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Spatio-Temporal Variations in Paddy Cultivation: A Case Study of Paschim Medinipur District, West Bengal

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Abstract

Agricultural growth leads to broad-based economic growth and development as linkages between farm and non-farm economies generate income and growth. Agricultural growth, in true sense denotes a change in crop area and production over different time periods. It plays a key role in alleviation and eradication of rural poverty and hunger. Paschim Medinipur district is predominantly an agricultural district of West Bengal where more than 80 percent of the total population resides in the villages, with surplus production of paddy, vegetables and potato. The cultivators constitute 22.80 percent of the total working population of 25.91 lakhs in the district; small and marginal farmers comprise 31.14 percent of the total cultivators and contribute 28.39 percent to Net District Domestic Product. Present study is focused upon the changing growth pattern and instability in area and yield of major paddy varieties (*aus, aman, boro*) in Paschim Medinipur district from 1992-93 to 2012-13, at district and blocks. Growth and instability in paddy have been measured by growth rate (%) and Cuddy Della Valle Index (CDVI) respectively. The study reveals that positive growth rate in area was found in case of *boro*, whereas growth in area under *aus* and *aman* was found to be negative. Seasonal and annual variability in monsoon contributes to the annual variability of growth in area and yield of *aus* and *aman*. Overall, there was stability in area and yield for all the three crops in the district, but there were widespread intra-block disparities in crop area and production in the district in terms of growth and instability.

Keywords: Intra-block, growth, Cuddy Della Valle Index, paddy, area, yield,

Introduction

Agricultural growth and instability have been one of the major concerns of discussion in agricultural economics and matter of endless debate in India. Instability is the inherent character of agricultural growth. Here, growth denotes rate of change over time, whereas agricultural growth means rate of change in outputs in terms of area, production, yield and price between two given time periods. Instability is the fluctuation in growth caused by physical, social, economic and behavioral factors. Despite rapid growth in agricultural technology, large annual fluctuations in agricultural output are a matter of concern,

more so in Indian context. These fluctuations are caused by frequent floods and droughts, resulting in negative growth in agriculture. In addition, spatio-temporal variability in adoption of new technology in the form of HYV seeds, fertilizers, irrigation and farm implements accentuate these fluctuations in agricultural production. Agricultural instability increases the risk of farm production and affects farmers' income and decisions to adopt high cost technologies. Instability in production affects the market price of outputs and ultimately affects low income marginal farmers. Existing literature regarding the relationship between growth and instability of area and yield may be categorized into two periods i.e. pre-green revolution and post-green revolution phase. The present study includes post-green revolution time period for the analysis (due to non-availability of block level individual crop data before 1992). The study conducted by Mehra (1981) and Hazell (1982) reveal that adoption of new technology has been instrumental in increasing instability in area and production. According to Ray (1983a) levels of instability increased after green revolution. Rao et. al. (1988) supported the views of Mehra (1981), Hazell (1982) and Ray (1983b) and opined that amplitude of fluctuation in output significantly increased in post-green revolution periods. Larson et. al. (2004) concluded that green revolution played a very significant role in increasing production but contributes to higher instability in production and yield. In contrast to this, other studies reported that instability declined with growth of agriculture (Das, 1978; Mahendradev, 1987; Tripathy, 1990; Sharma et. al. 2006; Chand & Raju, 2009).

Study Area

Located in the southern part of West Bengal, Paschim Medinipur has been carved from the erstwhile Medinipur district, and came into existence in the present form on the 1st January 2002. Paschim Medinipur district is the southernmost district of the Burdwan Division, is situated between 21^{0}36' 35" and 22^0 57' 10" North latitudes and between 86^{0}33' 50" and 88^0 12' 40" East longitudes. Its boundary lies in Bankura and Purulia districts in the north, Mayurbhanj and Balasore districts of Odisha in the south, Hugli and Purba Medinipur districts in the east and Singbhum district of Jharkhand and part of Odisha in the west. The total geographical area of Paschim Medinipur district is 9345.00 sq. km. and contains twenty-nine blocks. Net cropped area of the district is about of 5, 73,575 ha (Census, 2011). Major crops grown in the district are paddy (*aus, aman and boro*), wheat, potato, vegetables, oilseeds, pulses, sugarcane, jute, maize, betel vine, mat-stick etc. The district is surplus in production of cereals, potato and other vegetable crops. Objectives of the present study are to measure spatio-temporal growth and instability of paddy varieties (seasonal) and to understand the relationship between growth and instability of paddy varieties in Paschim Medinipur district.

Data sources and Methodology

The study uses a time-series secondary data on area and yield of *aus, aman* and *boro* (seasonal paddy varieties) *from* the period 1992-1993 to 2012-2013. Due to non-availability of block level individual crop data before 1992, the secondary data were collected from various issues of District Statistical Handbook Paschim Medinipur district during1992-1993 to 2012-2013. The period of study was categorized into four periods - 1993 to 1997, 1998 to 2002, 2003 to 2007 and 2008 to2013, to make the analysis more comparative for the measurement of instability in area and yield among crops and periods as well.

Growth rate in area and yield was calculated with the help of percentage of

growth rate for three seasonal varieties of paddy i.e. *aus, aman* and *boro*. To reduce the effects of production fluctuation due to climatic variability three-year average data of area and yield of each crop was calculated, followed by estimation of their growth rates.

Growth (%) $= \frac{(P_2 - P_1)}{P_1} X100$

Where,

P_1= Value of Previous year (percentage of area or yield)

P_2=Value of Present year (percentage of area or yield)

The study used Cuddy Della Valle Index (CDI) to measure crop instability in area and yield (Cuddy and Valle, 1978). Many studies (Hazell, 1982; Larson, 2004 and Alemu, 2005) have applied coefficient of variation (CV) to show variation but there are some limitations in time-series data analysis. In general, measurement of instability of time series data using coefficient of variation considered the linear relationship among variables, but in major cases the reality was different as the studies ignored the non-linear pattern of relationship. So, simple CV can over-estimate the instability level. In this regard, Cuddy-Della Valle Index firstly investigates the appropriate relationship, i.e., whether it is linear or non-linear then calculates magnitude of instability. In the present study, Cuddy-Della Valle Index (Ix) attempted to de-trend the CV by using coefficient of determination (R^2). Thus, Cuddy-Della Valle indices (Ix) enable a better measure of instability. Further, linear trend model ($\mathbf{Ix_1}$) and log-linear trend model ($\mathbf{Ix_2}$) both were tested. Accordingly, level of significance CV, IX_1 or IX_2 were chosen.

