.05%) was hihgly volatile just a 1.08% change in rainfall, followed by Chikkamagaluru (107.63%), Uttara annada, and Bengaluru Urban.In the production minimum volatility observed from the districts of Bagalakote (32.7%), Davanagere (34.51%), Mysuru (35.12%) followed by Belagavi, and Haveri even a -0.78-6.57 % changes in rainfall and 1.95-2.15^{o}C change in teperature. Along with that highest variation in production was found in Raichuru (182.11%), Chikkamagaluru (111.65%), Kolara (111.3%), followed by Uttara Kannada, Beedar, and Dakshina Kannada. In the revnue of the state, less fluctuations have seen from Bengaluru Urban (37.25%), and Kodagu (55.56%), other than these almost of the districts face most of the variation but highest have seen from Kolara was 164.95% and Uttara Kannada was 160.80% even a positive cghange in rainfall due to heavy rainy regions.

Table 2 Parameter estimation to the revenue of Maize crop.

Variable	Variable Labels	Parameter Estimate	Approx Pr > |t|
Intercept		**42.0371**	**<.0001**
AFsq	**Area of forest cover (in Ha)**	**-1.38E-11**	**0.0068**
MAICW	**Maize area irrigated crop wise (in Ha)**	**0.0000243**	**<.0001**
MAUICW	**Maize area unirrigated crop wise (in Ha)**	**0.0000275**	**<.0001**
CCOsq	Cloud Cover (in %)	-0.000348	0.3118
GFF	Ground Frost Frequency (integer /Day)	2.4528	0.1687
lnPE	**Potential Evaporation (in mm /Day)**	**-9.2197**	**<.0001**
TEMPsq	Temperature in ^{o}C)	0.001703	0.3282
lnRAIN	**Rainfall (in mm)**	**-1.5893**	**0.0006**
WDFsq	**Wet Day Frequency (Above 10mm)**	**0.0181**	**0.0627**
WDsq	Water Deficit (in mm /Day)	-0.000102	0.2165
fRAIN	**Fertilizer*Rainfall**	**5.69E-06**	**0.0211**
AUHYVsq	**Area used High Yielding Varities (in Ha)**	**0.000159**	**0.0671**
FCsq	**Fertilizer consumption (in Kg /Ha)**	**0.0000541**	**0.0002**
PCI	**Per Capita Income (in Rupees)**	**0.0000109**	**<.0001**
Dep. Variable	Maize Revenue		
R-Square	0.6341		

The estimation of regression function (table 2) to the maize revenue will assess the amount of effects from agro-climatic and other variables. An one prcenta of changes by increasing in area of forest cover (AFsq) can positive influence the maize revenue bringing more and more rainfall. It will positive encourage the cultivation activitise of Maize crop in irrigated area (MAICW) and un-irrigatd area (MAUICW) are statistically significant at <.0001. The increase in day time and temperature level was highly cause to evaporation (lnPE) was statistically significant <.0001 but

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR525

negatively associated at -9.2 percent. Along with that, the reduction in amount of rafall and rainy days lnRAIN) were increasing from 1950 according to KSNDMC was negatively associated with Maize revenue in Karnataka.However, wetness of land above the 10mm (WDFsq) positvely associated under 10 percent level (0.0627).

To come out of these climatic effects and risks farmers are ready to face with the help of technological change or adoptation, even by spending more to get highr revenue as increase their PCI was positive and statistically significant (<.0001). On technological side farmers are prepatred different varieties of seeds wich may stand even an decline in the rainy pattern such as by using HYVs, water resistance crops, etc.. (AUHYVsq) are positively correlated with Maize rave under 10 percent level (0.0671). Also, to bring higher output and revenue or profit farers are applying fertlizers (FCsq) was statistically significant, even they can use fertilizers in less rainy period (fRAIN) will also positively influence the revnue of farmers. Along with these farmers were using pestisides, machinery, new tecniques and technology to get highr outcomes as much as possible.

