Chapter 2
Problems and Prospects of Cultivating Indigenous Flood and Brackish Water-Resistant Varieties of Paddy in the Context of Projected Sea Level Rise: A Case Study from Karnataka, India

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2.1 Introduction and Literature Review

Scientific evidence shows clearly that anthropogenic and biogenic emissions of greenhouse gases are the causes behind the accelerated change in earth's climate (Chattopadhyay and Hulme 1997; Nicholls et al. 1999; Nicholls and Cazenave 2010; Uddin et al. 2017; Pidgeon 2012). However, the negative impacts of variability of climate are not felt equally in different parts of the world; sensitive areas like mountain and coastal ecosystem around the world are more prone to be negatively impacted by climate change. The impact of climate change is expected to intensify in the twenty-first century and will have significant impact on agricultural production and food security especially in the tropical regions. Further, food productions in developing countries are needed to be doubled by 2050 to cater the demands of the increasing population (FAO 2012). Global climate change has the potential to increase the risk of hunger by 10–20% where currently 800 million people are undernourished (FAO 2012).

Rice (paddy) is the staple food for half of the global population, but 90% of the production are produced from Asian countries, and about 50% of the production come from India and China (FAO 2012). India has the largest growing area (44.0 Mha) of paddy cultivation and is the second largest producer of rice (106.29 million tonnes, 2014) in the world (Bhambure and Kerkar 2016). Paddy cultivation in India

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is not only the only choice of millions of poor farmers for their livelihood, but also the rural economies of India are directly interlocked with rice productivity performance (Fan and Chan-Kang 2005; Soora et al. 2013). Again, the paddy cultivation in India occupies one-quarter of the total cropped area which contributes to 40–43% of total food grain production and plays a critical role in the national food and livelihood security system (Bhambure and Kerkar 2016). Thus, the performances of paddy cultivation in terms of yield are having significant relation with poverty reduction programmes in rural India.

The cultivation of paddy are done round the year with diverse ecosystems across different season in India. The lowland rice ecosystem of the coastal region of earth only consists of 2% of the world's land area but has 10% of the world population (McGranahan et al. 2007; Spalding et al. 2014). Indian agriculture will have diminishing agriculture yields due to exacerbating land and water scarcity and in the future will translate from food secure area to insecure zone (Aggarwal 2008; Wani et al. 2009; Roudier et al. 2011). Moreover, variability in meteorological forcing coupled with population pressure and ecosystem degradation will exacerbate existing risks to food and livelihood security of coastal communities along coastline of India.

