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Full Length Research Paper

A Study of Monsoon, Irrigation and Agriculture of Uttar Pradesh, India

Jyoti Tripathi[1*], Dr. Rekha Gupta[2]
[1] Assistant Professor Department of Economics Government PG College, Musafirkhana, Amethi, Uttar Pradesh, India
[2]Assistant Professor Department of Economics University of Allahabad, Uttar Pradesh, India

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Corresponding Author:
Jyoti Tripathi

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ABSTRACT

The agriculture development of any country depends on the water resources available there. So irrigation development is first step of development process of society. Present study evaluates the irrigation development in Uttar Pradesh since 1950. It has been done through the calculation of agriculture dependency on monsoon rainfall. Lower the dependency on monsoon rainfall reflects higher the efficient irrigation system. To calculate the impact of rainfall on agriculture production regression analysis had been used. four variables to indicate agriculture production has taken for analysis. These variables are- Net State Domestic Product (NSDP), Agriculture NSDP, Food Grain Production (FGP) and Paddy Production of Uttar Pradesh. The result indicates that correlation between summer monsoon rainfall and NSDP is negligible but AgNSDP, food grains and paddy production are significantly correlated with monsoon. Variations in AgNSDP, food grains and paddy have found 33.1%, 67% and 49% respectively. This is high a fluctuation for an agrarian country. But this is comparatively low to all India level. Even its impact did not appear on NSDP. Correlation coefficient and r^2 is 0.126 and .016 respectively. The main reason for this is that NSDP growth is largely depended on the service sector and industry rather than agriculture in recent years.

1. Introduction

Water is the first need for agriculture and plays important role in food security. In other words, irrigation has a catalyst role to provide the food security to millions of people. According to World Bank report irrigated land represent 20% of total cultivated land and 40% of total food grain production† worldwide that is not called enough for 8 billion people. Due to population growth and climate change fresh water will be decreased rapidly and need of food grain increase day by day. In Indian context where agriculture is the base of economy, irrigation techniques are not well advanced and agriculture is dependent on monsoon rainfall. So, this is the demand of time that irrigation facilities have been developed to meet the challenges of population growth and environmental changes. Present study covers Uttar Pradesh state which makes a special

Author can be contacted at: Department of Economics Government PG College, Musafirkhana, Amethi, Uttar Pradesh, India.

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†www.worldbank.org

contribution to the national economy. In recent years by increasing the production of other states, share of Uttar Pradesh in primary sector has declined but overall, the state is remained top most in agriculture production. So, the progress of state economy cannot be resolved without a paradigm shift in irrigation and water facilities. Therefore, government of India and state government have high priority in five year planning for improvement of irrigation facilities. (Srivastava S.K.; 2013). Present study presumes the irrigation efficiency of state through the calculation of agriculture dependency on monsoon rainfall. Lower the dependency on monsoon rainfall reflects higher the efficient irrigation system. The paper is organized as follows: firstly, the paper presents trend of monsoon rainfall and correlates it to food grain production, paddy production and lastly the paper discuss on irrigation growth in India.

Uttar Pradesh shares 17.7 % in total food grain production of India followed by Madhya Pradesh, Punjab[‡]. After 1990s states contribution declined by 6-7 % but overall production is increased. Paddy, wheat, pulses(including tuar, gram, black gram, pea) maize, sugarcane, mustard are the main crops of the state. Majority of state's farmers are depended on paddy and wheat crop for their livelihood. Paddy crop is a khareef (summer season) crop, mostly depends on monsoon rainfall for irrigation and wheat is a rabi crop(winter season) incorporates dry crops. But khareef and rabi both are influenced by monsoon rainfall because late or abnormal monsoon push the khareef crop till December to January.(Avinash Kishore; 2004). As a result, sowing of rabi crop is delayed and total production declines.

Therefore, if monsoon is abnormal total food grain production and agriculture supply chain is affected. Since agriculture is the backbone of state economy, it affected to overall economy in abnormal monsoon year. The present study attempts to investigate the impact of summer monsoon rainfall in overall economy in general and agriculture in particular.Study incorporates the net state domestic product (NSDP), net state domestic product of agriculture (AgNSDP), total food grain production and paddy production to assess the impact of monsoon variation on overall economy. These four variables present the overall economy. NSDP is the key indicator of production and employment. Due to agrarian state AgNSDP is the base of the economy. Total food grain has the largest share in AgNSDP and paddy is the main crop of the state and mostly farmers are engaged in paddy cultivation and are directly affected by it.

