

A review on extreme weather events and livelihood in Odisha, India

SANGRAM KISHOR PATEL, BINCY MATHEW, ANKIT NANDA,

SANGHAMITRA PATI* and HIRALAL NAYAK**

Population Council, Zone 5A, IHC, Lodi Road, New Delhi, India

**ICMR- Regional Medical Research Centre, Bhubaneswar, India*

***UNICEF, National Health Mission, Bhubaneswar, Odisha, India*

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e mail : sangramkishor@gmail.com

सार – पिछले कुछ वर्षों में मौसम की चरम परिघटनाओं ने तबाही मचाई है और वैश्विक स्तर पर इसका व्यापक प्रभाव जारी है, जिसका मुख्य कारण जलवायु परिवर्तन है। हालांकि, मौसम की चरम परिघटनाओं के प्रभाव बड़े पैमाने पर विकासशील देशों में असमान और विनाशकारी रहे हैं, क्योंकि वहाँ संसाधनों की कमी, कमजोर अनुकूलन क्षमता और जलवायु संवेदनशील आजीविका पर अधिक निर्भरता है। भारत के पूर्वी तट पर स्थित ओडिशा चक्रवात, सूखा, बाढ़ और उष्ण लहर जैसी चरम परिघटनाओं के नियमित होने से भारत में सबसे अधिक आपदाग्रस्त होने वाले राज्यों में से एक है। राज्य की आजीविका मुख्य रूप से मौसम के पैटर्न पर प्रत्यक्ष रूप से आधारित है (खेती, मत्स्य पालन) या अप्रत्यक्ष रूप से (गैर-कृषि मजदूरी, डेयरी फार्मिंग) मौसम की चरम परिघटनाओं के लगातार घटित होने के कारण यहाँ सदैव संकट बना रहता है। हालांकि, इस पर बहुत सीमित अध्ययन उपलब्ध हैं जो राज्य में आजीविका के संदर्भ में मौसम की चरम परिघटनाओं की स्थिति, प्रभाव और लचीलापन का वर्णन करते हैं। वर्तमान अध्ययन ओडिशा में आबादी की आजीविका पर मौसम की चरम परिघटनाओं (जैसे: चक्रवात, बाढ़, सूखा और उष्ण लहर) के प्रभाव की समीक्षा और जांच करने के लिए इस दिशा में किया गया एक प्रयास है। इसके अलावा, यह अध्ययन राज्य में मौसम की चरम परिघटनाओं पर लोगों द्वारा अपनाए गए स्वस्थ रवैये और सरकार द्वारा अपनाए गए कार्यक्रम और नीति की जांच करता है। अध्ययन के निष्कर्षों से पता चलता है कि मौसम की चरम परिघटनाओं ने बड़े पैमाने पर आबादी को प्रभावित किया है, जिससे काफी आर्थिक नुकसान हुआ है, और समाज के कमजोर वर्गों जैसे: बटाईदार कृषकों, छोटे और सीमांत किसानों, पिछड़े समुदायों, भूमिहीन मजदूरों, दिहाड़ी मजदूरों, रिक्शा चालकों और विक्रेताओं के काम की प्रकृति पर भारी असर पड़ा है और वे मौसम की चरम परिघटनाओं के प्रभाव के प्रति अतिसंवेदनशील हैं। उष्ण लहर, सूखा, बाढ़ और चक्रवात मौसम की मुख्य चरम परिघटनाओं में से हैं जो ओडिशा में आजीविका को नुकसान पहुंचाते हैं। इन परिघटनाओं के बार-बार होने की वजह से गरीब और हाशिए के लोगों की आजीविका में गिरावट आई है। स्थानीय स्तर पर तात्कालिक मुकाबला करने वाले तंत्र लोगों को कुछ राहत प्रदान करते हैं, परंतु इन आपदाओं में लोगों की अनुकूलन की क्षमता इन आपदाओं के बार-बार आने से गंभीर रूप से प्रभावित होती है और इसके लिए अधिक टिकाऊ और आजीविका समाधान के लिए लंबे समय तक ध्यान केंद्रित करने की सख्त आवश्यकता होती है।