Appropriate Instability index can be expressed as:

$$\mathbf{Ix = CV\sqrt{(1 - R^2)}}$$

Ix= Appropriate Instability Index (Cuddy Della Valle Index)

CV= Coefficient of Variation

R^2= Coefficient of Determination

The low value of this index indicates low instability in area and yield and vice-versa. Cuddy Della Valle Index values were divided into five categories which represent the different ranges of instability to make the analysis more comparative by different crops in Paschim Medinipur district. Based on 100 percent instability value blocks were categories into equal five classes: very high instability (Above 80), high instability (80-60), moderate instability (60-40), low instability (40-20) and very low instability (below 20).

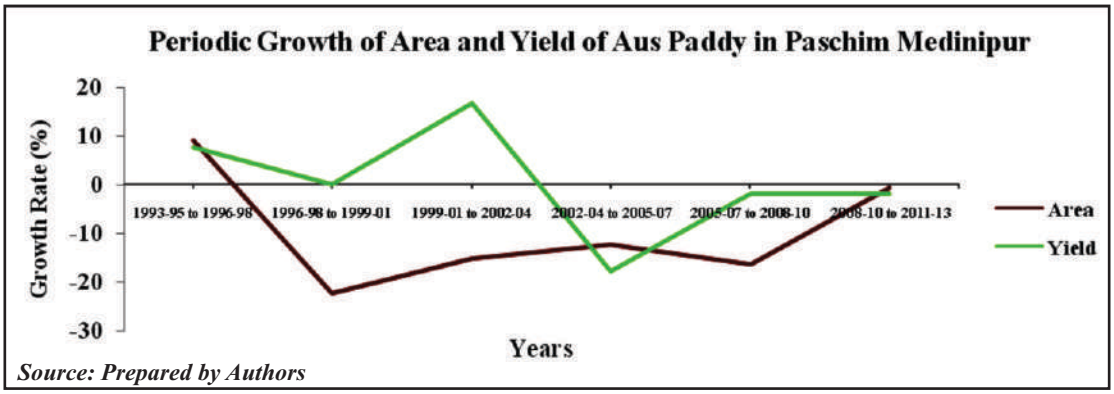
Result and Discussion

Periodic Growth of *Aus* Paddy

Paddy is the principal cereal crop of Paschim Medinipur district and is mainly produced on a subsistence basis. One of the seasonal varieties of paddy which is cultivated in summer and harvested in autumn is locally known as *aus*. It is a high-water consuming crop. The available data shows that growth rate of area under *aus* was positive during the first period, but thereafter, declines to negative continuously for the next five periods (Figure 1). Yield of *aus* started decreasing after 1999-01 to 2002-04, a trend that continued up to 2008-10 to 2011-13. Paschim Medinipur district experienced a better growth of yield of *aus* from 1999-01 to 2002-04.

From 1993-95 to 2011-13, seven blocks of the district showed positive growth in area of *aus,* among which Pingla, Sabong, Daspur-I, Daspur-II and Ghatal performed exceptionally better compared to other blocks. Negative growth in area was registered in Binpur-II, Kharagpur-I and Chandrakona-II where cent percent area had decreased. Except Salboni and Garbeta-I, remaining blocks stopped the production of *aus*. But surprisingly, the yield of *aus* increased across the blocks except in Binpur-I, Debra, Chandrakona-I, Kharagpur-I, Dantan-I and Dantan-II (Figure 4). During the

last 20 years, maximum area under *aus* has decreased due to poor quality of rice being produced, having a lower demand. Pearson's correlation co-efficient value of growth rate in area and yield of *aus* was insignificant i.e. r=0.0, which denotes that the change in an area



Source: Prepared by Authors

Figure 1: Periodic Growth of Area and Yield of Aus Paddy

had not affected the yield of *aus* in various blocks of Paschim Medinipur district.

Periodic analysis of area under *aus* presents a different scenario. From 1993-95 to 1996-98, the area under *aus* decreased in a number of blocks due to lack of irrigation facilities and over dependency on rainfall (Tripathy, 1996). In comparison to area, the rate of yield increased due to adoption of better quality seeds and implements. From 1996-98 to 1999-01, Debra, Pingla, Keshiary, Sabong, Chandrakona-II and Daspur-I blocks showed negative growth rate in the area under *aus*. Out of twenty-nine blocks, seventeen blocks showed negative rate of growth in yield. From 1999-01 to 2002-04, in contrast with other blocks, a considerable amount of area increased in Daspur-I, Daspur-II, Ghatal, Kharagpur-II, Mohanpur, Narayangarh, Dantan-II, Pingla and Debra blocks. The main reason behind the positive growth in area was the adoption of groundwater irrigation *(C-DAP,2010*). Positive growth in yield of *aus* was found in number of blocks of the district (Figure 4) From 2002-04 to 2005-07, *aus* registered a positive change in growth rate of area, but yield was found to be low in a number of blocks due to poor irrigation facilities. The most notable positive rate of growth in area under *aus* was found in Binpur-I, Sankrail, Salboni, Garbeta-I, Garbeta-III, Medinipur and Kharagpur-II from 2005-07 to 2008-10. A positive growth in the area was found in maximum blocks from 2008-10 to 2011-13, but rate of yield became negative due to drought which destroyed a large percentage of cropping area and production (DSHB, 2011). Shrinkage in area under *aus* was partly a result of infertile lateritic soils, besides, of course the use of traditional low yield paddy varieties by the farmers, as against improved high yielding varieties. Other significant cause behind the periodic variability in the area under *aus* cultivation was lack of proper irrigation facilities which may otherwise facilitate more area under cultivation. Jhargram, Binpur-I, Jamboni, Nayagram, Kharagpur-I, Gopiballavpur-I, Gopiballavpur-II, Keshpur, Dantan-I and Mohanpur blocks come under this category and continuously displayed a negative growth in the area under *aus* due to terrace track and rugged topography. Also, the combined effect of water logging due to heavy rainfall, hail storm and drought destroys

standing crops almost every alternative year, leading to losses worth crores of rupees in terms of area and production under *aus*.

