11. Natural calamities induced production losses in rice

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11.1 Introduction

Odisha is one of the most natural calamity prone states in India. Its unique geographical position with seven big and innumerable small rivers, 480 km long coastal belt with the Bay of Bengal, and the irregular and unpredictable behaviour of monsoon, make it highly vulnerable to natural calamities causing colossal damage to life, property and livelihood systems. Among the natural calamities frequenting the state, the more common are drought, flood and cyclone. Over the years, both the frequency and severity of these calamities have increased considerably and they are striking new areas every year. The Intergovernmental panel on climate change (IPCC) has projected that rainfall in India will increase 10-12% by the end of 21st century with more frequent and heavy rainfall days, while the mean annual temperature will rise by 3-6°C (IPCC, 2014). Droughts and floods of various intensities have become an annual affair and cyclones, a more or less regular occurrence in the state. These three calamities affect the state economy, and more particularly its agriculture, extensively.

It is no gainsaying that agriculture sector is the back bone of the Odisha economy in terms of its share in Gross State Domestic Product (17.7%) and total employment (62%) and rice is the main staple food of the people of Odisha. More than 92% of farm holdings in the state are small and marginal (< 2 ha). On account of subsistence nature of the crop and the typical agro-climatic conditions in the state, almost all farmers in the state grow rice. On the average, during recent period, rice is grown on an area of 41 lakh ha in the state, though there are fluctuations in area from year to year due to natural calamities. The rice area on the average accounts for 91% of the total area under cereals and 49% of the gross cropped area in the state. *Kharif* rice covers 93% of the total area under rice and contributes 87% to total rice production. Two-thirds of *kharif* rice is grown under rainfed conditions. During *kharif* season, the crop is grown under a variety of unfavourable situations resulting in low yield (Venkateswarlu *et al*., 1994).

Climate change induced temperature reduces rice yield through a decrease in crop duration, spikelet sterility, grain number and grain-filling duration, while rainfall affects rice yields through changes in moisture availability, water logging and submergence, and direct physical damage to the crop through cyclones, hail storms *etc.* Birthal *et al.* (2014) found that an increase in maximum temperature had an adverse effect on rice yield but rainfall had a positive effect. However, this could not counter balance the negative effect of temperature. Studies have recorded that droughts and floods occur almost every alternate year in Odisha (Reserve Bank of India, 1984; Concern Worldwide, 2011; Samal and Patra, 2012). Needless to say, that rice production is the greatest casualty of the natural calamities in the state. They not only impose direct loss by destroying standing crops, but also entail loss of production in many other indirect ways. The projected impact of climate change revealed an approximate 10% loss in the yield of irrigated rice in majority of the Indian coastal districts (INCCA, 2010). From the analysis of 123 years of rainfall data, Sivasamy (2000) concluded that the present knowledge on the causes of drought does not permit extrapolation of these events into the future. As the rainfall distribution is highly uncertain, the present knowledge and existing methodology have limited applicability to predict the exact distribution of rainfall. Hence, the predictability of rainfall in a particular year and occurrence of natural calamities like drought, flood and cyclone is very poor. The effects of continual climate change in recent years have further exacerbated the occurrence of natural calamities (Bouman *et al.*, 2007 and Johl, 2006).

Widawsky and O'Toole (1997) have estimated the yield losses from drought in eastern India to be 169 kg per ha per year. Using data for the period 1970-1996, Pandey *et al.* (2000) have estimated the yield losses of rice from severe drought at 1.5 Mt per year in Odisha. Ravichandran and Singh (2005) have estimated the production losses of rice in major states of India for the year 2002-03 in comparison to 2001-02, which was a normal year and the loss was estimated to be as high as 3.8 Mt for Odisha. Dorosh *et al.* (2016) have estimated the production losses due to EI Nino phenomenon at 11.4 Mt in South Asia. Krishnan et al. (2007) predicted an average yield loss of 7.20% and 6.66% using ORYZA1 and INFOCROP rice simulation models at current CO_2 level of 388 ppm, for every 1.8°C increase in temperature. Pandey (2000) has discussed various ex-ante and ex-post coping strategies farmers follow to smoothen income and consumption in case of production losses from the rice crop due to natural calamities. Sale of assets and migration are common in severe drought years (Pandey *et al.*, 2000; Samal and Pandey, 2005; Rathore, 2004; Samal and Patra, 2012), which causes reduction in productive assets in subsequent years resulting in low yield in subsequent years. Sharma *et al.* (2006) have recommended various measures like increase in irrigation facilities, developing crop varieties which are less susceptible to the vagaries of weather, restructuring institutions in the lagging regions and increasing investment in the agricultural research institutions to decrease yield variability of food grains in India, which accounts for a larger portion of production variability. Wassmann *et al.* (2010) have discussed the impact of climate change on global rice production and discussed various mitigation options to bring resilience in rice production.