Indian monsoon has two vital systems-namely – North east monsoon and south east monsoon also known as summer monsoon rainfall. North east monsoon rains in south Indian peninsular and Shrilanka. Agriculture and economy are not affected much by north east monsoon. That's why it did not get much attention in economic studies and literature. Other hand southwest monsoon is the nerve centre of Indian economy and especially north Indian states. Uttar Pradesh gets rainfall from, June to august by south west monsoon. This is the season of khareef crops including paddy, tuar, urad, maze and vegetables in state. Farmers are depended to a large extent on the rainfall in this season. So the present study considers only south west or summer monsoon rainfall to assess the rainfall impact.

The debate on monsoon and GDP & food grains in India is quite rich. Alot of studies have been done monsoon assessment. Sulochana Gadgil, D.R. Gadgil; 2006 have studied on time series data of monsoon, GDP and total food grain production of India. Study found that GDP and food grain production is highly correlated (0.76) with summer monsoon and impact of deficit monsoon on agriculture and GDP being larger than surplus monsoon. Virmani; 2005 also studied on GDP growth rate and rainfall. Study assumed that rainfall and oil shock are two exogenous variables which extremely effect Indian economy. About 45% of the variation in India's GDP growth is explained by the fluctuations in rainfall. Joy Deep Mukharjee et al (2004) have analyzed time series data of crops (rice, wheat, coarse cereals, pulses, and total food grains) and monthly rainfall (July to September). Variation in production were correlated with rainfall and founded that rice has highest correlation with monsoon. Other crops also positively correlated with monsoon. V. Prasanna (2014) has also studies on the impact of monsoon rainfall on crop productions. Study assessed the variation in khareef and rabi production since 1968 to 2008. Khareef crops were directly affected by monsoon rainfall but rabi crops did not show any significant variation with monsoon. Rabi crops influences through soil moisture which is affected by monsoon. Krishna Kumar et al (2004) has presented an analysis of food grains, pulses, oilseed, cereals and six different crops (namely rice, wheat, sorghum, groundnut and sugarcane) to assess the impact of monsoon variation. At all India level monsoon season crops were strongly correlated with all India summer monsoon (or monsoon predictors). Results were same for state level crop production and subdivisional monsoon rainfall statistics.

Mostly studies found that Indian agriculture is dependent on monsoon rainfall significantly. Virmani has shown that there is no change in the effect of rainfall on the GDP from agriculture from 1950-2003 while Mukharjee & Gadgil have supported high association between monsoon and GDP. Whenever monsoon was low production and GDP was also low.

[‡] Economic survey 2022-23, Statistical appendix

Present study provides the current scenario of monsoon and agriculture association in Uttar Pradesh. Study explores the questions like: what is the correlation between monsoon rainfall and NSDP? In the course of time how much is decreased the dependency of economy on monsoon. Which factors are responsible for decreasing dependency on the monsoon?

2. Methodology

2.1 Experimental Data

Study estimated the quadratic regression equations. Net state domestic products (NSDP), Agriculture GDP, total food grain production and paddy production are used as dependent variables and monsoon rainfall as independent variable. Agricultural and NSDP data were collected from Reserve Bank of India. For simplicity, we took agricultural data in a given financial year under the first calendar year. For example, the 'production in financial year 1950-51' is written as production in 1950. (Joydeep Mukharjee et al;2014) Data of monsoon rainfall was got from monsoon report of Indian Institute of Tropical meteorology, Pune. IITM divides UP into two zones - eastern UP and western UP for rainfall measurement§. Study used only eastern up data because eastern zone covers major area of state. Moreover, study used fluctuation in monsoon which is almost the same for both zones.

2.2 Statistical Analysis

In India, mostly rainfall is occurred from June to September. There was no long-term trend since 1950 but large fluctuations were observed around average rainfall value from year to year as it can be seen in figure 1. Trend line for monsoon is slightly downward. Monsoon is identified as abnormal if deviation of summer rainfall is more than 10 percent of the average value. (D.R. Gadgil, Sulochana Gadgil; 2006). In the present study average rainfall is considered 890. This is estimated by meteorological department of India on basis of rainfall data during 1870- 2016 data.