IV. FINDINGS AND SUGGESTIONS

The study forecasted future year production from the same of labor-intensive technology (2002-2009), if it continued up to 2010-2017 will brings higher revenue (*RevFMA*) than before, but not more than capital intensive technological adoption (figure 1). Even, the application of capital-intensive technology (2010-2017) to the 2002-2009 brings less revenue (*RevBMA*), even a higher production - *ABMA* due to the less prices (change in price is between 70-100) than 2011 (change in price is between 135-165) but the revenue is more than labor intensive technology. The implementation of capital-intensive technology has proved more output has brought higher revenue (Revenue) than labor-intensive technology due to the knowledge application and constant weather fluctuations. But the study observed, in 2009 and 2010 has also proved higher output in both capital and labour intensive technology (due to normal and constant weather pattern) but not in revenue (due to less prices than 2011-2017). And revenue in 2017 has reached the peak level even less crop arrival than 2010 due to higher prices. So, the crop arrivals (*AFMA*) and revenues *(RevFMA*) of labor-intensive technology are maintained a long distance with capital-intensive technology even increasing trend line. But the intervention of technology and mechanization in agriculture production may positively impact to the landowners and industries but it will destroy the life of labors who are works in agriculture and allied activities. Because it will reduce the working day's and push them to migrate from the work field to other area.

The actual arrival from 2002-2009 (labor-intensive technology) has loosed more than 2010-20017 (capital-intensive technology), as compared to the highest crop arrival (234.25 lakh quintals) in 2010 and from 2010-2017. There is a remarkably highest production or crop arrival seen in 2010 due to normal weather or rainfall but not after the 2011-2017 even a higher area of cultivation and the intervention of technology and mechanization due to weather volatility. The study found that, changes in production to the weather has direct relation but negative impact due to the extreme events and changes in the price has inverse relation to the production or quantity arrivals but causally related to the weather.

Study suggests, still land has more capacity to produce when we manage the weather, land, crop, and water. An increased capacity of water storage may push the area of cultivation as of monsoon even in summer also. That may double the agriculture output annually. So, the state has need of water management system because area of cultivation declines in summer due to less water and in monsoon period crops are rotten or destroyed due to excessive rainfall. So, the quality seeds and suitable crops are required for sowing in the area. To reduce that risks, land management is also required such as creation of sloping in a flat surface and usage of natural fertilizers to increase the productivity level. It only succeeds by the combination of farmers and the government intervention through policies and programmes.

V. CONCLUSION

In the area usage of maize cultivation, on an average, above 61 percent comes under rainfed area (is 70.2 percent in 2017) and 39 percent of area has irrigation facility (is 29.8 percent in 2017). Study estimates the revenues over a period form 2002-2017 based on the market data of crop arrivals and prices. The revenue dependent on the multiple factors such as productivity, economic factors, and climatic factors. The changes in weather has direct relation to the production but it negatively impacts due to the extreme events and changes in the prices has inverse relation to the production or quantity arrivals and climate change. The state has needed water management system because area of cultivation declines in summer due to less water and in monsoon period crops are rotten or destroyed due to excessive rainfall. So, there is also a need of farmer concentration on land management other than water and crop managements.

The result explains, revenue of the state has been increasing due to the higher production and higher prices, but even drastically impact found after 2009. The less production brings higher price and higher production determines lessor price rates. They may try to stabilize the economy, but it may inversely impact on marginal and small farmers. The forecasted future year production (after 2009) from the same of labor-intensive technology (before 2009) brings higher income due to higher production and higher prices, and application of capital-intensive technology (after 2009) to the before 2009 brings less revenue due to higher production (than labor-intensive technology) and low-price rate. But the adaptation of capital-intensive technology is more profitable than labor-intensive technology.