ABSTRACT. Over the years extreme weather events have been catastrophic and continue to have overwhelming impacts globally, mainly due to climate change. However, the impacts of extreme weather events have been uneven and devastating in developing countries largely because of lack of resources, weak adaptive capacity and large dependency on climate sensitive livelihoods. Odisha on the eastern coast of India is one of the most disaster-prone states in India with a regular prevalence of extreme events like cyclones, droughts, floods and Heat waves. The state's livelihood is mainly based on weather patterns directly (farming, fisheries) or indirectly (non-farm wage labour, dairy farming) are at stake due to the frequent occurrence of extreme weather events. However, there are very limited studies available which describe the situation, impacts and resilience of extreme weather events in the context of livelihood in the state. The present study is an attempt in this direction to review and examine the impact of extreme weather events (e.g., cyclone, flood, drought and Heat wave) on the livelihood of the population in Odisha. In addition, the study examines the resilience shown by the people and the program and policy adopted by the government on the extreme weather events in the state. The study findings highlight that extreme weather events have affected populations at large, caused substantial economic losses and exerted a disproportionate effect on the vulnerable social groups such as sharecroppers, small and marginal farmers, backward communities, landless labourers, wage labourers, rickshaw pullers and vendors as the nature of work in which they are engaged is susceptible to the effects of extreme weather events. Heat waves, droughts, floods

and cyclones are the important extreme weather events that hamper the livelihoods in Odisha. Frequent occurrence of events has caused a blow to the livelihood resilience of the poor and marginalized people. While immediate coping mechanisms at the local level do provide some relief to the people, but the ability of people to adapt to these disasters is severely affected by the increased frequency of these disasters and there is a dire need to focus towards more sustainable and long-term livelihood solutions.

Key words – Climate change, Extreme weather events, Natural disasters, Livelihood, Resilience, Odisha, India.

1. Introduction

Extreme weather events have been historically ruinous and continue to have overwhelming impacts world-wide. The world experienced 1.5 times more extreme weather-related catastrophes in 2016 than the average in the last 30 years (Jones, 2016). A rise in frequency of extreme events is cataclysmic for the lives of people and for economies. In 2015, 22,773 people died, 98.6 million people were affected and US\$66.5 billion was incurred in economic damage due to natural disasters (UNISDR, 2016). Studies indicate that developing countries are more vulnerable during natural disasters (Watson, 2007; Ferrier and Spickett, 2007). Recurrent of extreme weather events can hinder adaptive capacities of people in low income countries that often have poor infrastructure and poor access to basic services. Among the South Asian countries, India has been ravaged by catastrophic extreme events of epic proportions and the increasing frequency of natural disasters has been a blow to lives of the people. It is among the most disaster-prone countries in the world owing to its climatic and physiographic conditions (NDMA, 2016).

In the eastern region of India, multiple extreme weather events (particularly, Heat waves, cyclones, droughts and heat waves) have been damaging Odisha for a long time, which is particularly vulnerable due to its geographical location and climatic conditions (OSDMA, 2016). Odisha, a state in the eastern region of India, has 30 districts with 314 blocks and 317 tehsils with Bhubaneswar as its capital. It extends over an area of 155,707 km² and has a coastline stretching upto 480 kms and has a high density of population in the coastal areas rendering it vulnerable to cyclones and floods (Singh and Jeffries, 2013). The population of the state is 41.9 million and out of that about 17 per cent people stay in urban areas and 83 per cent stay in rural areas. Odisha is primarily an agrarian state with about 70% of the population dependent on agriculture and animal husbandry. Small and marginal farmers constitute a majority of the agrarian community with paddy and pulses being the major crops. Large population of livestock helps in animal husbandry with small household-based units being the dominant form. It helps the small and marginal farmers and the landless labourer to supplement their income. The normal rainfall in the state is 1451.2 mm.

With majority of population dependent on agriculture, river systems play an important role in their livelihood while also making them prone to multiple floods. The extreme events like floods, cyclones, droughts, heat waves and lightning have claimed the lives of millions of people and have had devastating impact on the communities. They have especially caused damage to the livelihoods and hurt the income prospects of people in the State (Government of Odisha, 2015). Livelihoods have been impacted for the long-term due to the increasing frequency of extreme weather events and it indirectly affects the prospects for better income, healthcare, food security and development. The nature of employment is mainly climate sensitive in Odisha and extreme events cause damage to an already poor infrastructure and livelihood resources. Limited comprehensive studies are available on effects of multiple extreme weather events on livelihoods in Odisha. This review study seeks to understand the extreme weather events and its effects on livelihoods of people in Odisha. In addition, it tries to explore the livelihood resilience among the community, programs and strategies undertaken by government in the line of extreme weather events in the state. Further, this study tries to provide possible recommendations for it.