3. Results

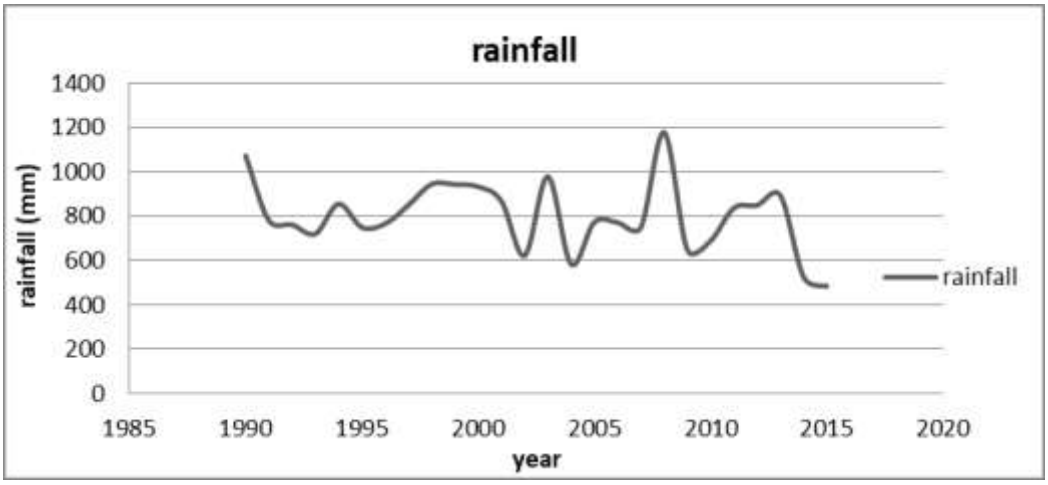

Figure 1: variation of average monsoon rainfall of Uttar Pradesh during 1950-2015. *Data source: www.tropmet.res.in*

Other hand, an increasing trend in net state domestic production (NSDP), net state domestic productof agriculture (AgNSDP), total food grains and paddy production have been recorded during this period.Presentstudy considers the trend of growth rates only since economic reform. During this period total NSDP increased up to 337.69%** .Though the growth was not continuous. Many slight dips are found in NSDP trend path but growth rate was never negative in this period. Agriculture NSDP (primary sector) is also increased absolutely buttotal contribution of agriculture in NSDP is declined (table 1).Total production of agriculture and allied sector is confined 75485 lakhrupee to 117468 lakh††rupee from 1990 to 2015 and average growth rate in primary sector was 2% but deviation in growth rate was high.‡‡Range of growth was -0.2% to 4% in extreme situations. If we exclude the commercial crops and other allied sector and estimate only food grain production, fluctuations in

§ Groundwater year book 2014-15
** In real value, base year 2011-12
†† Base year 2011-12
‡‡Aloka Kumar Goyal& Kumar Sandeep(2103)

trend curve become higher. Absolute production of food grain is increased in last 25 year but fluctuation component is high. In 1990 total production of food grain was 36743 tonne which is reached 49903 tonne by 2015 and maximum fluctuation was up to 1000 tonne in 2014-15.Total Agriculture NSDP was relatively more stable than food grain production. Actually as we move to the core of agriculture, we see a greater fluctuation in production. Paddy crop has the most unstable trend during this period. If we trace out the trend of paddy crop production, more deviation is seen in it (table 4 &5).