Periodic Growth of *Aman* Paddy

Aman is also one of the major seasonal varieties of paddy being produced in Paschim Medinipur district. As per crop calendar of Paschim Medinipur (Agricultural office Paschim Medinipur, 2011) *Aman* is sown during rainy season (July-August) and harvested in winter (November-December). *Aman* is cultivated as subsistence as well as commercial basis to compensate for the loss of *aus*. The analysis of *aman* cultivation shows that growth rate in area under this crop was negative during second, fifth and sixth periods (Figure 2). The growth rate in yield was positive upto the fourth period, but growth in area became negative from 2005-07 onwards. Out of twenty-nine blocks, sixteen blocks registered negative growth in area, among which Garbeta-III registered the highest negative growth (-35.44%). *Aman* is the most popular and largest produced varieties of paddy cultivation in Paschim Medinipur, a fact that accounts for high positive growth rates in yield during the period of 1993-95 to 2011-13 among all the blocks, except Dantan-II and Narayangarh (Figure 4), where the area under *aman* has shifted to *boro* cultivation and the farmers prefer to produce vegetables rather than paddy. Another cause of the shift is variability in the advancement of monsoon which results in massive loss in *aman* production. Correlation between growth in area and yield of *aman* is very insignificant i.e. r=0.16 which denotes that the change in the area of *aman* has not affected the growth rate of its yield in Paschim Medinipur district.

Dynamic periodic change in area and yield can be seen in case of *aman* (Figure 2). Between 1993-95 and 1996-98, eleven blocks of the district showed positive growth in the area in which Binpur-I (68.42%) recorded the highest followed by Gopiballavpur-I (33.46%), Sankrail (16.19%), Daspur-I (15.73%) and Kharagpur-I (12.83%) etc. Noticeable growth in yield was registered by Chandrakona-I and

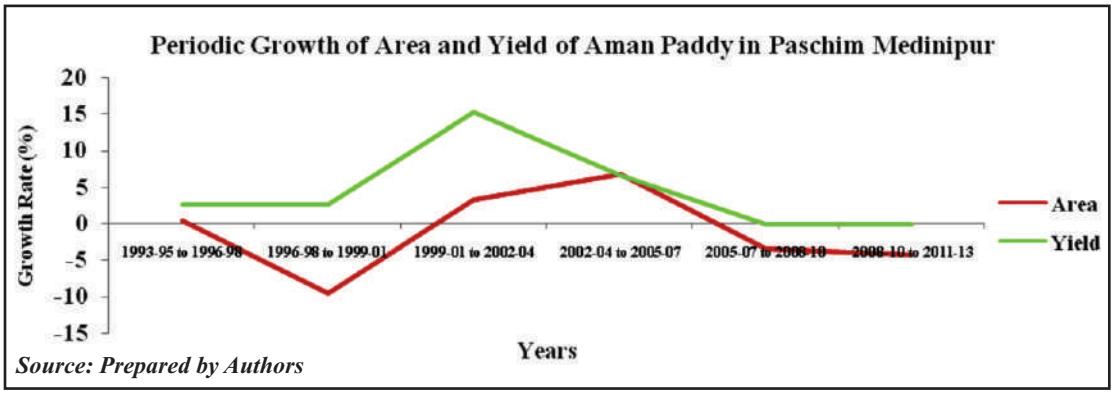


Figure 2: Periodic Growth of Area and Yield of Aman Paddy

Chandrakona-II blocks, i.e., 53.29 percent and 92.85 percent, respectively.

In most of the blocks, relation between the rate of growth in area and yield was positive, i.e., with an increase in area, the yield too registered an increase and vice-versa. An analysis of the growth in area under *aman* from 1996-98 to 1999-01 reveals that out of twenty-nine blocks, nineteen blocks registered negative rates. In sharp contrast, only nine blocks registered a decline in yield. The reasons for the same are not very difficult to

locate as annual floods inundate a large chunk of area under cultivation, thus it is playing a significant role in decreasing area and yield of *aman*. For the period from 1999-01 to 2002-04, the positive growth rate of the area was highest in Jhargram (56.32%) block followed by Jamboni (18.44%), Keshiary (14.56%) and other blocks. The key correlates of such massive growth in area and yield have been the adoption of modern technology and application of HYV seeds. The area under *aman* also increased due to an increase in agricultural area, but different blocks showed slightly negative growth in yield. From 2002-04 to 2005-07, a decreasing trend in area under *aman* was found in blocks due to the inundation of large croplands by the consecutive floods of Kansabati (Kasai) and Silabati (Silai) rivers. Highest positive growth rate in area was reflected in Garbeta-I (45.72%) and Salboni (38.14%) in respect of previous period due to extension of *aman* area over and above existing cropped area. A significant positive growth in yield was found in Gopiballavpur-II (33.30), Nayagram (27.61%), Mohanpur (27.07%), Daspur-II (21.95%) and Jhargram (21.77%) blocks only. From 2005-07 to 2008-10, almost all the blocks of the district registered a negative growth trend in the area, caused by heavy rainfall leading to extensive loss of *aman* area and yield in annual floods. Highest positive growth in yield was observed in Sabong (54.67%) during the period of 2005-07 to 2008-10, followed by Debra (26.75%), Keshpur (19.32%), Mohanpur (12.52%) and Keshiary (12.10%). Mohanpur registered positive growth rate in the yield for three consecutive periods due to the introduction of HYV seeds, fertilizers and modern agricultural implements. Growth rate in area under *aman* was considerably negative in a number of blocks from 2008-10 to 2011-13 (Figure 4). The growth rate in yield of *aman* was found to be exceptionally high in Daspur-II (110.68%) block. Blocks of Kharagpur subdivision showed a declining trend in yield from 2008-10 to 2011-13.

Largest cereal production in the district was registered by *aman* which is a monsoon dependent crop cultivated under rainwater. Application of HVY seeds, fertilizers, pesticides and modern agricultural implements together give very high yields. During the post-independence period, especially in last 20 years, agriculture has undergone substantial structural transformation which helps in positive growth in yield. Seasonal and annual variability of monsoon characteristics contribute annual variability of growth in area and yield of *aman*. The blocks under direct influence of river channel have faced periodic flood conditions and the large parts of the crop area go under water during rainy season. As a result, there was a huge loss in terms of area and production that ultimately reduced yield and the earnings of the farmers. Periodic variability in area and yield was very high due to monsoonal effect.