The Indian lowland coastal ecosystem is experiencing the rising tendency of the sea level between 1.06 and 1.75 and with a regional average of 1.29 mm year^{-1} (Unnikrishnan and Shankar 2007). In fact, this densely populated Indian coast is going to be submerged fully or partially and easily exposed to face the climate-induced natural disasters (Walker et al. 2005). Further, the adverse impact of sea level rise not only leads to inundation of coastal area and saltwater intrusion in aquifers but also increases the vulnerability of coastal agriculture due to flooding, storm surge and tsunami. More than 2 Mha of coastal ecosystems in India are reported to be affected by salinity and thus low productivity (Bhambure and Kerkar 2016). The monsoon season (June–October, kharif crop) is a major period for paddy cultivation contributing to 86% of annual production of rice and the rest 14% in winter (November–March, rabi crop) and summer (March–June, zaid crop). Therefore, changes in behaviour of monsoon are critical factors in crop production in the coastal zone of India. According to the IPCC AR5 report, there will be a net annual temperature increase of 1.7–2.2 °C in India about 2030 with respect to 1970, and maximum increase will be in coastal region with value of 1–4 °C. The projected increase in temperature will likely to affect agricultural production by 10–40% in India by 2080–2100. Further, the majority of aquifers in Coastal India are suffering from saltwater intrusion due to over-abstraction, making the water quality unfit for drinking and agriculture purpose. Further, intrusion of saline water to coastal zones occurs naturally (flooding, storm surge and sea level rise) but also occur due to anthropogenic interferences like overpumping, hydrogeological characteristics of the aquifer and low groundwater levels (Thilagavathi et al. 2012; Singaraja et al. 2013). Although frequency of cyclones is likely to decrease in the 2030s, with increase in cyclonic intensity, the economic damage is going to rise. But, the same report summarized that flood and drought are likely to increase in Coastal India and will have a negative impact on agricultural production in the coastal zone due to poor infrastructure and demographic development. Thus, population growth, development, extreme events, salinity and sea level rise are going to generate multiple stresses on crop productivity in the poverty-ridden coastal region of India making a high-risk choice for farmers living along the coastlines. However, the Coastal Indian farmers cultivating paddy are going to struggle not only with changing environmental condition but also with pressure from yield stagnation, land conversion, industrialization, water resources and other resources. Thus, coastal farmers cultivating paddy in coastal saline soil will be looking for traditional varieties of paddy tolerant to changing condition in the twenty-first century. However, majority of studies on adverse impact of climate change on food security emphasises on crop models (increase or decrease of yield due to global warming) rather than the adaptive capacities of indigenous crops (Parry et al. 2004). In fact, these models do not incorporate local indigenous knowledge or culture to deal with shocks of changing environment. It is important for investigation to integrate empirical knowledge while systematically analysing the impact of climate change on coastal food security. Again, the salinity level of paddy field in the Indian coast is increasing due to occurrence of high-intensity tidal floods, storm surge, seasonal seawater intrusion and sea level rise. However, paddy cultivation is susceptible to salinity and then a majority of the agriculture scientist in India is having discourse that paddy cultivation in coastal zone is unproductive and unsustainable. That is the reason why scientists are advising decision-makers in India to have more flood/salinity resistant indigenous paddy farming, as a way to increase productivity. The traditional varieties are highly heterogeneous within populations in contrast to modern improved varieties, which are genetically homogenous (Sathya 2014). Indian rice (*Oryza sativa* var. indica) is believed to have consisted of more than 100,000 landraces until the advent of the Green Revolution in the 1960s, when most of the traditional varieties were replaced with a handful of "modern cultivars" (Bhambure and Kerkar 2016). In fact, more scientific investigation are needed to map the amazing range of adaptation of remaining indigenous varieties of paddy to different changing scenario of coastal ecosystem in India. This chapter thus reviews the indigenous varieties of rice grown in coastal saline soil Karnataka emphasizing specifically on indigenous varieties paddy tolerant to different abiotic and biotic environmental conditions.

2.2 Case Study

Flanked by the Arabian Sea, Karnataka is a coastal state in the southwest of India. It is the eighth largest state by size and the ninth by population. While the Western Ghats account for a bulk of the state's forest cover, over 77% of its geographical area is arid or semiarid. It has a 320-km-long and 48–64-km-wide coastline between the Western Ghats and the Arabian Sea, which receives moderate to high rainfall levels. A total of 104 lakh hectares of land is under cultivation. Karnataka is divided in ten agroclimatic zones, taking into consideration the rainfall pattern, soil types, texture, depth and physiochemical properties, elevation, topography, major crops and the