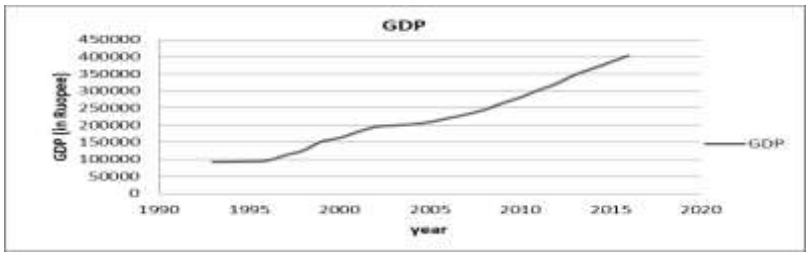

Figure 2: Trend of GDP (in rupee) Source : RBI

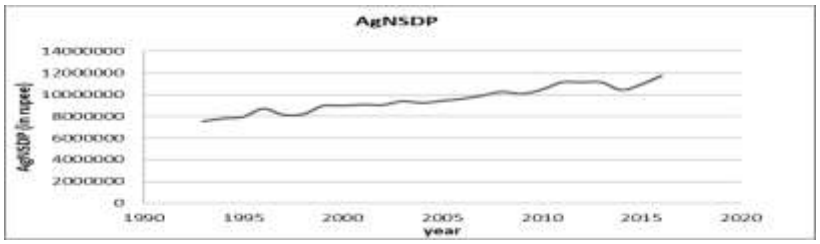

Figure 3: Trend in Agriculture NSDP Source : RBI

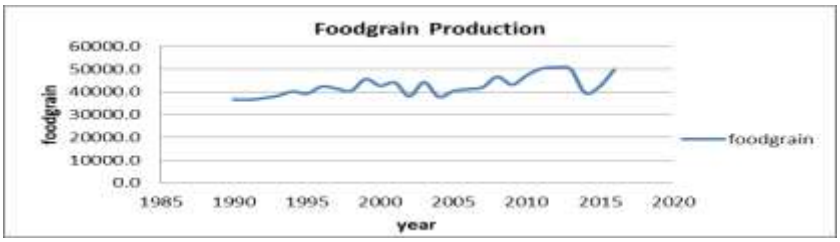

Figure: 4 Trend of food grain production Source : RBI

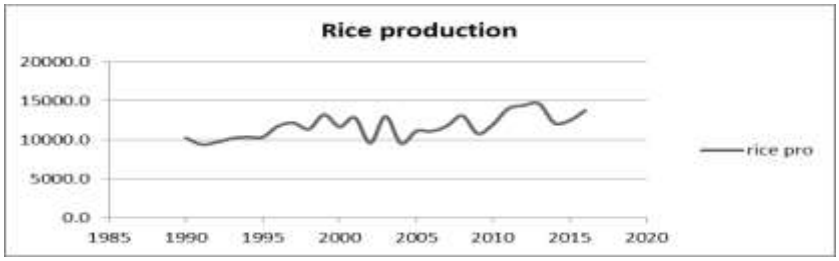

Figure :5 Trend of rice production Source :RBI

The above description shows that the absolute production of agriculture and allied sector of Uttar Pradesh have been increased since 1990 and growth rate was not continuous in. Highly fluctuation component in yield and production were appeared around the trend line. If we compare the trend of rainfall fluctuation to agriculture production during 1990 to 2015, the years when monsoon was extreme abnormal the growth of primary sector and agriculture production in particular was declined. Since 1990, monsoon was deficit in 1993, 1997, 2002, 2009, 2014, and 2015. Parallel to it agriculture NSDP and seasonal crop production was also fall in these years. Paddy crop has shown maximum flexibility with monsoon rainfall fluctuation. (Table 1 and table 2). But there was a little variation in aggregate NSDP respect to monsoon rainfall fluctuation.

It should be noted that generally deviation and growth rate of NSDP and food grain production (FGP) of each year is determined with respect to base year as given below (Virmani; 2004)-

NSDP = 100*NSDP (year) –NSDP (year-1)/ NSDP (year-1)
FGP = 100*(FGP (year) – FGP (year-1)/ FGP (year-1)

A lot of studies have been done on this method. But estimation of growth rate is very sensitive due to base effect. Base effect makes difficult to assess actual growth rate. Sometimes observed deviation seems very high than actual value. For example 1987 was drought year and actual growth rate was very low but base year 1986 was also very low. It subdued the impact of monsoon. Moreover 1965, 1966 and 1967 were the drought years but actual growth of 1966 and 1967 do not appeared due to low base year of 1965. So that, to remove the base year effect, present study has used trend lines or best fit curve. It shows the long term average growth path. Another advantage of the trend line method is that if data for any year is not available, analysis can be done on the basis of estimated value. Our analysis of the impact of the monsoon is based on the premise that while the monsoon(and hence factor depending on monsoon) fluctuates from year to year, most of the other factors leading to the growth of the agriculture production and the economy are characterized by a time scale of several years. We assume that the fluctuations in the food grain production and agriculture GDP in any year from long term trends to be related to the impact of the monsoon of that year. So under this method we have converted the absolute production value into log value and calculated the long term trend of log value and again converted on exponential function of log production. Then find the deviation from actual value to estimated value of long term trend for that year. However it must be noted that other special variables, events which have time scale of the order of a year or so (like epidemic or war) can also contribute to such deviations and the impacts of such events are also seen in our analysis.(SulochnaGadgil; 2004).

Here we need to understand that when fluctuation in monsoon is large, whole state experience the same situation (It may be drought or excess rainfall). But whenever fluctuation is low or near to average value (less that 10 percent, drought or excess rainfall), different areas have different experience. It is seen the large spatial variation in rainfall anomalies over the state, with deficit in some part and normal or excess rainfall in other part of the state. The previous studies also show that the variation in theall India production depends on the variation in the production in different climatic zone of the country. But the present study covered only Uttar Pradesh state. Therefore, no such classification has been done in this study. It is assumed for simplicity that when fluctuation is very large in rainfall (above 10%), to have a large impact on the whole state. That is why study consider only eastern UP rainfall. In order to assess the impact of the monsoon on the agriculture on economy for a specific year, we need to estimate what the production would have been in the absence of monsoon fluctuations that is called the long term trend. We expect the rate of the growth in production at any point in time to be proportioned to the value of the production at that point in the time. It is called the growth to be exponential. Parthsarthy et al (1998) has also used this method. So we have used exponential growth function for NSDP, AgNSDP, foodgrain production and paddy production.