2. Methodology

We followed a review process for this study. This included holding team meetings at the inception, midpoint and end of the article review process to discuss challenges and uncertainties and the selection of key words to extract from selected articles. The primary research questions we followed here were the following: What are the empirical researches available on impact of extreme weather events/natural disasters on livelihood particularly focusing on the state of Odisha, India? A second line of inquiry examined the resilience and coping mechanisms adopted by the people and the government policies associated with the extreme events reported. We focused on climate-related extreme weather events that occurred in Odisha and included situations such as heat waves, temperature, rainfall, droughts, floods and cyclones and excluded situations such as war, epidemics and technological disasters. We searched for peer reviewed as well as grey literature through Google Scholar, Pub Med, government websites and other online databases. The main key words

searched were extreme weather events, natural disasters, livelihood, impact, resilience, adaptation, coping mechanism, policy, program, strategy, Odisha, India etc. A total of six reviewers were involved in reading the literature in the initial phase, with every citation and reports assessed independently by two people. Disagreements between reviewers were resolved through discussion with at least one other reviewer.

3. Impact of extreme events on livelihood in Odisha

3.1. Impact of heat waves on livelihood

Since the unprecedented heat wave of 1998 that claimed the lives of over 2,000 people in Odisha, the government has introduced heat wave action plans and disaster management programmes to prevent heat wave-related deaths. Research shows that the daily mean temperatures both the maximum and the minimum have been gradually increasing in Odisha (average 0.42 °C increased in last 15 years and average temperature was 45 °C during May-June) and continue to do so in future if proper measures are not taken in account (Mishra, 2017). However, heat waves continue to cause thousands of health-related issues and deaths each year in Odisha. Swelling, fainting, dizziness, headache, weakness, skin infections, vomiting, diarrhoea are the major signs and symptoms of health-related issues due to heat wave in Odisha along with increased mental stress (Patel, 2018a). Heat wave also adversely affects old people, children, labours, vendors, rickshaw pullers and people living in urban slums (Mishra, 2017). Heat waves affect most of the districts in Odisha (Government of Odisha, 2015) and with overwhelming majority of people employed in the unorganised sector, long duration Heat waves force people to stay indoors and lose out on income earning opportunities (OSDMA, 2016). Excessive heat affects the health of workers causing heat stroke and lowering their productivity. For instance, Heat wave has affected mining areas and excessive heat contributes to mining accidents (Government of Odisha, 2015). Another report showed that Heat waves have made it difficult for people to perform labour intensive work or Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) work (Action Aid, 2016).

It may be said that the nature of economic activities in Odisha have contributed to the rising temperature and intensified Heat waves, which in turn have impacted livelihoods of people especially engaged in outdoor based work. One of the reasons attributed for the increasing temperature and frequency of Heat waves in Odisha is the industrial sector and coal fired plants that every year emit 164 million tonnes of carbon dioxide, which is roughly equivalent to 3 per cent of the projected growth in

anthropogenic greenhouse gases worldwide (Parichha, 2016). Mining has further led to degradation of forests and the percentage of degraded forests in the mining districts has been increased over time. Further, this has contributed in disturbing the rainfall patterns and making them erratic (Mishra, 2017). Climate change along with increasing urbanization, industrialisation and population growth is anticipated to intensify Heat waves in Odisha (OSDMA, 2016). Several studies have demonstrated that the fall in groundwater level and water sources, was said to have impacted the livelihood of people by impacting on agriculture (Moharana, 2013; OSDMA, 2016). Another study also points out that a rise in temperature affects the agricultural sector in coastal areas of Odisha (Mishra and Sahu, 2014). Livestock are also affected by heat stress and fall ill thus impacting the rural livelihoods dependent on animal husbandry (Patel, 2018a).

3.2. Impact of droughts on livelihood

Among the multiple extreme weather events in Odisha, droughts are more recurrent and often affect vast geographical areas. The state has experienced drought in most of the years since independence and over the years new areas are also becoming drought prone with drought impacting districts like Kendrapara and Sundergarh (Roy, Mruthyunjaya and Selvarajan, 2002). In 2015-16, 27 out of 30 districts in the State were impacted by drought (Open Government Data, 2016). Agriculture is the main source of livelihood for majority of people in Odisha. Since the sector is primarily rain dependent and has poor access to irrigation, droughts pose a serious threat at regular intervals in the event of monsoon failure (OSDMA, 2016). There have been five years (e.g., 1965, 1974, 1976, 1979 and 1996) in the last 50 years when the rainfall has been below 1000 mm (OSDMA, 2016). A large number of farmers with small land holdings practice subsistence farming in Khaliakani village of Kalahandi district, a drought prone district in Odisha, where unpredictable monsoons were a major concern for agriculture (Jülich, 2011).