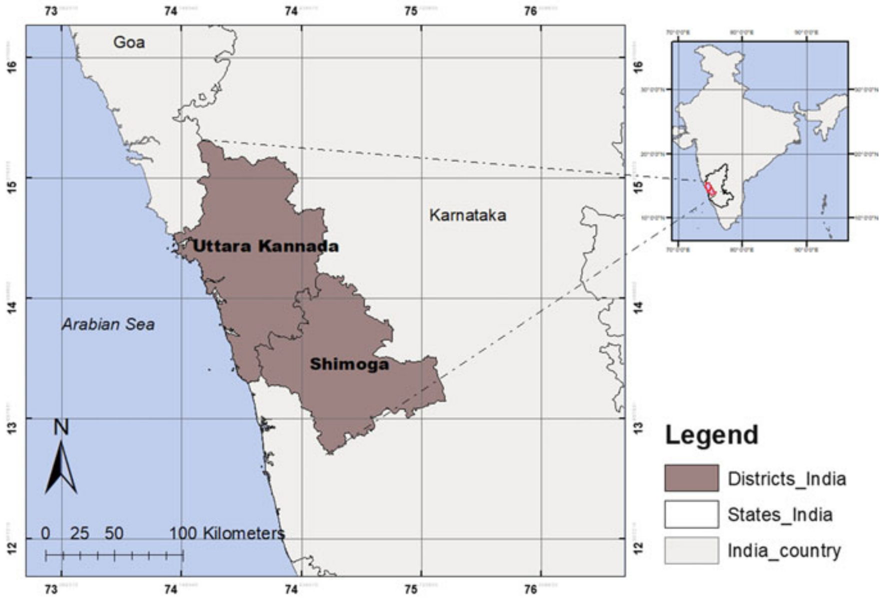

Fig. 2.1 Two coastal districts of Western Karnataka (Uttar Kannada and Shimoga)

type of vegetation; 64.6% of the geographical area of the state is under cultivation, and farmers and agricultural labourers account for 56.5% of Karnataka's workforce. Karnataka's coast stretches across 320 km therein the districts of Dakshina Kannada (62 km of coastline), Udupi (98 km) and Uttara Kannada (160 km). The area is predominantly agrarian involving about 60% of the workforce. More than 70% of cultivated land is under cereals with rice as the principle crop. We present case studies from two coastal districts of Karnataka—Uttar Kannada and Shimoga (see Fig. 2.1)—situated in the Varada basin.

2.2.1 The Practice

Farmers in the Varada basin region have a large collection of indigenous varieties gathered over centuries that can survive in floods. These deepwater varieties are grown organically using traditional methods. Some flood-resistant rice varieties in the Varada basin are Nereguli, Karibatha, Sannavaalya, Karijaddu, KaniSomasale, Jenugoodu, Nettibatha, Karikantaka, Edikuni, Karekaldadiga, Naremuluga, Karibhatta, Buddha Bhatta, Dikuni, Kariesadi and Mullari. Farmers have developed and preserved these varieties over centuries. However, in the name of development, high-yielding varieties of seed have been introduced to farmers that have led to a change in cultivation practice, even though they have not solved the problems of crop losses and famine in the region.

In recent years, development initiatives have been posing a threat to the delicate flood cycle of the Varada river. Climate change has made its impact felt on the delicate flood cycle of the Vardar basin. Due to deforestation and growing number of intense rain fall episodes, the area of the flood is spreading even to lands that never experienced floods. As a result, farmers are preferring cultivation of deepwater rice varities.

2.2.2 Demand for Flood-Resistant Variety

The total area of flood resistant rice varities is on the rise since the flood area is expanding; in addition, instead of one flood of long duration, there are two short floods in some years which have also increased the demand for varieties like Siddesale, which are more tolerant to repeated flooding. Farmers say erratic rains are also leading to pest attacks, but again, local verities are less affected than conventional one.

2.2.3 Unique Benefits and Unique Practices

The most traditional indigenous rice varieties of this region are long-duration—5 to 6 months—and have comparatively lower yield, 1.5–1.8 tonne per acre against the state average of 2.5–4 tonnes, but drawback is more than made up for by several factors apart from their sheer survival strengths. Many varieties of rice, like Nereguli, Kari Batta and Kari Jeddu, have a high market demand because of their superior taste and health-giving properties, and earn farmers a good price. Nereguli, a red rice with strong flavour and fragrance, for instance, is in great demand in Kerala and Goa, and Kari Batta is revered for its medicinal properties. Over centuries, farmers have evolved unique cropping patterns that survive not just the floods but also the fluctuations in flooding patterns. In Yelkundli, where the flood lasts for 30–35 days, for instance, farmers group Nereguli, Kari Batta and Netti Batta in an intricately synchronized cycle. Where the floods are shorter, varieties like Ratnachudi, Dodbile Batta and Yedikuni, which can survive 8–15 days of flooding, are grown. After the paddy season, from June to January, farmers grow legumes organically, which, apart from meeting food needs, enrich the soil for the next paddy crop, eliminating the need for chemical fertilizers. Overall deepwater rice makes better economic and ecological sense, specifically in the wake of projected climate change impacts in the region. It is crucial for government departments to work in tandem with farmers to increase the adaptive capacity of the farming community to better empower farmers to deal with climate change effectively and efficiently.