3.1 Trends

The variation with the time of the natural logarithm of the aggregate NSDP, NSDP of agriculture, food grain production and paddy crop production is shown in figure (7), (8), (9)and (10) respectively. There is log value of NSDP, AgNSDP, food grain production (rabi and khareef seasons) and paddy production is presented in figure (7), (8), (9) and (10) respectively. The equation for the best fit curves also presented below (GadgilSudha; 2004)-

$LogNSDP_f = 11.43 + 0.062y$ (1)
$NSDP_f = \exp(LogNDP_f)$
$LogAgNSDP = 11.23 + 0.017y$ (2)
$AgNSDP = \exp(LogAgNSDP)$
$Log\ FGP_f = 10.51 + 0.009y$ (3)
$FGP_f = \exp(LogFGP_f)$
$LogP_f = 9.236 + .009y$ (4)
$P_f = \exp(LoP_f)$

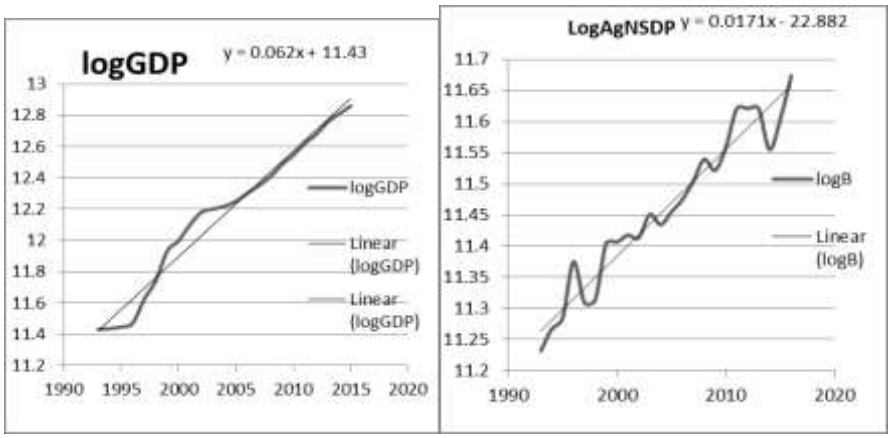

Figure 6: variation in NSDP and AgNSDP (log value)Source: RBI

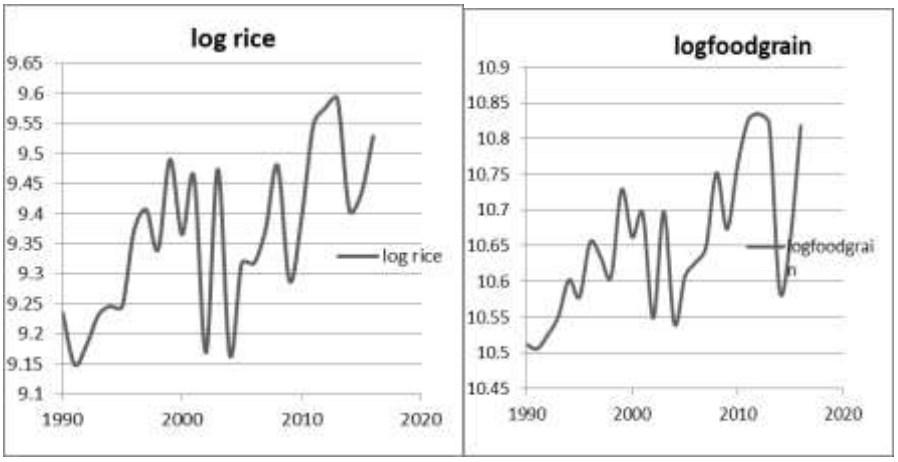

Figure 7: Variation in paddy production and food grain production (in log value) Source: RBI

3.2 Impact of monsoon on Economy:

We expect observed deviations of food grains from the long term trends for a specific year to be related to the important events that year and particularly rainfall of that year. The methodology of the assessment of the impact on food grains and NSDP is given as below-

$NSDP_{dev}$= $NSDP_a$–$NSDP_f$(year)

Where,

$NSDP_{dev}$= Deviation in NSDP in year Y

$NSDP_a$= Actual value of NSDP of year Y

$NSDP_f$= Expected (or fitted) values of NSDP of year Y

AgNSDP, total food grains production and paddy crop is defined in same manner-

$AgNDP_{dev}$= $AgNSDP_a$(year) - $NSDP_f$(year) (5)

$TFGP_{dev}$= $TFGP_a$(year) – $TFGP_f$(year) (6)

PP_{dev} =PP_a(year) – P P_f (7)

Since the actual NSDP varies considerably over the fifty year period.The expected NSDP (from the trend line) that is the $NSDP_f$(year) is used to normalize the deviation of each year and express it as a percentage of the $NSDP_f$(year). Thus for any year the normalized NSDP deviation (in percentage) is defined as:

DevNSDP(year)= 100*$NSDP_{dev}$(year)/$NSDP_f$(year)

In same manner

DevAgNSDP(year) = 100*$AgNSDP_{dev}$(year)/$AgNSDP_f$(year)

$DevTFGP_{dev}$= 100*$TFGP_{dev}$(year)/$TFGP_f$(year)

$DevPP_{dev}$= 100*PP_{dev}(year)/PP_f(year)
Since, there is no long term trend in summer monsoon. Fluctuation in monsoon is defined in the terms of the long term average of summer monsoon rainfall (SMR) and actual rainfall of that year-
FluctuationSMR = 100*SMR (year)-AverageSMR/AverageSMR

Variation in NSDP is depicted in figure 11.NSDP has not shown strong correlation with monsoon variation. Deviation in NSDP is negative in all drought years. NSDP growth is stable only in normal rainfall years. Correlation coefficient is positive, very low which is not significant. The best fit curve is governed by –

$NSDP_{dev}$= 0.80+ 0.025x^2; *x* = Fluctuation in Rainfall

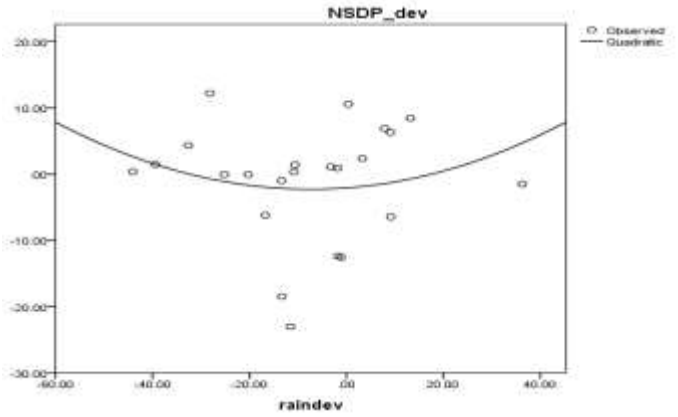

Figure 8: variation in NSDP with rainfall Source: RBI

Agriculture NSDP has shown more flexibility with monsoon variation. Deviation in AgNSDP is negative for all drought years and positive for all excess rainfall years. Though a downward progress in AgGDP is visible when monsoon is variation is larger than +20%.r^2valueis 33.1 % which is significant at 99% confidence level. The best fit curve is shown in figure 12 which is governed by –

AgNSDP = 0.062x^2 - 0.002x + 2.11; *x* = Fluctuation in Rainfall
The most important fact is that deviation inAgriculture NSDP with monsoon was larger in deficit years. In other words agriculture production is more sensitive to drought monsoon. When monsoon has beenbelow to 40%, it has an impact on agriculture production of about – 4 to - 5 %. But when monsoon was excess with 40%, growth was declined but remained positive. Excess rainfall has an impact on agriculture growth of about 1.5%.

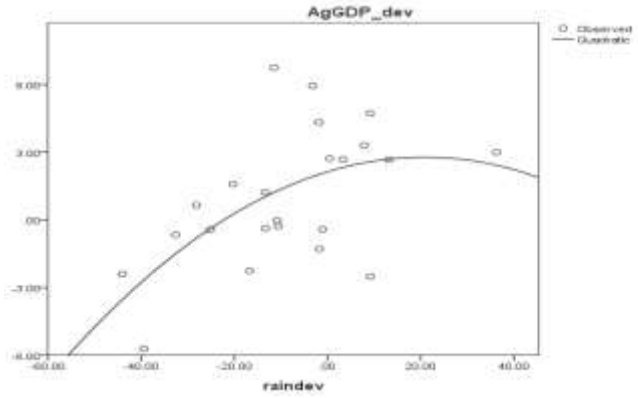

Figure: 9: variation in AgNSDP with rainfall Source: RBI

Monsoon rainfall was highly correlated with total food grain. Rainfall affected the total food grain production of the country with positive correlation(r =). Food grain production has also shown greater sensitivity with deficit monsoon as agriculture

NSDP has shown. Total food grain production was maximum on 20% surplus rainfall and then downward trend has been seen again. The best fit curve shown in figure 13 is governed by-

$Foodfrain_{dev} = 5.7 + 0.22x^2 - 0.005x$; x = Fluctuation in Rainfall

Paddy is the most water intensive and monsoon dependent crop. Joy deep Mukharjee and V. Prasanna found very high correlation between monsoon and paddy crop at all India level. In the present study correlation coefficient is 0.70 which is significant at 95% level. Notable point is that paddy crop has not shown any downward trend with surplus rainfall. At 40% excess rainfall paddy production increased more than 10%.