Given the growing frequency and extent of droughts, there is crop failure, land alienation, unemployment, indebtedness and migration and small and marginal farmers and agricultural labourers are more severely affected (OSDMA, 2016). A study shows that diverse socio-economic factors made different blocks in Western Odisha vulnerable to drought in varying degrees. In Saintala for instance, the socio-economic factors that made it more vulnerable to drought were the percentage of people staying in rural areas and high percentage of people in the BPL (Below Poverty Line) category. Whereas in Titlagarh, low insurance coverage of crops was the primary factors affecting farmers (Swain and

Swain, 2011). Another study showed that the situation of people during drought was aggravated as people had not received their ration for months and there was decrease in forest produce which people usually relied on for consumption during the lean season (Action Aid, 2016). In Alapaka village, which is mainly inhabited by Oraon tribe, in Sundergarh district of Odisha, there was loss of 70 to 75 per cent of paddy and drought condition owing to scarcity rainfall in 2002 resulting in low purchasing power and loss of capacity to invest. Agricultural lands were left barren and there was a fall in demand for wage labour, leading to migration (Mishra, 2007).

Another study showed that drought affected the landless severely and the landless Dalits were the worst affected. Landless Dalits did not have seeds for the subsequent season and were left with hardly any options for work and forced to migrate and even MGNREGA could not stem migration owing to delayed payments and paucity to work (Action Aid, 2016). The impact on forest produce which considerably declines during drought period is rarely taken into consideration when accounting for negative effects of drought. Like most disasters, during drought marginal farmers and landless households are the worst impacted (Action Aid, 2016). In Nuapada district of Odisha, it has also been evident that even the agriculture land holders are forced to change their livelihood or migrate for work due to the continuous drought in the region (Patel, 2018b).

3.3. *Impact of cyclones on livelihood*

Among the extreme weather events that affect Odisha, cyclones have caused the most ruin in Odisha: it has claimed thousands of lives and has been devastating for peoples' livelihoods. Even though Odisha has been vulnerable to cyclones, people were unprepared for the magnitude of loss and deaths that the Super Cyclone in 1999 caused. Tens of thousands of people were killed in the Super Cyclone in 1999. It wreaked havoc on climate sensitive livelihoods of people ranging from agriculture to fisheries. For instance, the livelihood of people engaged in fishing was affected severely during the Super cyclone, when 76970 boats and nets were damaged (OSDMA, 2016). Agriculture was ravaged due to saline water inundation ruining the livelihood of farmers (Sinha, 2002). Cyclones have affected crop cultivation in terms of yield and productivity both in the short and long term (Chhotray and Few, 2012; Duncan *et al.*, 2017). During the Super Cyclone over 1 million hectares of land was affected. The cyclone wreaked havoc three weeks prior to the harvest destroying paddy fields, vegetable crops and sugarcane (Sinha, 2002). With deaths of thousands of animals, animal husbandry suffered a major blow. A study by Chhotray and Few (2012) also shows that even ten years

after the super cyclone people have not able to recover to the pre-cyclone condition. With reduced harvests and in turn decline in the availability of fodder for large bovines, people have moved on to rearing of small animals like chicken and duck (Chhotray and Few, 2012). Another study also highlights that over the years due to the impact of Super cyclone, the livelihood on tiger prawn cultivation was replaced by the white shrimp cultivation in the area as an alternative mechanism by community people (Patel, 2018c).

Over 15 years after the Super Cyclone, Cyclone Phailin in 2013 destroyed an array of livelihoods. It resulted in the submergence of fields and crop damage, particularly in Nayagarh, Cuttack, Jajpur, Kendrapara, Jagatsinghpur and Bhadrak districts. Horticultural crops also suffered damage and nurseries and buildings of the horticulture department were particularly affected. Large number of livestock deaths further hampered the livelihood and food security of the population. Artisans engaged in making handicrafts were affected due to damage caused to raw materials, finished products, work shed and equipment. Cyclone Phailin and ensuing floods severely affected the livelihood of the people in fisheries and those employed in Micro, Small & Medium Enterprises (MSMEs) were damaged (Singh and Jeffries, 2013). A year later, cyclone Hudhud caused damage to agriculture and horticulture in Odisha (NDMA, 2015). Vulnerable sections such as scheduled caste, wage labourers and sharecroppers were particularly affected by Cyclone Phailin (Singh and Jeffries, 2013). Another study notes that compared to medium farmers, marginal and small farmers were more acutely affected as they found it tough to cope with climate extremes (Paltasingha and Goyarib, 2015). A study conducted in Jagatsinghpur and Kendrapara districts of Odisha showed most farmers suffered over 50 per cent crop loss due to Cyclone Phailin in 2013 (Duncan *et al.*, 2017).