Periodic Growth of *Boro* Paddy

Boro is a seasonal paddy variety and highest yielding cereal crop. *Boro* cultivation is carried out by farmers for commercial purpose only. The analysis of available data shows that growth of area and yield was found to be almost parallel during all the periods. Positive growth in area and yield was found in 1993-95 to 1996-98, 1996-98 to1999-01, 2002-04 to 2005-07 and 2005-07 to 2008-10 (Figure 3). Periods 1999-01 to 2002-04 and 2008-10 to 2011-13 viewed negative growth in both area and yield. The overall growth rate of yield was lower in comparison to the growth rate in area. The last period from 2008-10 to 2011-13, registered minimum growth in yield.

For the entire period starting from 1993-95 to 2011-13, *boro* registered exceptionally high

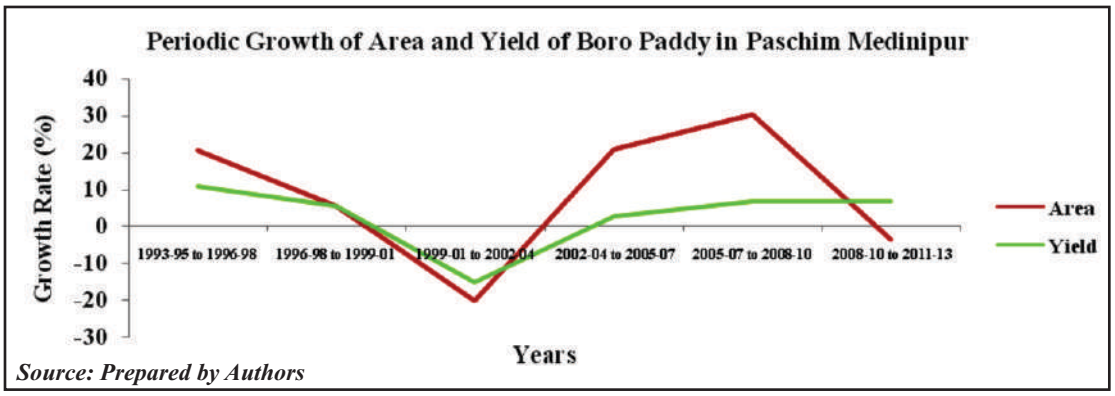


Figure 3: Periodic Growth of Area and Yield of Boro Paddy

positive growth rate in area in Chandrakona-I (436.66%), Keshiary (388.4%), Narayangarh (247.82%), Dantan-I (250.27%), Mohanpur (189.23%), Keshpur (168.79%), Kharagpur-I (160.15%), Dantan-II (125.08%) and Chandrakona-II (112.77%) blocks (Figure 4). This trend was due to an increase in irrigated area. On the other hand, Binpur-II (-44.2%), Garbeta-I (-11.23%), Narayangarh (-7.86%), Nayagram (-4.27%), Medinipur (-2.11%) and Jamboni blocks (-1.45%) were registered negative growth rate in yield. Correlation between growth rate in area and yield of *boro* was very insignificant (r=-0.11). The area under *boro* increased across the blocks of Paschim Medinipur district at a higher rate in comparison to that *aus* and *aman,* but failed to achieve higher levels of growth in yield. The district recorded high periodic variability in all six periods. During 1993-95 to 1996-98, the highest growth in the area was registered by Binpur-I (523.66%) followed by Kharagpur-I (124.32%) and Medinipur (110.20%). The highest positive growth rate in yield was found in Ghatal block (398.78%), also being the highest in the entire period. Only six blocks showed negative growth rate in yield. During 1996-98 to 1999-01, very high positive growth rate was found in both area and yield; the highest growth in area being recorded in Binpur-II (156.46%) followed by Gopiballavpur-I (87.97%), Keshiary (79.79%), Chandrakona-I (56.14%), Kharagpur-II (55.44%), Daspur-II (46.98%) and Garbeta-II (42.49%) blocks. The positive growth rate in yield has found in twenty-six blocks.

Overall, majority of the blocks showed negative growth in the area, but yield still maintained positive growth due to the introduction of groundwater irrigation, HYV seeds and farm implements. During the period of 1999-01 to 2002-04, growth trend was found to be negative in both area and yield in most of the blocks. Only six blocks experienced a marginal positive growth rate in the area. In case of yield rate, only two blocks showed positive growth: Medinipur (2.62%) and Daspur-I (6.60%). The consecutive impacts of flood and drought during this period caused massive crop failures in the district.

During 2002-04 to 2005-07, highest positive growth rate in area was found in Chandrakona-I (481.17%) followed by Garbeta-III (100.21%), Binpur-II (93.37%), Salboni (87.08%) and Keshpur (80.70%) blocks. Positive growth in yield was found in Nayagram (43.32%), Gopiballavpur-II (34.44%), Pingla (19.55%) and Binpur-II (18.20%) blocks. The phenomenal positive growth in the area was experienced by *boro* in

comparison to growth in yield. In case of Gopiballavpur-II, growth in area it has been found negative but yield was found positive (Figure 4), i.e. decelerated growth in the area but an accelerated yield.

A rapid increase in the area was observed in Paschim Medinipur district during period of 2005-07 to 2008-10. A number of blocks showed exceptionally highly positive growth rate in area and yield under *boro*. The relationship between growth in area and yield showed accelerated growth in the area with decelerated yield. The block-wise growth rate in area was found to be remarkably positive during the sixth period (2008-10 to 2011-13), but growth in yield was not found significant. To minimize risks associated with monsoonal affect, *boro* cultivation was started in Paschim Medinipur district with sufficient modern facilities, including proper irrigation during winter. *Boro* cultivation has tried to compensate for the loss of *aus* and *aman*. The use of HVY seeds, fertilizers and implements help to bring more area under *boro* cultivation. Majority of the blocks registered very high positive growth in area under *boro* compared to other cereal crops, although growth in yield does not take place at considerable rate across the district.

Blocks endowed with fertile river alluvium (Figure 4), experienced the higher yields in comparison to the others. On the whole, the growth of area and yield under *boro* showed positive but very high spatial variability in growth rate in area and yield. Drought is mainly responsible for the periodic variability in the area of *boro*. In addition, poor irrigation facilities, lack of HYV seeds, fertilizers and pesticides together contributed to the reduction of rate of growth in yield of *boro*. Sometimes huge loss during *aman* cultivation creates financial distress among farmers, especially the small and marginal farmers which de-motivates them to cultivate *boro*.