In the above background, this chapter is an attempt to estimate the loss in rice production in different calamity years during 1964-65 to 2015-16 for the state of Odisha. Three types of natural calamities *i.e.* drought, flood and cyclone have been considered for the purpose. The second objective is to suggest needed actions for developing rice technologies and other investment measures with a view to increase yield, stabilize rice production and income of farmers.

11.2 Collection and processing of data

The production losses have been computed with respect to *kharif* rice as the natural calamities like drought, flood and cyclone occur mainly during *kharif* season.

11.2.1 Collection of data

The area, production and yield data of *kharif* rice and rainfall data for the state of Odisha for 56 years *i.e.* from 1960-61 to 2015-16 (obtained from Directorate of Economics and Statistics, Odisha, Bhubaneswar and Department of Revenue and Disaster Management, Government of Odisha, Bhubaneswar respectively) have been used for this study. The declared natural calamity years (due to drought/flood/cyclone), number of districts affected and other related information have been ascertained from the Department of Revenue and Disaster Management, Government of Odisha, Bhubaneswar. The year 1964-65 was chosen as the base year to compute production losses, as the new semi-dwarf varieties of rice seeds (TN 1 and IR 8) were introduced to the state in that year.

11.2.2 Classification of production losses

Natural calamities do not exhibit any definite pattern of occurrence and they are also not uniform in their intensities from year to year. Therefore, they are classified on the basis of their severity, extend of grain losses and distribution across districts (number of districts affected). Accordingly, drought have been classified as mild, moderate and severe depending on the production losses and distribution across districts following the methodology of Ravichandran and Singh (2005) and Samal and Patra (2012). Likewise, the floods have been classified as mild/flash flood and severe on the basis of production losses in the state. The cyclones have been classified into 3 types such as mild, moderate and super cyclone depending on the amount of loss they cause to rice production in cyclone affected regions.

11.2.3 Derivation of production losses

Kharif production comes from autumn rice (short duration and grown in uplands) and winter rice (long duration and grown in low lands under standing water conditions). The production losses due to different natural calamities have been estimated by taking the difference between the year in which last highest production was obtained and the production obtained in a particular year for *kharif* season, as the calamities occur during this season. This is because new production technologies are developed in the course of time and farmers are adopting the new production technologies in the process, thus, increasing the production potential from a fixed area. There are some years, in which production losses have occurred due to moisture stress and/or flash flood. However, those years are not taken into consideration for yield loss estimation as government of Odisha has not declared it a calamity year. It has been assumed that the average losses due to biotic stresses like weeds, diseases and insect pests are similar in all the years.

11.3 Growth and fluctuation in area, production and yield

Rice is grown in *kharif* and summer season in Odisha. *Kharif* season rice is grown during June-December, while rice grown during December–May is called summer season rice. Presently, *kharif* and summer rice accounts for about 93 and 7% of total rice area and contributes about 87 and 13% to the total rice production respectively. In a normal rainfall year, about 40% of rice area is irrigated. However, during deficit rainfall year, the irrigated area reduces due to less water in the reservoirs. The *kharif* season rice are subjected to a number of natural calamities like drought, flood and cyclone at different stages of their growth periods, causing production losses of various magnitudes in different years. Summer season rice is grown under irrigated condition and relatively risk free.