- *Conflict of Interests:*

  There is no conflict of Interest to be declared.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR525

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APPENDIX

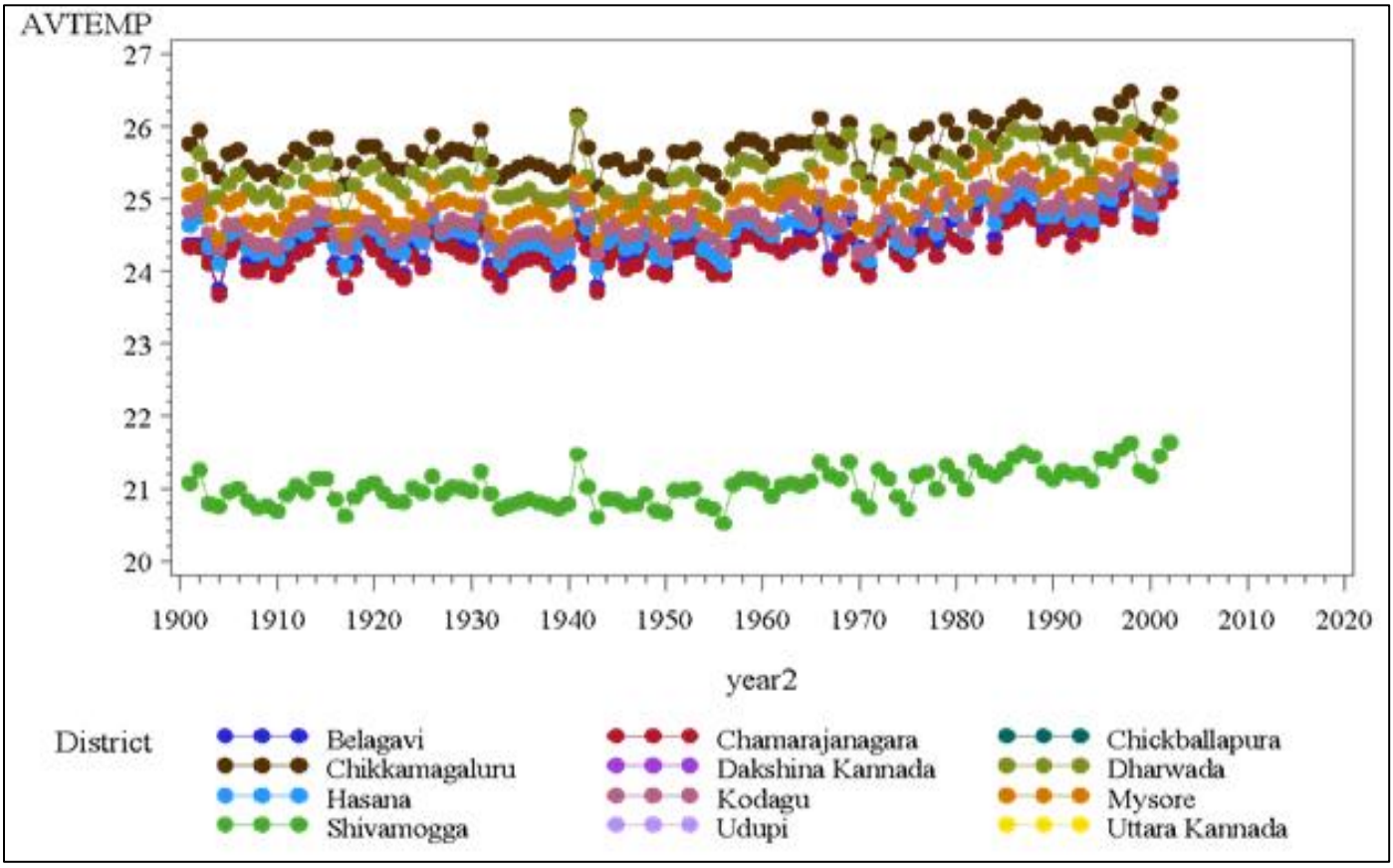