Instability of *Aus* Paddy

Overall, block-wise analysis of the rate of instability in area and yield of *aus* depicted a very interesting picture. There were wide-ranging variations in levels of instability in both area and yield in different blocks of the district as evident from Figure 5. During 1993 to 1997, there was a wide spatial variation in the levels of instability in area of blocks of the district. Very high instability in area was found in Daspur-II followed by Daspur-I, whereas other blocks witnessed low levels of instability due to increasing growth. From 1998 to 2002, blocks located in the eastern and south-eastern parts of the district experienced very high instability in area due to both increasing and decaling growth in area. During the third period, blocks like Binpur-I, Keshiary, Chandrakona-II and Daspur-I experienced high instability in area due to growth in area, whereas reduction in area was responsible for very high instability in the area in Binpur-II, Nayagram and Kharagpur-II. During 2008 to 2013, levels of instability in the area remained high and very high in maximum blocks induced by massive fall in area.

During 1993 to 1997, levels of instability in yield varied between low to very low. Maximum blocks experienced instability due to the increasing growth in yield. During the second period, the blocks maintained better yield rate, which varied between low to moderate levels of instability (Figure 5). Except in Binpur-II, Gopiballavpur-II, Garbeta-II and Garbeta-III, other blocks experienced increased growth in yield leading to its instability. During the third period, levels of instability in yield remained more or less similar to second period, but maximum blocks experienced instability due to declining trend in growth, except Binpur-I, Jamboni, Sankrail, Gopiballavpur-I, Gopiballavpur-II, Garbeta-III

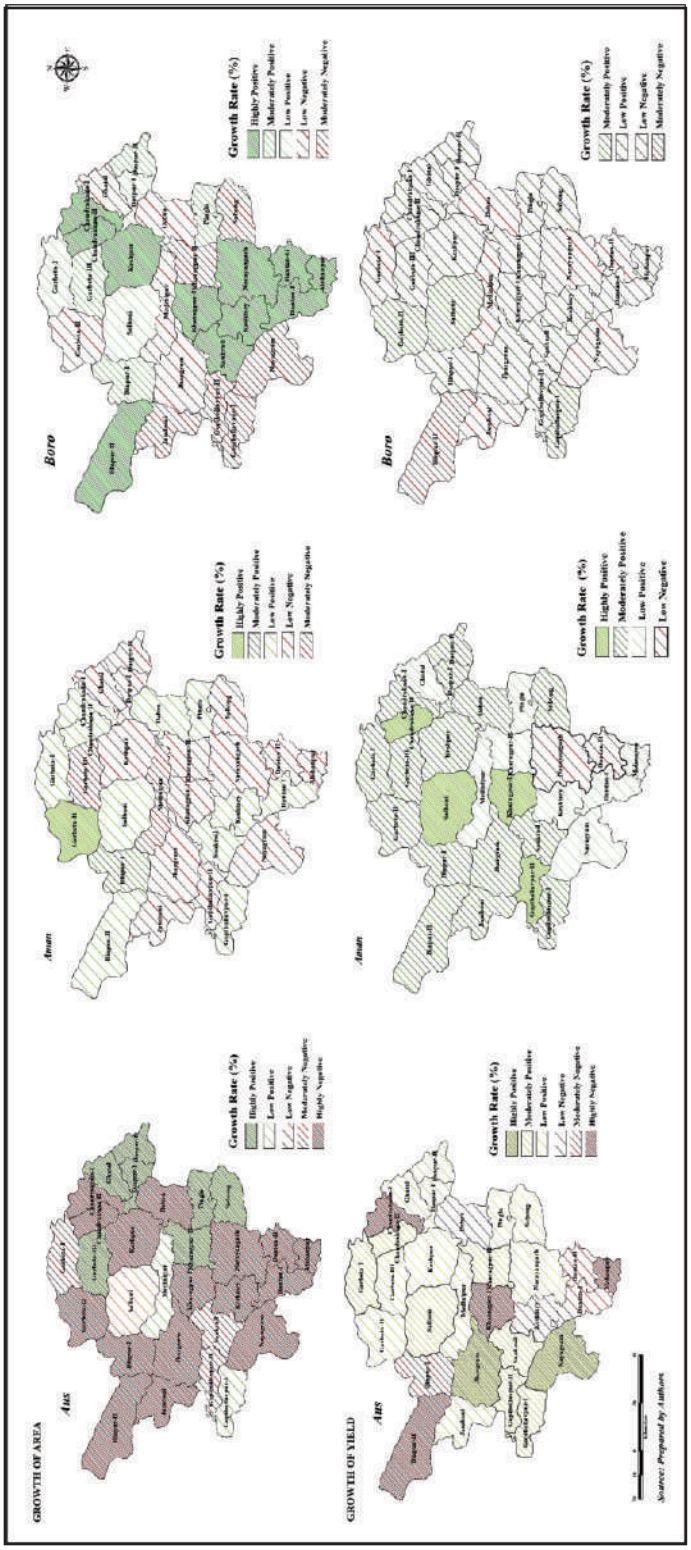


Figure 4: Block wise Growth of Aus, Aman and Boro Paddy

and Pingla blocks. During 2008-2013, level of instability in yield was very high in Binpur-II, Mohanpur, Kharagpur-I, Chandrakona-I and Daspur-II. Daspur-II for the first time experienced instability due to increase growth in yield and other blocks showed instability due to cent percent decline in yield. Magnitude of instability of *aus* was higher in case of area in comparison to its yield. Being a summer crop, *aus* is a high water requirement crop which requires 75-58 cm of water (C-DAP, Paschim Medinipur, 2011) that has to be fulfilled by irrigated means. The instability increased in area and yield mainly due to frequent and severe droughts during 1991, 1995, 1999, 2000, 2003, 2007, 2009, and 2011. Further, a decline in area under irrigation also contributed to higher instability.

Due to low groundwater potentiality, blocks like Keshpur, Kharagpur-I, Kharagpur-II, Gopiballavpur-II and Sankrail had restricted irrigation during summer as prohibition of irrigation was imposed by Department of Agriculture in Sabong, Pingla, Mohanpur, Debra and Narayangarh blocks. These factors ultimately reduced the area under *aus* cultivation. Sometimes, instability in area and yield also occurred due to higher production as an outcome of more application of HYV seeds, chemical fertilizers, pesticides and modern agricultural implements.

Instability of *Aman* Paddy

Aman is the largest produced, rainfall-dependent paddy variety sown in Paschim Medinipur district, with minimum investment in irrigation, fertilizers and pesticides. During 1993-1997, all the blocks witnessed low to very low levels of instability in the area as annual coverage of *aman* area remained same during this period. During 1998-2002, low to very low instability in the area was found in twenty-nine blocks (Figure 6), out of which eighteen blocks recorded instability in area due to the increased growth in area (Figure 6). During 2003-2007, very low instability in the area was found in twenty-nine blocks, out of which maximum blocks showed instability because of fall in area. Except Jamboni, Mohanpur and Sabong, other blocks registered very low instability in the area during 2008-2013.