11.3.1 Growth

There has been significant increase in absolute production and yield of rice between the period 1960-61 and 2015-16. The average triennium ending figures of 1962-63 and 2015-16 revealed that the total production and yield have increased from 37.19 lakh tons and 926 kg ha^{-1} to 72.62 lakh tons and 1768 kg ha^{-1} respectively, which is computed to be an increase of 93 and 91 per cent respectively (Table 11.1). The phenomenal increase in summer rice area from 0.42 lakh ha to 2.78 lakh ha (an increase of 563%) during the above said period is due to expansion of irrigation facilities during that season. The area under *kharif* rice has increased by 4% only, when the figures of triennium average ending 2015-16 and 1962-

Table 11.1: Seasonwise area, production and yield of rice in Odisha

Particulars	Seasons		Total
	Kharif	Summer	
Area ('000 ha)			
2015-16*	3818	278	4096
1962-63*	3994	42	4035
% increase	4.4	562.7	1.5
Production ('000 tonnes)			
2015-16*	6323	939	7262
1962-63*	3684	35	3719
% increase	71.6	2583.8	95.3
Yield (kg ha^{-1})			
2015-16*	1652	3373	1768
1962-63*	927	800	926
% increase	78.2	321.7	90.9

*Triennium ending

63 was considered. However, the area under *kharif* rice has decreased in recent years after reaching a peak of 45.7 lakh ha during 1973-74, due to diversification of uplands for growing other agricultural enterprises and other non-farm activities. The yield of *kharif* and summer rice has increased from 927 and 800 kg ha^{-1} to 1652 and 3373 kg ha^{-1} respectively due to expansion of irrigated area, adoption of high yielding varieties and improved management practices.

11.3.2 Fluctuation

The fluctuation in area, production and yield of total, *kharif* and summer rice is depicted in Fig. 11.1, 11.2 and 11.3 respectively. These fluctuations are mainly due to erratic rainfall (in timing and amount) during different stages of crop growth in *kharif* season causing droughts and floods (Table 2). The summer season fluctuation is due to increase/decrease in area and biotic stresses and much less than *kharif* season (Fig. 11.2 and 11.3). Further, severe weather disturbances in Bay of Bengal bring cyclones to the state during the months of September to November. It is observed from fig. 11.1 that the highest production was observed in the year 2014-15, when the production has touched 82.98 lakh tonnes with maximum yield also. In that year, the *kharif* rice production was

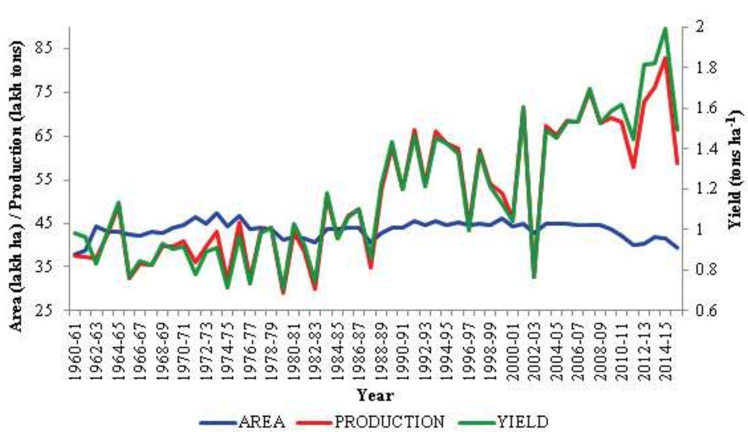

Fig 11.1: Trend in area, production and yield of total rice in Odisha (1960-61 to 2015-16)

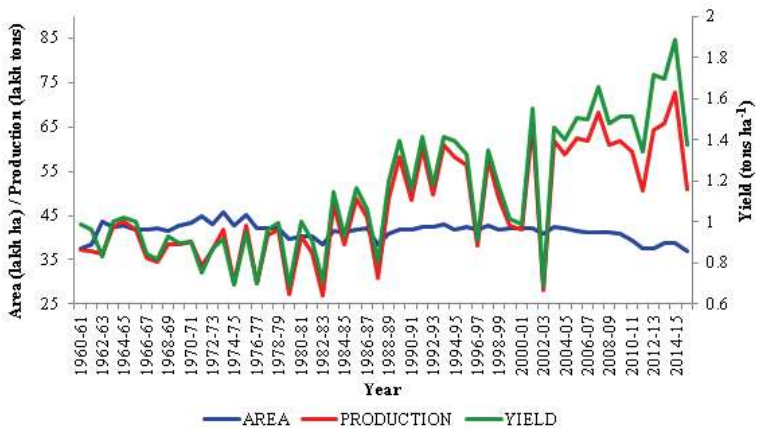

Fig 11.2: Trend in area, production and yield of kharif rice in Odisha (1960-61 to 2015-16)