A better approach would be to improve the existing varieties through participatory breeding with involvement of farmers to improve yields and to provide wider markets for the rice.

2.2.4 Kagga in Peril

Kagga is an indigenous variety having tolerance to the inundation and salinity. Kagga has the following features:

- Kagga rice crop in the Aghanashini Creek doesn't require any investment, and there is no risk of crop failure. It is a saline-resistant variety.
- It is pest-free and resilient to environment stress.
- Kagga rice suits the health needs of farmers. It gives strength and energy to work long hours and increase stamina as compared to other conventional rice varieties.
- It has nice flavour, which conventional rice does not have, and curative properties.
- It works as a coolant.
- Soup made from this rice prevents heatstroke and keeps one cool.
- It makes an excellent baby food.

Cultivated in Uttara Kannada district by about 3000 families, the area under this saline-resistant variety has come down from about 2000 ha to 1200 ha. Mainly due to following reasons, farmers say that poor market returns, commercial prawn cultivation and government apathy are fast wiping out this rice variety, though it's cultivation is easy and requires little labour.

2.2.4.1 Poor Market Prices

Kagga rice gets rejected in the market because people are not aware of its qualities. Government agencies make no effort to push it. Many farmers have given up Kagga cultivation for petty jobs in shops, and other establishment and are content with money they get just from prawn cultivation. Kagga cultivation processes, such as puddling and guarding the crop, require collective effort.

2.2.4.2 Extreme Weather Evens

In recent years, many farmers have lost crops on account of extreme weather conditions. To help them, some farmer groups have set up seed banks and started marketing endeavours, but these are not sufficient. The Karnataka SAPCC says, "A grave problem of coastal regions is saline water intrusion and the subsequent destruction of large spans of standing agriculture and horticulture crops. Instance of saline water intrusion have been recorded on the coast due to sea erosion and tidal influx in the estuary. On the river bank, the main reason for tidal water intrusion is the poor quality of bund construction causing breaches. To address this problem, the govt of Karnataka initiated the construction of seawalls to prevent the entry of salt water into paddy fields. However, the poor construction destroyed the wall in part and the problem persists." The 12-km-long bund, built in 1973–1974, is in a deplorable state. As many as 16 sluice gates have collapsed, resulting in flooding of the area and subsequent crop losses. The government has made no effort to repair bunds and gates, which maintain the water and salinity levels in the paddy fields.

2.2.4.3 Lack of Government Support

The agriculture department and scientific institution agree that Kagga is an important germ plasm and regard it as endangered even though Kagga is being replaced with the improved varieties as its yield is 2000–2200 kg per ha compared to 4500–5000 kg per ha in improved varieties. The use of improved varieties has already increased the use of chemical fertilizers and pesticides. A change in government policy to protect indigenous rice varieties and their cultivars is a need of the hour. Unless the government changes its iron-curtain attitude, the resilient-rice variety, so uniquely suited to the ecosystem, may be lost forever.

2.3 Conclusion and Way Forward

Under the projected climate change impact scenario in the region, Kagga rice may offer a ray of hope to farmers, as it is a time-tested saline-resistant variety that can survive under the unique local geographical characteristics of the region. However, since it is a low-yielding rice variety and not much in demand as the public is little aware of its unique properties, the government has to promote it and make available its seed to the farmers.

Other conventional varieties promoted by the government are not as successful and sustainable in this region. They require high input cost because of the use of chemical fertilizers and pesticides. In such a scenario, traditional rice varieties like Karikagga may be the answer. They have the low input cost and resist environmental stress successfully. Risk of crop failure is negligible as compared to other conventional rice varieties promoted in this region.

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