Fig 6 Tends and Pattern of Rainfall and Temperature Over 1900-2018

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR525

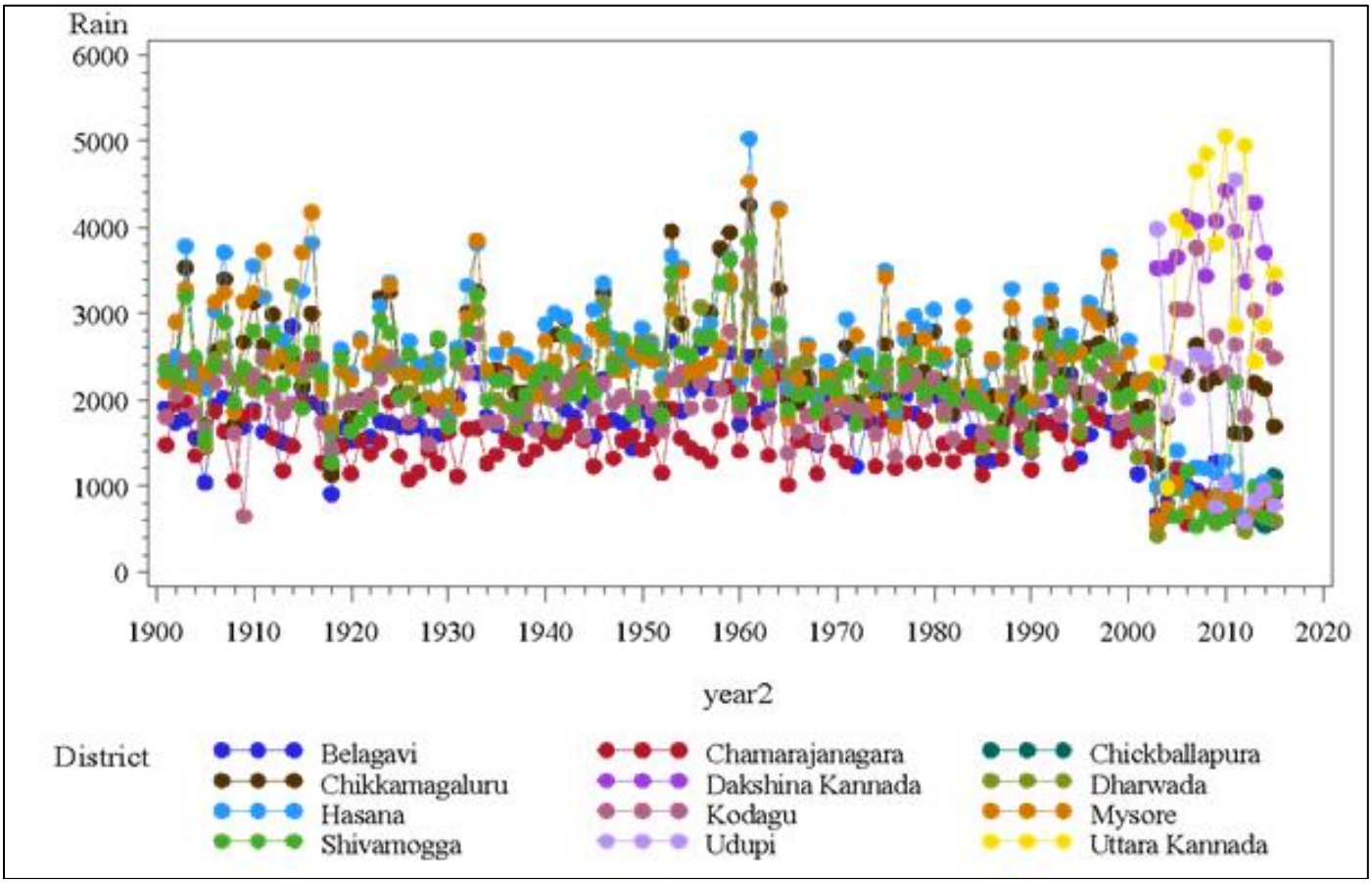

Fig 7 Distribution of Maize Crop Revenue Over Time Across the Karnataka State