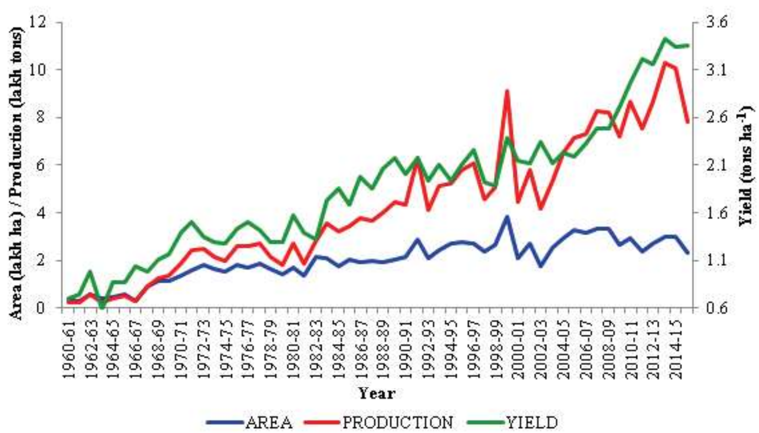

Fig 11.3: Trend in area, production and yield of summer rice in Odisha (1960-61 to 2015-16)

72.9 lakh tons (Fig. 11.2). During 1960-2015, the total rice production fluctuated between 29.2 lakh tonnes (1979-80) to 82.98 lakh tons (2014-15). The production was depressed too much during severe drought years (1965-66, 1974-75, 1976-77, 1979-80, 1987-88, 1996-97 and 2002-03) and some cyclone years like 1982-83 and 1999-2000. In post-green revolution era, the total area varied from 40.5 lakh ha in 1987-88 to 47.7 lakh ha in the year 1992-93. During severe drought years, the rice area has reduced to the maximum extent due to initial drought conditions prevailed during those years.

11.4 Production losses due to drought, flood and cyclone

Odisha being situated on the eastern coast of India is extremely vulnerable to multiple natural hazards like drought, flood, cyclone, heat wave, hail storm, tsunami *etc.* and rice crop is mainly affected by the first three calamites to different degrees depending on their intensity, duration and stage of the crop.

11.4.1 Losses due to drought

Drought refers to a situation when rainfall is less than or equal to 5 mm for a week and agricultural drought in India is a period of four such consecutive weeks from mid-May to mid-October or six such weeks during rest of the year. Almost every year, Odisha faces some kind of drought or moisture stress due to uneven and erratic distribution of monsoon rains. The early season (June-July), mid-season (August-September) and late season (October-November) droughts affect crop stand and production to different extent