3.4. *Impact of floods on livelihood*

Over the years, floods are the most frequent and devastating natural disaster in Odisha. Nearly 1.40 lakh hectares of geographical area is flood prone in Odisha (OSDMA, 2016). With large number of communities living in riverside locations, flooding has become a regular feature of their life. In the 2006 floods over 67 lakh people were affected, 1,30,460 houses were damaged, and 105 people died. In the 2007 floods more than 27000 houses were damaged and in 2008 floods, over 45,000 houses were damaged (OSDMA, 2016). Along with the destruction caused to lives and property, livelihoods were also impacted. For instance, cyclones and floods cause damage to boats, nets, community roads and fish landing centers (Iwasaki *et al.*, 2009). Rudimentary

infrastructure, product stock and equipment belonging to rural artisans and weavers were destroyed by floods and cyclones. In 2011-12 floods, 2260 weavers were affected, and damage was caused to looms, raw materials and finished products (OSDMA, 2016). Floods have also been destructive for agriculture. A study done in Puri district of Odisha showed that floods lead to crop submergence and subsequent crop failure and contributes to increasing the vulnerability of people (Sam *et al.*, 2017). After the 2006 floods in Odisha, crop loss was reported in 42,743 hectares and nearly 1,22,000 hectares of total crop area was affected (UNICEF, 2006).

Socio-demographic factors often play a role in making people more susceptible to floods. The vulnerability to flooding increases due to high population densities in flood-prone areas and encroachment in the floodplains. What aggravates the situation of people staying in these areas is their poor socio-economic condition and their dependence on monsoon paddy (OSDMA, 2016). A study showed that Alanda village in Puri district of Odisha had higher vulnerability than other villages in terms of its less adaptive ability because of their high dependency ratio and illiteracy, female-headed households and backwardness etc. (Sam *et al.*, 2017). A study in Chasakhand and Tarasahi villages of Jagatsinghpur district shows that the floods have a drastic and long-term impact on the landless and marginal farmers as their food intake during the flood year is reduced. The quality of food consumed is also inferior to non-flood years further impacting their health. The selling of assets like jewellery, cattle and land was a common coping mechanism during and after the floods (Mishra and Mishra, 2010). Another study indicates how human activities can exacerbate the conditions of people who stay in disaster prone areas and are dependent on climate sensitive livelihoods. A study done on farmers vulnerable to floods and storms in Puri and Ganjam districts and Bhubaneswar illustrates this. Respondents in the study believed fish catch livelihood had reduced in the past two decades since the inception of prawn farming, which was also believed to be harmful for ecological sustainability of the Chilika lake. Salt farmers felt that construction of a new canal was responsible for reduction in fish population owing to decline in saline water flow and which ultimately impacting their livelihood (Vivekananda *et al.*, 2014).

4. Resilience to extreme weather events

A variety of strategies have been taken up by people and the government to build resilience and have proper livelihood security in order to adapt to increasing frequency of extreme events. Among the measures undertaken by the community, a study done in IB valley, a coal mining region of Odisha showed that people with

minimum five years' education reduced the number of work hours during Heat wave. However, people with low income continued to work due to paucity of other resources for earning income. Another finding in the study showed that people belonging to lower caste categories were more likely to work during the Heat waves in contrast to upper caste (Hota and Behera, 2014). The Oraon tribe in Sundergarh district of Odisha took up many coping mechanisms during the drought in 2002, that included migration for work, change of occupation (e.g., wage labourers), sold non-timber forest produce and firewood, and some cultivated and sold vegetables (Mishra, 2007). Another study showed that people took up off-farm activities such as dairy, non-agricultural labour, petty business as floods led to huge losses in agriculture and some even reduced their food intake and took up the sale of cattle (Mishra and Mishra, 2010). A number of studies indicate that people migrate in search of work after natural disasters (Jülich 2011; Mishra, 2007; Mishra and Mishra, 2010). Some of the coping strategies in drought, cyclone and flood prone districts of Nuapada, Kendrapara and Jagatsinghpur in Odisha included taking loans for agricultural activities from moneylenders, family, self-help groups and banks (Patel, 2018b&c; Mishra and Mishra, 2010). Nearly 18 per cent people took loans after the crop losses in 2008 floods in Odisha. Other coping mechanisms included the sale of livestock or taking wage labour work although such work was not available throughout the year and even MGNREGA was of little help (Duncan *et al.*, 2017).