In case of yield, the levels of instability remained low to very low in all the blocks during 1993-97, among which fifteen blocks showed fluctuation in growth of yield due to its decline. During 1998-02, an exceptional, very high instability in yield was recorded in Chandrakona-II (Figure 6), while other blocks witnessed low to very low levels of instability. During 2003-07 and 2008-13, low levels of instability in yield were found in almost every block of the district, out of which maximum blocks experienced instability because of growth in yield. The western and southern blocks of the district experienced fall in yield due to lack of proper agricultural inputs, infrastructure and social development.

The data reveals that instability in area was more prominent than yield because of a gradual decrease in cultivated area due to extension of settlement and other development projects in cultivable land. In major cases, *aman* experienced an instability due to fall in area and yield from 1992-93 to 2012-2013. It was mainly due to erratic, irregular and insufficient rainfall over the years. Physiographic set-up and spatial distribution of rainfall caused floods during the rainy season in different blocks. All blocks of Ghatal sub-division faced annual floods. Major floods occurrences were recorded during 1993, 1997, 2001, 2003, 2007, 2011 and 2013 which led to almost total crop failure due to inundation of crop land.

During harvesting period, a low pressure over the Bay of Bengal causes winter rainfall which affects a large area and affects the overall production. Instability in area and yield also

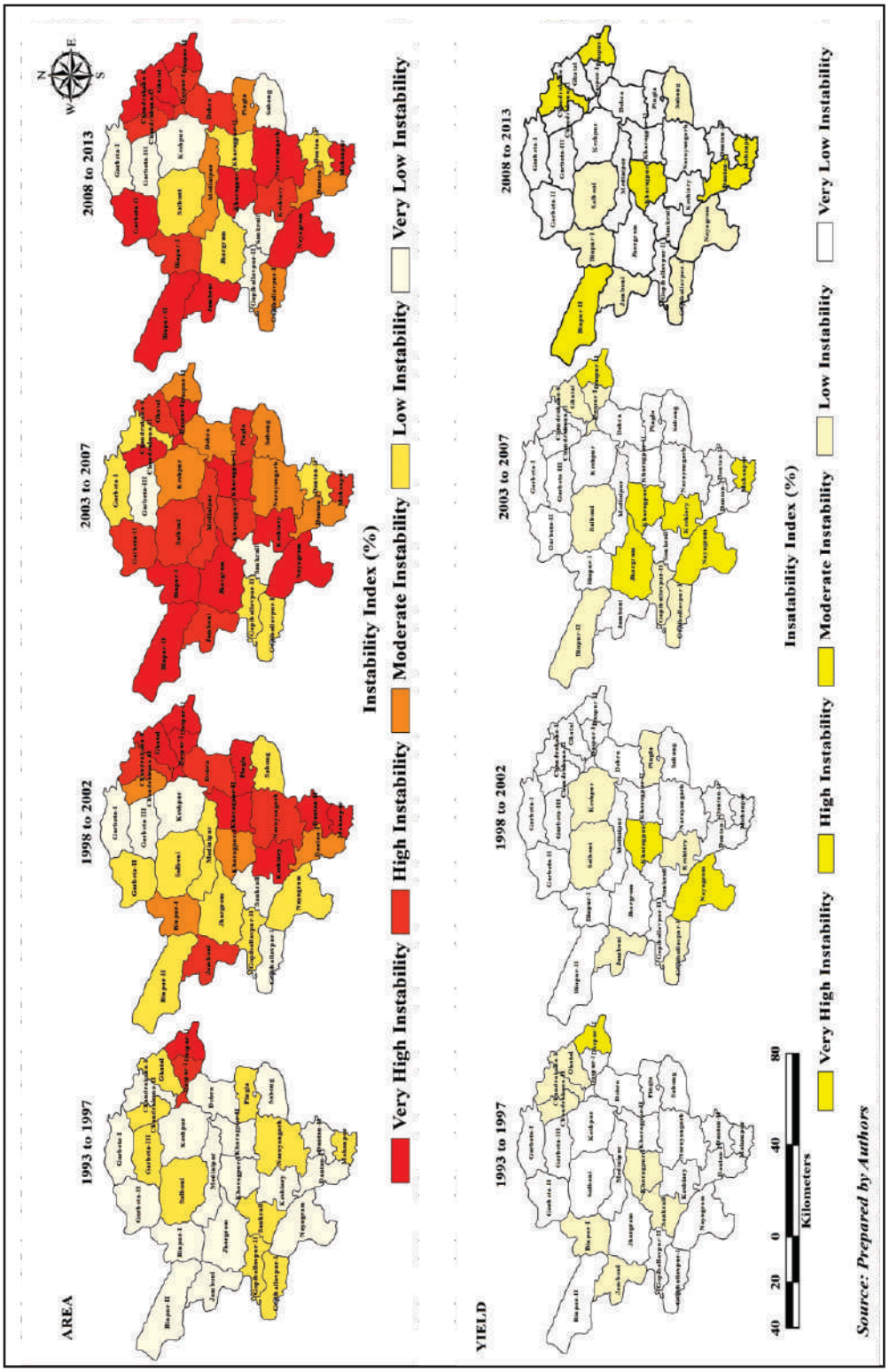


Figure 5: Block-wise Area and Yield Instability Index of Aus Paddy

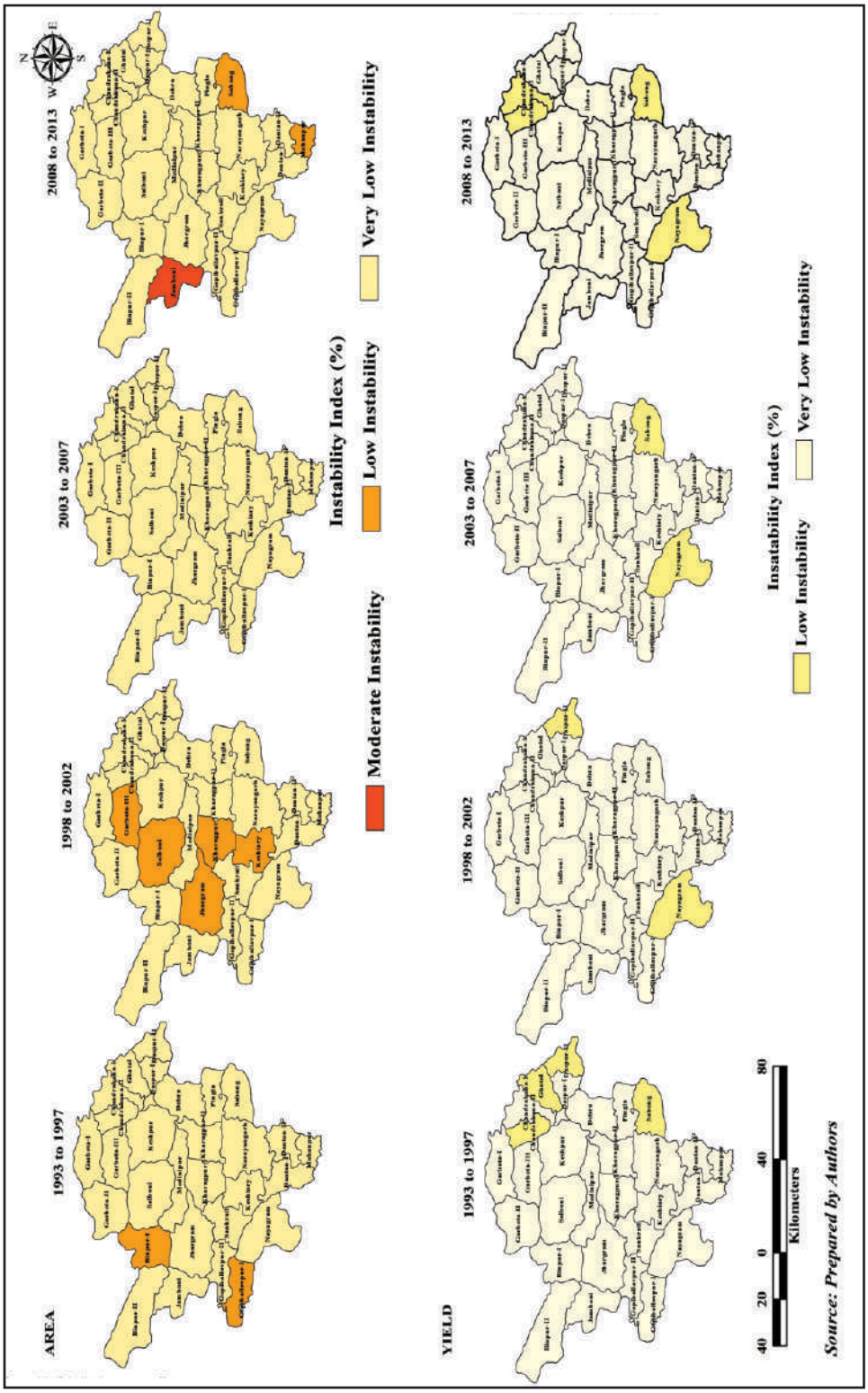


Figure 6: Block-wise Area and Yield Instability Index of Aman Paddy

occurred due to the application of sufficient HYV seeds, modern agricultural implements and fertilizers.

Instability of *Boro* Paddy

Boro is the highest water requirement crop i.e. 150-175 cm (C-DAP, Paschim Medinipur-2011:81) which completely depends on artificial irrigation system. Levels of instability in the area of *boro* during 1993-97 were found to be high in Chandrakona-II and Garbeta-I blocks, while the remaining blocks came under very low to moderate category, among which