Table 11.2: Rainfall and natural calamities of Odisha

Year	Normal rainfall (mm)	Actual rainfall (mm)	Deviation from Normal		Natural calamities
			(mm)	(%)	
1964	1336.0	1408.4	72.4	5.42	-
1965	1336.0	997.1	-338.9	-25.37	Drought
1966	1336.0	1134.9	-201.1	-15.05	Drought
1967	1336.0	1326.7	-9.3	-0.7	Cyclone
1968	1336.0	1296	-40	-2.99	Cyclone
1969	1336.0	1302.1	-33.9	-2.54	Flood
1970	1336.0	1660.2	324.2	24.27	Flood
1971	1336.0	1791.5	455.5	34.09	Cyclone
1972	1336.0	1177.1	-158.9	-11.89	Drought
1973	1336.0	1360.1	24.1	1.8	-
1974	1336.0	951.2	-384.8	-28.8	Drought
1975	1336.0	1325.6	-10.4	-0.78	Flood
1976	1336.0	1012.5	-323.5	-24.21	Drought
1977	1336.0	1326.9	-9.1	-0.68	Flood
1978	1336.0	1261.3	-74.7	-5.59	-
1979	1336.0	950.7	-385.3	-28.84	Drought
1980	1336.0	1321.7	-14.3	-1.07	Drought
1981	1336.0	1187.4	-148.6	-11.12	Drought
1982	1336.0	1179.9	-156.1	-11.68	Drought & Cyclone
1983	1336.0	1374.1	38.1	2.85	-
1984	1336.0	1302.8	-33.2	-2.49	Drought
1985	1336.0	1606.8	270.8	20.27	Flood
1986	1336.0	1566.1	230.1	17.22	-
1987	1336.0	1040.8	-295.2	-22.1	Drought
1988	1336.0	1270.5	-65.5	-4.9	-
1989	1336.0	1283.9	-52.1	-3.9	-
1990	1336.0	1865.8	529.8	39.66	Flood
1991	1336.0	1465.7	129.7	9.71	-
1992	1336.0	1344.1	8.1	0.61	Drought
1993	1336.0	1421.6	85.6	6.41	-
1994	1336.0	1700.2	364.2	27.26	-
1995	1336.0	1588	252	18.86	-
1996	1336.0	990.1	-345.9	-25.89	Drought

Table 11.2 contd.....

Year	Normal rainfall (mm)	Actual rainfall (mm)	Deviation from Normal (mm)	(%)	Natural calamities
1997	1336.0	1493	157	11.75	-
1998	1336.0	1277.5	-58.5	-4.38	Drought
1999	1336.0	1437.2	101.2	7.57	Cyclone
2000	1336.0	1035.1	-300.9	-22.52	Drought
2001	1336.0	1616.2	280.2	20.97	
2002	1336.0	1007.8	-328.2	-24.57	Drought
2003	1336.0	1663.5	327.5	24.51	Flood
2004	1336.0	1273.6	-62.4	-4.67	-
2005	1336.0	1519.5	183.5	13.74	-
2006	1336.0	1682.8	346.8	25.96	Flood
2007	1336.0	1591..5	255.5	19.12	-
2008	1336.0	1523.6	187.6	14.04	Drought & Flood
2009	1336.0	1362.6	26.6	2.0	Flood
2010	1336.0	1293.0	43.0	3.2	Drought
2011	1336.0	1338.1	2.1	0.2	Flood
2012	1336.0	1384.1	48.1	3.6	Drought
2013	1336.0	1653.1	317.1	23.7	Cyclone
2014	1336.0	1608.7	272.7	20.4	-
2015	1336.0	1224.7	111.3	8.3	-

Note: Normal rainfall has been computed on the basis of average rainfall for 40 years *i.e.* from 1960-1999

based on their intensity, duration and stage of the crop. The early season drought results in area reductions, delay in sowing nursery, transplanting main field and upland sown rice. The mid-season drought affects upland rice at maturity stage and lowland rice at vegetative stage. The late season drought affects the lowland rice at maturity stage.

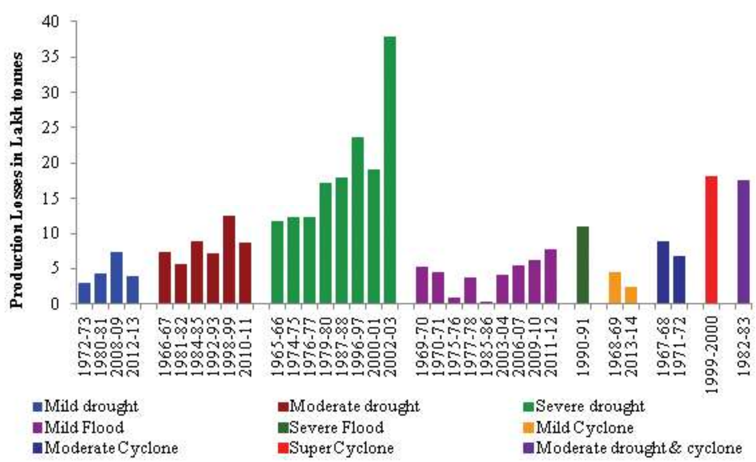

Fig 11.4: Trend in area, production and yield of summer rice in Odisha (1960-61 to 2015-16)