A study undertaken in an inland and coastal area to assess the resilience of communities a decade after the Super Cyclone study showed that the recovery efforts had severe limitations. It pointed out that people resorted to wage labour besides engagement in agricultural activities. While employment in intensive road works were some of the opportunities people gained from in Siyali, a coastal area, in the wake of the Super Cyclone, these activities did not increase over the 10 years period since the Super Cyclone. Many people started prawn cultivation after the Super cyclone. However, this was not a successful venture due to disease and because these farmers did not have either technical knowledge or credit to continue prawn cultivation and had incurred debts in the process (Chhotray and Few, 2012).

Interventions and programmes were introduced by the government and NGOs to help vulnerable communities adapt to climate change and effects of extreme events on their livelihood. After the Super Cyclone, Action Aid sought the rehabilitation of livelihoods of the affected people by providing an amount of Rs 476000 to 170 families for livelihood restoration.

Under the Household Livelihood Restoration Support Project of Cooperative for Assistance and Relief Everywhere (CARE), 40,000 farmers and sharecroppers in 500 villages were provided paddy seeds (Sinha, 2002). As part of the Partners for Resilience Programme, livelihood diversification was introduced, farmers were encouraged to use saline tolerant and low-cost rice varieties and self-help groups were promoted, with the aim of improving livelihoods and reducing disaster risk caused by cyclones (Iwasaki *et al.*, 2016). In a study, Swarna-Sub 1, a flood tolerant seed variety was distributed among farmers in Jajpur district of Odisha as a strategy to adapt to the effects of the changing climate on agriculture. The paddy yield from Swarna-Sub 1 was found to be higher compared to traditional varieties as well as other high yielding varieties (Swarna and Puja (Dar *et al.*, 2017).

The Western Orissa Rural Livelihoods Project (WORLP) assisted farmers with crop diversification, aquaculture and vegetable gardens. It improved the capacity of women to adapt to adverse climate change effects *via* participation in self-help groups that have been strengthened and made it possible to manage common property resources more efficiently (Sharma *et al.*, 2014). Interventions aimed at management of natural resources improved the adaptive capacity of community to climate change effects. These activities are mainly aimed at checking runoff from catchments and reducing sediments in water bodies. Soil and water conservation was done in collaboration with communities by using local labour and participatory micro-planning. This enabled ground water recharge and improved crop production (Sharma *et al.*, 2014).

The government has also undertaken several measures to help communities adapt to the changing climate and recurrent natural disasters. It has introduced policies and programmes for helping the State deal with effects of climate change and extreme events. For instance, through the State Disaster Management Plan, entities such as Indian Meteorological Department (IMD) disseminate disaster alert. Mock drills are conducted involving the community, task force members, school students, Anganwadi workers, Panchayati Raj Institutions (PRI) representatives, NGOs, Fire Service, Orissa Disaster Rapid Action Force (ODRAF) units and National Disaster Response Force units (OSDMA, 2016). Climate-resilient works under the MGNREGA, an employment guarantee scheme, have been introduced in India. Loopholes in government programmes have been brought to the forefront. Studies have drawn attention to drawbacks of the MGNREGA scheme in terms of its failure in stemming migration (Action Aid, 2016).

5. Discussion

The study clearly shows that in recent years, the livelihoods of people in Odisha have increasingly been impacted by extreme weather events which has largely been inflated by climate change. It shows that extreme weather events have affected populations at large, caused substantial economic losses and exerted a disproportionate effect on the vulnerable social groups such as sharecroppers, small and marginal farmers, backward communities, wage labourers, rickshaw pullers and vendors as the nature of work in which they are engaged is highly susceptible to the effects of extreme weather events. Heat waves, droughts, floods and cyclones are among the main extreme weather events or natural disasters that cause damage to livelihoods in Odisha. Frequent occurrence of events has caused a blow to the livelihood resilience of the poor in particular owing to poor access to resources and low adaptive capacity. Even though community and government strategies have been undertaken, it has not been sustainable to a large extent as people are often forced to migrate and do not have adequate human capital to switch to viable occupations. With the destruction of natural capital due to the changing climate and with little or no financial capital, the adaptive abilities get further reduced. Women face a greater brunt of these extreme events due to their role as care takers of the family. The destruction of houses and lack of sanitation facilities also has a greater impact on women as their privacy and security needs get compromised. Old and frail women, single women and Dalit women are even more exposed to these effects of disasters (Singh and Jeffries, 2013). With Dalits in rural areas living in poor conditions and facing social exclusion and isolation, the Dalit women are further disadvantaged on account of multiple oppressions.