$Paddy_{dev} = 4.2 + 0.35x^2 - 0.002x$; x = Fluctuation in Rainfall

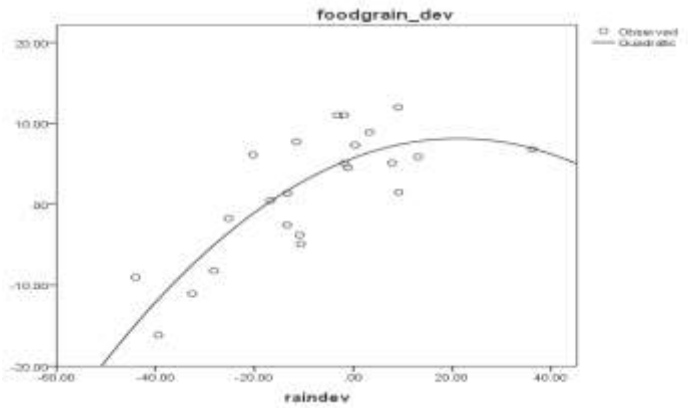

Figure 10 : variation in food grain production with rainfall Source: RBI

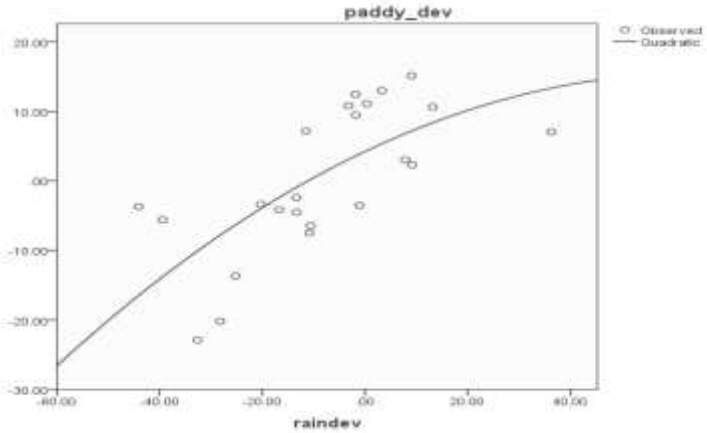

Figure 11 : variation in paddy production with rainfall Source: RBI

4. Conclusion

The major findings and conclusion that we can draw from above results are:

First, we estimate the average impact of monsoon on NSDP of Uttar Pradesh. We can see that the variation was only 0.7% in NSDP due to monsoon. Previous studies on GDP and monsoon at all India level show very high correlation between SMR and GDP. Mukherjee et al has found very high correlation coefficient (0.83)and Sulochna Gadgil's study also found high (0.76) correlation coefficient between monsoon and growth rate. Though Uttar Pradesh is agrarian state, in spite of this the present study found very low and not significant correlation between SMR and NSDP. Main factor behind it the share of agriculture and

allied sector is decreased rapidly in recent years. During last ten year structure of economy has been changed. GDP growth is largely depended on the service sector and industry rather than agriculture. In 2017-18 budget of Uttar Pradesh agriculture sector contribute 22% while service sector has shared 56% of total NSDP. If we trace the impact of monsoon before economic reform, the correlation coefficient and $r^2$is significant. After economic reform service and industry grown rapidly. So the overall impact of monsoon on growth of economy is significantly decreased since 1990'.

Contribution of primary sector has been decreased but absolute production is increased in term of value and amount. Agriculture NSDP growth remained between 1-3 % in normal monsoon year. Growth is negative only in drought years (figure 11). Primary sector is fallen up to -3% in extreme drought years (-40%) and highest growth was achieved. The impact on food grain production is also clearly visible. Around 67.7% variation is seen in food grain production which is significant at 99%.Among the food grains, paddy is most water intensive and monsoon oriented crop. Therefore paddy crop has the most adverse impact of deficit monsoon; there is high correlation coefficient (0.70, significant at 99%) between paddy production deviation and rainfall fluctuation. If we compare the all India data or the past data of Uttar Pradesh there is a good indication that Uttar Pradesh has got self-reliance in irrigation facilities and maintained agriculture productivity.

A notable point is that the impact of deficit monsoon has larger than surplus monsoon.(Gadgil; 2004, Prasanna V; 2014). The same result has been found in previous studies. Total GDP, Primary sector, total food grain production and paddy crop achieved negative growth in drought years. In surplus monsoon years, NSDP, primary sector and food grain productions have grew slower pace but the growth was never negative. Only paddy crop which is highly correlated to monsoon rainfall has upward trend in surplus monsoon years too. Higher the rainfall, grater the production was in paddy. This shows that state has developed the basic infrastructure in agriculture sector in these years. Surplus monsoon has been managed over the time but deficit monsoon is the headache for Uttar Pradesh economy till now. However the effect of deficit monsoon has also decreased over time.