Table 11.3: Production loss estimate of rice in Odisha due to droughts, floods and cyclones

Year	Production losses (lakh tonnes)	Severity of the natural calamity
1965-66	11.7	Severe drought
1966-67	7.3	Moderate drought
1967-68	8.9	Moderate Cyclone
1968-69	4.6	Mild Cyclone
1969-70	5.2	Mild Flood
1970-71	4.5	Mild Flood
1971-72	6.7	Moderate Cyclone
1972-73	3.0	Mild drought
1974-75	12.2	Severe drought
1975-76	1.0	Mild Flood
1976-77	12.3	Severe drought
1977-78	3.8	Mild Flood
1979-80	17.3	Severe drought
1980-81	4.4	Mild drought
1981-82	5.6	Moderate drought
1982-83	17.6	Moderate drought and moderate cyclone
1984-85	8.8	Moderate drought
1985-86	0.3	Mild Flood
1987-88	18.0	Severe drought
1990-91	11.0	Severe Flood
1992-93	7.2	Moderate drought
1996-97	23.6	Severe drought
1998-99	12.4	Moderate drought
1999-2000	18.1	Super Cyclone
2000-01	19.2	Severe drought
2002-03	37.8	Severe drought
2003-04	4.2	Mild Flood
2006-07	5.4	Mild Flood
2008-09	7.3	Mild Drought
2009-10	6.3	Mild Flood
2010-11	8.7	Moderate drought
2011-12	7.8	Mild flood
2012-13	4.0	Mild drought
2013-14	2.4	Mild cyclone

The production losses due to droughts, floods and cyclones in different years for the period 1965-66 to 2015-16 are shown in Table 3 and Fig. 11.4. It is revealed from the figure and table that the losses due to droughts are much more than those due to floods and cyclones. During the period 1964-65 to 2015-16 (52 years), droughts have occurred in 19 years, floods in 10 years and cyclones in 6 years. The probability of occurrence of drought, flood and cyclone in a year has been worked out to be 0.37, 0.19 and 0.11 respectively.

Out of the three types of drought, the moderate drought has occurred in 7 years, while severe drought has occurred in 8 years. Mild drought has occurred only in 4 years, when the production losses were about 2 to 7.3 lakh tonnes. It is revealed from the figure that the production losses from severe droughts vary from 11.7 to 37.8 lakh tonnes. The maximum production loss of 37.8 lakh tonnes has occurred during the latest severe drought year, *i.e.* 2002-03.

Out of 7 years of moderate drought, in one year, it has occurred along with moderate cyclone in 1982-83, when production losses have touched 17.6 lakh tonnes. Otherwise, during moderate drought years, the production losses varied from 5.6 to 12.4 lakh tonnes.

11.3.3.2 Losses due to flood

Like drought, flood also occurs in some parts of Odisha almost every year. The river system of Odisha comprises of the rivers Mahanadi, Brahmani, Baitarani, Subarnarekha, Vansadhara, Bhudhabalanga, Rusikulya, Nagabali, Indravati, Kolab, Bahuda, Jambhira and other tributaries and distributaries. The first seven rivers cause major floods in the state during wet season (July to October). As a result, large areas are submerged causing damage to life, property and standing crops in the field. Out of total 22 lakh ha of rainfed lowland of

Odisha, about 50% are submergence/flood prone (Singh, 2006). Floods affect rice crop in early season (June-July) or mid-season (August-September) or late season (October-November) or a combination of the three periods. During early season flood caused damage to the crop in nursery stage, standing direct sown rice and early transplanted rice. The mid-season flood causes damages to upland rice in maturity stage and medium and long duration rice at vegetative growth stage. The late season flood causes severe damages to medium and long duration rice at maturity stage. Besides, drought and cyclone years, floods alone caused production losses depending upon its intensity and stage of the crop. The damage due to flood varied from 0.3 lakh tonnes (1985-86) to 7.3 lakh tones (2011-12) in a mild/flash flood year. It is estimated to be higher at 11 lakh tonnes in a severe flood year (1990-91).