Findings of the study corroborated with the previous findings to elaborate that extreme weather events in Odisha have had adverse impact on livelihood, (Singh and Jeffries, 2013; OSDMA, 2016). With majority of people dependent on livelihoods derived from natural resources, extreme events pose a risk to the lives and livelihood of people. Extreme events have had an impact on varying topographies in Odisha from coastal areas to forests. Not only has the geographical location made Odisha more vulnerable, but the changing climate has posed a major threat to livelihoods that are natural-resource dependent. For instance, a study points out that fishing activities in Chilika lagoon are impacted by climate change making it difficult to fish during heavy rain and cyclones (Iwasaki *et al.*, 2009). Arguments through this study and other studies (Vivekananda *et al.*, 2014; Parichha, 2016) describe that climate change adversely affects the ecosystem and climate sensitive livelihoods get affected in

the process, which further affects their income, health and development. In addition, anthropogenic activities have furthermore contributed to making impacts of extreme weather events worse for people and their livelihood (Vivekananda *et al.*, 2014; OSDMA, 2016; Parichha, 2016; NDMA, 2016).

There is enough evidence to show that agriculture is among the main livelihoods that is affected by the changing climate and multiple natural disasters (Mishra, 2007; Chhotray and Few, 2012; Moharana, 2013; OSDMA, 2016; Duncan *et al.*, 2017). Climate change has pronounced effects in India as vast sections of its population is dependent upon agriculture, which has become increasingly unviable in recent decades especially owing to climate variability and the impact of extreme events. Numerous studies in the review showed that paddy crop was among the most affected crops in the state (OSMDA, 2016; Government of Odisha, 2015; Duncan *et al.*, 2017). The review shows that different natural disasters in Odisha have impacted agriculture, the primary occupation of people in Odisha. For instance, even though there have been only three major cyclones in Odisha in the past 20 years, the agricultural yield and productivity has been severely impacted in the long run, forcing people to migrate. The impact of climate change on agriculture has been widely reported (Government of Odisha, 2015; OSDMA, 2016). Floods, similar to cyclones, have led to saline water inundation and submergence of crops. Nearly 4 lakh hectares is vulnerable to saline intrusion and about 3.54 lakh hectares is exposed to floods in Odisha. As distribution of rainfall in Odisha is erratic and uneven, floods and droughts occur regularly, and their recurrence affects Kharif rice production. Droughts has affected few areas and on other occasions the entire State has been affected (OSDMA, 2016). The State witnessed a decline in food grain production in 2015-16 owing to severity of drought: while the area under food grain declined by 6 percent, the area under rice fell by 39.42 lakh hectares owing to the drought (Government of Odisha, 2017). Besides agriculture, people dependent on animal husbandry, forest resource and fishing activities have also been impacted (OSDMA, 2016). Even occupations that are not climate-sensitive get affected as cyclones cause damage to raw materials (Singh and Jeffries, 2013; OSDMA, 2016). Numerous studies have showed the effects of cyclones (Chhotray and Few, 2012; Duncan *et al.*, 2017; Singh and Jeffries, 2013; Paltasingha and Goyarib, 2015) and floods (UNICEF, 2006; Iwasaki *et al.*, 2009; Vivekananda *et al.*, 2014; Sam *et al.*, 2017) on livelihoods of people in Odisha.

The loss of livelihood in the communities most directly affects the level of food security. Availability of sufficient quantity of nutritious food and the ability to

acquire the same in a socially acceptable way is severely undermined. This further affects other socio-demographic indicators such as nutrition (Pattnaik, 2012, Rodriguez-Llanes *et al.*, 2011). The lack of nutritional food further affects infants, small children and pregnant and lactating women. While floods and cyclones lead to loss of crops and stored grains, drought results in crop failure. The erratic and uneven rainfall can lead to certain sections of population being food insecure even in non-disaster years. This increases the dependence of people on purchased food and in combination with rising food prices and loss of livelihood drives families and communities into severe poverty (Gulati *et al.*, 2009). The increasing levels of poverty and lack of food security can cause health issues for the people beginning with the most vulnerable sections. As Pattnaik and others have shown, drought leads to adverse health issues for vulnerable sections in Odisha (Behera *et al.*, 2002; Pattnaik, 2012; Sahu, 2012). A study in Mathanpalla and Jugirata villages in Odisha showed that drought leads to a fall in the calorie intake, which leads to health problems as well as death owing to malnutrition among children (Pattnaik, 2012). Health problems relating to water were common, in addition to weakness, pregnancy related issues and pre-mature deaths in Bolangir and Kendrapara districts after drought (Sahu, 2012). Floods similarly affect nutrition of children in Odisha. A study showed that children in flood affected communities were stunted and underweight compared to non-flood affected areas in Odisha (Rodriguez-Llanes *et al.*, 2011). In another study, instances of severe wasting in children was three times higher in areas affected by floods in comparison to non-flooded areas in Jagatsinghpur district after the 2008 floods (Rodriguez-Llanes *et al.*, 2016). However, there are limited studies that look at how livelihood loss can lead to indirect impacts that cause health problems specifically nutrition related issues in women and children in Odisha during disasters situations.