instability in area was found in most of the blocks due to the increased growth in area except Binpur-II, Gopiballavpur-I, Gopiballavpur-II, Garbeta-I, Garbeta-II, Garbeta-III and Daspur-II blocks. During 1998-02, very high instability in area was found in Binpur-II, Chandrakona-I and Gopiballavpur-I blocks and other blocks showed moderate to very low levels of instability. During the third period, the highest levels of instability were found in Nayagram, followed by Jhargram, Medinipur, and Garbeta-III. Among these blocks, maximum blocks showed instability in the area because of its rising growth (Figure 7). During 2008-13, highest instability in area was recorded in Binpur-II and Kharagpur-I (Figure 7) among which instability occurred in Jamboni, Salboni, Keshpur, Chandrakona-I and Daspur-I blocks due to significant increasing growth in area under *boro*.

During 1993-97, very high instability in yield was found in Ghatal block only and other blocks witnessed low to very low levels of instability among which maximum block registered instability due to the reduction in yield of *boro*. Moderate instability was found in Binpur-II, Jamboni, Garbeta-II and Daspur-I blocks due to agricultural drought and other blocks remained low in levels of instability in 1998-02. Levels of instability in yield were found high in Jamboni, while rest of the blocks showed low to very low levels of instability during 2003-07. During 2008-13, instability in yield remained very low in almost every block except Binpur-II (Figure 7). Among these blocks, fifteen blocks registered instability because of reduction in yield. Instability in *boro* was caused by successive droughts that lead to massive crop failures. Sometimes, excessive rainfall too during growing and harvesting periods caused crop failures in blocks during 1995, 1999, 2000, 2003, 2007 and 2012. Further, the decline in area under irrigation was accounted for by the reduction of yield. Insufficient irrigation facilities and lack of infrastructural development contributed to higher instability in crop production. The instability was also caused by the adoption of new and improved technology that helped in achieving a substantial increase in *aman* production brought the district close to attaining food self-sufficiency and increased stability in area and yield.