11.3.3.3 Losses due to cyclone

Cyclone is not preventable. Proper planning can minimize the losses. Odisha being situated in the eastern coast of India is vulnerable to high wind or cyclone affecting the rice crop at maturity stage. The crop at flowering, grain filling and maturity stage are affected to a great extent due to lodging and shattering of pollens. In extreme cases, there is complete damage to the crop. The mature grains germinate due to lack of dormancy in some varieties.

The losses due to cyclones have been quantified. The occurrences of cyclones were in 6 out of 52 years. The losses varied from 4.6 lakh tonnes during a mild cyclone year in 1968-69 to as large as 18 lakh tonnes in a super cyclone year *i.e.* 1999-2000.

Droughts and floods occur due to erratic rainfall distribution during crop growth periods. In some years, like 1969, 1975, 1977, 1980, 1984 and 1992, 1998, 2009, 2010, 2011, 2012 though it appears from the rainfall data (Table 11.2) to be normal, but due to erratic distribution of rainfall during the season, droughts and floods have occurred. The occurrence of drought is much more frequent than floods and cyclones, and the production losses from droughts are more than those from other natural calamities.

11.4 Action points

Climate policy of governments and development of technologies resilient to climate change can only ensure effectiveness. Adaptation to climate change can not only minimize negative impacts but also increase productivity. Currently available varieties may be able to perform better under better input efficiency regimes. However, in the long run, development of varieties tolerant to drought, submergence, heat at different crop growth stages and longer seed dormancy after maturity stage coupled with efficient management practices will become essential. The success story of submergence tolerant varieties is a case to be noted and varieties containing *sub-1* gene has been widely adopted (Bailey-Serres *et al.,* 2010). Irrigated rice requires genetic and agronomic improvements. Rainfed rice requires development of stress tolerant varieties as well as appropriate nutrient management strategies. Incentives by the governments (both national and state level) that promote water savings, reduced use of chemical fertilizers and pesticides and system of cultivation that reduce greenhouse gas emissions are necessary. Laser leveling and timely irrigation are required to reduce the water requirement of rice. Moreover, enhanced research funds to develop climate resilient rice technologies are need of the hour. Crop insurance should be promoted on priority in rainfed areas of the state, which will bring stability in income of the farmers. Above all, investment in irrigation development, particularly tube well irrigation, will mitigate drought effects to a great extent.

Climate change cannot be mitigated by actions of a single nation. Therefore, multinatinal initiative more particularly in and around the Bay of Bengal region must foster regional development and the sharing of knowledge, lessons and technologies for adaptation to and mitigation of climate change.

11.5 Conclusions

Rice is the main food crop of Odisha and the year to year fluctuations in production are large due to frequent occurrence of natural calamities and erratic rainfall. The losses from various natural calamities were estimated and it was found that drought caused much higher losses (38 lakh tonnes) than flood (11 lakh tonnes) and cyclone (18 lakh tonnes). To bring stability in production, short term, medium term and long term policy measures are suggested. In the short term, the presently available climate resilient rice varieties should be promoted through extension agencies working in the state to bring stability in production, as the varieties are ecosystem and area specific. Drought stress can be mitigated to some extent by providing supplemental irrigation at critical stages of crop growth. Among all types of irrigation, tube well irrigation has proved to be cost effective and timely. Therefore, in the medium to long term, Government should encourage expanding tube well irrigation in Odisha, wherever it is feasible. This will bring stability in rice production in Odisha. This type of irrigation will also help in taking a second crop like black gram/ green gram, which requires very less water and will not only add to farmers' income but also sustain the soil fertility. In the long run, more research funds should be diverted to develop rice varieties tolerant to various abiotic stresses like drought and submergence with seed dormancy for at least one month. Other needed actions to bring resiliency and efficiency in production are discussed. Crop insurance is not widely followed. Government should take necessary steps to encourage crop insurance in all the rainfed areas of the state. Lastly, more non-farm income opportunities should be created in rural areas to increase the income of farmer, as more than 92% of the farm holdings are small and the livelihood of these farmers cannot be met from rice farming alone.

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