The study highlighted that main coping strategies undertaken by people that included taking up no-farm activities, changing of occupations and migration. People took up wage labour and in other cases migrated to cope with the onslaught of natural disasters in Odisha. The importance of natural resource management and engaging the community in livelihood regeneration efforts was highlighted in the review (Sharma *et al.*, 2014). The review showed that some NGOs assisted communities in adapting to climate change (Sinha, 2002; Sharma *et al.*, 2014). It also highlighted some of the government strategies like MGNREGA, formation of self-help groups (SHGs) under state livelihood programme and other programmes introduced to enable people to cope with the changing climate and extreme events. The drawbacks of government measures were also brought to the forefront. The study pointed out the limitations in livelihood

recovery owing to limited and lackadaisical external support (Chhotray and Few, 2012). Prawn cultivation proved to be of limited help to the poor owing to lack of financial capital (Chhotray and Few, 2012; Vivekananda *et al.*, 2014). Another study illustrates that the state had hardly made any investments in generating employment. Training of farmers was said to have been done only in selected panchayats in Erasma block and the lack of initiative in providing saline resistant paddy varieties was also highlighted (Chhotray and Few, 2012). Further, Government benefits like crop damage compensation provided to the land holders does not benefit sharecroppers and landless labourers even though their livelihood is severely hampered by crop damage (Singh and Jeffries, 2013).

The review clearly asserts that the possibility of loss of livelihood due to extreme events and the ability to cope and adapt to its adverse effects is socially determined. The social structures prevalent in a society and the level of physical, social and economic resources available to a household determines how debilitating the long-term effects of disasters will be and also the efficacy of the recovery. Further, the repeating nature of these disasters in Odisha when combined with poor infrastructure, prevailing levels of poverty and the inability of the state to provide strong institutional support creates a vicious cycle of increasing vulnerability. As Few, Chhotray and others have argued, this shows a compelling need to not view disasters in their isolation and loss of livelihood as its direct consequence but as a long-term concern of the population where the existing vulnerabilities are aggravated with every new extreme event (Chhotray and Few, 2012). There is also a need to ensure that institutional efforts are not limited in their focus towards livelihood but go beyond to ensure that there is change in the prevailing social conditions which inhibit the resilience of the most vulnerable and marginalised. Given paucity of resources in developing countries and the increasing frequency of extreme events there is a further strain on available resources, thus impairing the adaptive capacity of these regions like Odisha.

6. Conclusion and policy implications

The study concluded that people have reduced abilities to deal with climate change owing to recurrent and severe nature of extreme events in Odisha. Considering the impact climate change and extreme events have had on livelihoods of people, stronger and sustainable measures need to be taken to enable the community to adapt. The vulnerability analysis by Paltasingha and Goyarib (2015) reveals that the household income of the farmers and thus their financial security was directly linked to their ability to cope with the extreme

events. Whereas others have argued that lack of financial assets and poor institutional support are the major constraints on overcoming the negative effects these disasters have on livelihood (Chhotray and Few, 2012). In this regard there is an urgent need to ensure that farming communities are able to diversify their income sources which enhances their financial condition and also acts as a hedge against extreme events. Diversification of crops, growing drought and flood resistant varieties of crops and water harvesting are some of the measures that can be undertaken. Interventions in agriculture need to be such that they are able to benefit all sections of society. This can be achieved by collaborating with village level volunteers for distribution of drought/flood resistant seeds and dissemination of early warnings on natural disasters. In drought prone areas another effective measure could be afforestation by using drought-resistant vegetation like Jackfruit trees. Employment generation measures need to be taken with a focus towards youth in these communities by providing training towards skill development. Monitoring mechanisms are required to ensure that government programmes such as the MGNREGA are implemented in a more effective manner to ensure basic income security. SHGs also need to be supported in order to provide alternate livelihoods that are not directly dependent on natural resources. Any measure undertaken for livelihood regeneration needs to ensure that discussions are held with the community to ensure that their interests are taken into account. People belonging to communities that are the most disadvantaged such as poor and the landless need to be engaged in a deeper manner in this regard. Further research is required on efficacy of adaptation mechanisms for livelihood security in this region.

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