Association between Growth and Instability

In this sub-section, an attempt has been made to analyze that whether growth in area and yield is correlated with instability of various crops or not. The correlation between growth and instability in area and yield of major crops of district is presented in Table 1 Pearson's Correlation Coefficient values (at 5 percent significance level) indicate that there exists an inverse relationship between trends in growth of area under a crop and instability rates for that crop for four selected periods. This means that an increase in growth of area decreases the instability and vice-versa. In stark contrast, correlation between growth in yield of a crop and instability in yield of that crop depicted a positive relationship for the selected periods except from 2003 to 2007. This means a growth in yield levels of a crop increases its instability, a welcome

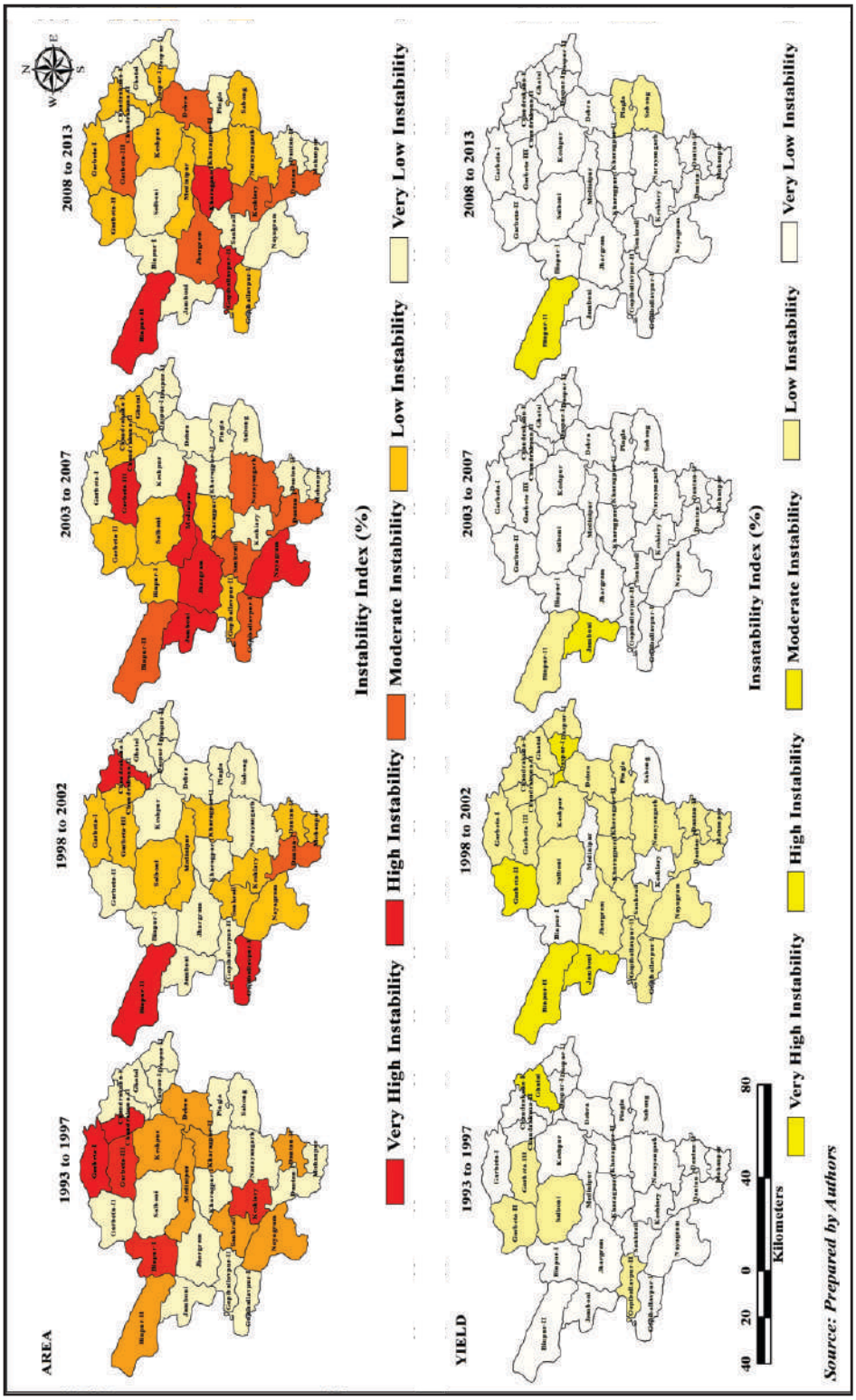


Figure 7: Block-wise Area and Yield Instability Index of Boro Paddy

development. This reveals that correlation between growth and instability in area and yield of paddy were both positive as well as negative, and contributed to higher spatio-temporal inequality in the district as a whole and also at block-level.

Table 1: Matrix showing correlation between Growth and Instability

	Instability in Area (1993-1997)	*Instability in Area(1998-2002)*	*Instability in Area(2003-1997)*	*Instability in Area(2008-2013)*	*Instability in Yield(1993-1997)*	*Instability in Yield (1998-2002)*	*Instability in Yield (2003-2007)*	*Instability in Yield (2008-2013)*
Growth in Area (1993-1997)	-0.874	-0.277	-0.699	0.194	0.278	0.579	-0.696	0.364
Growth in Yield (1993-1997)	-0.078	-0.111	-0.121	-0.769	0.455	0.123	0.078	-0.736
Growth in Area (1998-2002)	0.024	-0.768	-0.050	-0.132	0.174	-0.113	0.263	-0.490
Growth in Yield (1998-2002)	-0.162	-0.140	-0.531	0.551	0.345	0.611	-0.790	-0.341
Growth in Area (2003-1997)	-0.741	-0.356	-0.606	0.333	0.360	0.606	-0.573	0.500
Growth in Yield (2003-2007)	-0.500	-0.147	-0.788	0.387	0.342	0.822	-0.870	-0.168
Growth in Area (2008-2013)	0.321	0.463	0.314	-0.847	0.035	-0.213	0.450	-0.461
Growth in Yield (2008-2013)	-0.361	-0.038	0.050	-0.518	0.061	-0.089	0.337	0.460

Source: Calculated by authors

Conclusion

The overall analysis of instability in area and yield of crops reveals that the growth of area was highly unstable in comparison to its yield and it is applicable for all crops in Paschim Medinipur district. Higher stability in area and yield growth was found in case of *aman* and *boro,* whereas *aus* experienced highest instability in the district. Hence, there are periodic and crop-wise variabilities in relationship between growth and instability. The relationship between growth and instability of area was negative which signifies that higher the growth in area contributed lower crop instability in area and vice-versa. In case of yield, both positive and negative relationships were found. Instability in area and yield of major crops showed different spatial patterns depending upon prevailing agro-ecological settings of different blocks. So, there was a declining trend of growth in area and yield of major crops during post-green revolution period. Climatic fluctuations and poor irrigation facilities together accounted for a decline in the cropping area. The study also reveals a trend of shift from traditional crops to profitable *boro* cultivation. Besides, as far as relationship between growth and instability is concerned, there was no specific pattern of relationship emerging in case of yield. A negative relationship existed in case of area; wherein higher growth caused lower instability but yield portrayed a completely different picture. Instability in crop production is an inseparable component of growth. Yield instability mostly depends upon market demand and price, crop value, attitude and ability of the farmers to take a risk.

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