There are a lot of factors working behind it. Some natural and development factor can be credited for it. Uttar Pradesh has large surface water, ground water and sufficient rain fall. Fluctuation in rainfall is also low comparison to all India levelbut development factor is more important here. The most prominent factor is the expansion in ground water irrigation during last 25years.After independence irrigation sources and irrigated area has increased a lot. Since 1951 government had given considerable important to development of canals and ground water irrigation. As result India has gross irrigation on other hand the wells, tube wells, water extraction machines accounted 29% total irrigated area in 1950-51 and now they share 63% of total irrigated area. Though there is dark side of canal irrigation. Canal irrigation has fall down from 40% to 24% since 1951 which is matter of concern.

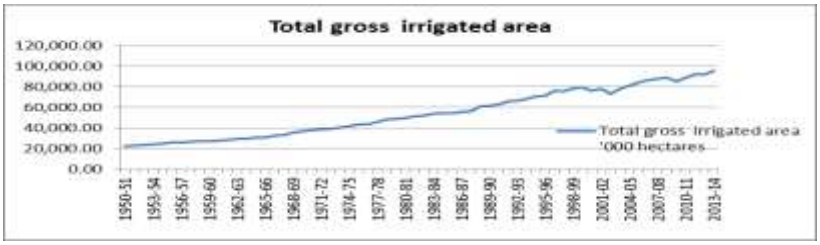

Figure: 12. total gross irrigated area since 1950 Source: www.indianstatistics.org/irrigation

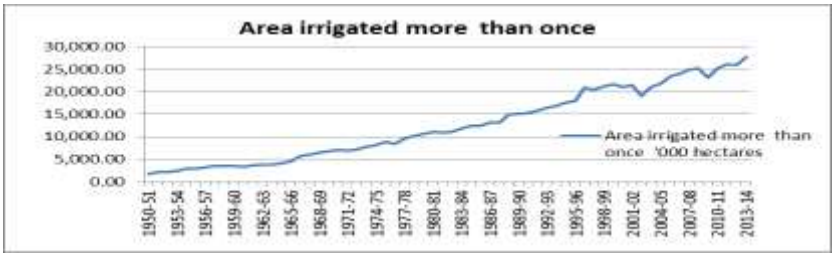

Figure 13: Total irrigated area more than once. Source: irrigation and water resource department

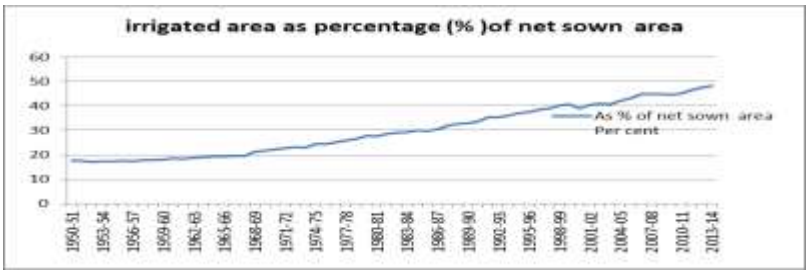

Figure 14: Net irrigated area as percentage of net sown area. Source: www.indianstatistics.org/irrigation

Figure 15: Net irrigated area by canal (in hectare) Source: www.indianstatistics.org/irrigation

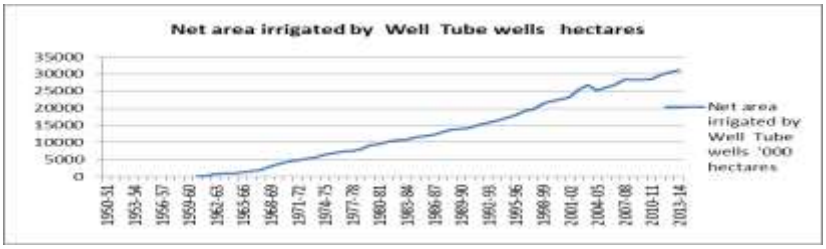

Figure 16: Net Area Irrigated area by Ground Water Extraction Source: www.indianstatistics.org/irrigation

Figure 16show that Government has made unprecedented progress in irrigation.This was possible by improving in power supply and subsidy on ground water irrigation equipments. The net irrigated area is increased by approximately 40percent in 25 years and ground water contributes 74% of total irrigation. Groundwater irrigation became a proper substitute of deficit monsoon.

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