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# Exploratory Study on Vulnerability Assessment of Onion Growing Farmers of Nashik due to Climate Change

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**Abstract:** Climatic variability in the last decade especially erratic rainfall pattern and extreme rises in temperatures led to a drastic reduction in the kharif onion crop yieldi.e., 30 to 40% in Nashik (M.S.). Increases in temperature, rainfall and relative humidity also affected the post-storage quality causing considerable losses in storage (up to 40%). Reduced production creates deficit in the domestic market supply resulting in steep price hike. Onion farming being a major source of income for the farmers of Nashik, reduction in yield increases their vulnerability. Keeping in view the constraints faced by the farmers, the study was undertaken to assess the vulnerability of kharif onion crop to changing climatic conditions in the last ten years. Asurvey of 300 farmers was undertaken from two talukas of Nashikthrough questionnaire and focused group discussions for the vulnerability assessment.84% farmers revealed germination failure between 40% to 70% due to excessive rainfall and from 40 % to 70% due to drought. 40% crop damage due to pests and diseases was reported by 57% farmers. An increased use of chemical fertilizers and pesticides was done by 83% of farmers and only 15% applied organic manures andbio fertilizers for improving crop performance. A reduction in bulb storage quality up to 60%, and more than 40% losses in yield were observed. 40% to 60% economic losses along with reduction in market price up to 80% were reported by 85% of the farmers. Implementation of climate resilient technologies like raised –bed, drip irrigation, organic and bio-fertilizers along with their mass demonstration are recommended.

**Keywords:** Climatic variability, vulnerability assessment, onion, survey

## 1. INTRODUCTION

At present due to anthropogenic activities like industrialization, urbanization and infrastructural projects changes in the climate are taking place, which in turn prove detrimental to crop productivity (Rakshit et al., 2009). According to Schneider (2007) vulnerability of any system to climate change is the degree to which these systems are susceptible and unable to survive with the adverse impacts of climate change. Climate change vulnerability was earlier defined by the IPCC using three primary indicators (i.e., exposure, sensitivity, and adaptive capacity) with all the three having equal significance (Parry et al. 2007). But, recently IPCC shifted the focus on sensitivity and adaptive capacity and risk exposure was merged into sensitivity (Field et al. 2014). The agricultural vulnerability to climate change is defined as the adaptive capacity of a farming system or community to respond to the impacts posed by climate change. Farming system's tendency to respond to the environmental stimulus and its induced hazards is termed as adaptive capacity andvarious factors influence the adaptive capacity of farming system such as institutional or policy-level and personal or farm-level attributes (Glaas et al. 2010).Suitable interventions at the institutional and policy level may provide farming communities with the much required support that may facilitate the farm-level adaptation or mitigation response (Berry et al. 2006). The adaptive capacity of the farmers can be enhanced by providing them with the access to information, financial support and technical support to help them incorporate climate-smart agricultural technologies in their farming systems. Additionally, farmer's adaptation strategies are also influenced by farmers' socio-economic profile and other farm-related attributes namely mode of farming, land assets, and adaptation in providing resilience against the livelihood risks (Zamasiya et al. 2017). Developing countries like India where 62 per cent of the total cropped area relies on monsoon rainfall is more vulnerable to climatic vagaries. Adeniyi (2013) reported that rainfall is one of the most important factors affecting crop production. Decrease in yield of kharif and late kharif onion crop by 30-40% due to erratic and untimely rains, occurrence of Anthracnose disease due to water stagnation and soil-borne and fungal disease build-up during kharif season was reported by Gadge et al. (2012).India is the second largest producer of onion in the world after China but far behind of many countries in terms of productivity. In India, Maharashtra is the leading state in area, production, productivity and export of onion. Besides being a pioneer state in onion production, it contributes 25% of country's onion. Maharashtra is the leading state in area, production, productivity and export of onion responsible for 90% of onion export amounting to Rs.800-900 crores. Nashik alone contributes about 50% of exports (Gadge and Lawande, 2012). In the last few years, a major drop in onion yield is seen in Maharashtra owing to the adverse climatic conditions i.e. extremely high temperatures and untimely and excessive rainfall. The changing climatic conditions have also led to post –harvest storage losses in addition to the loss in yield. The storage losses amount to as high as 40% at times leading to very less or no availability. Also, when the commodity affected is a widely and daily consumed item like onion both by the rich as well as by the poor, the adverse impact on producers and consumers also generate socio-economic ripples. Since due to rain uncertainty, agriculture on the rain fed areas remains a high –risk and low input enterprise for resource –poor farmers. Depending on the vulnerability of individual crop and the agro – ecological region, the crop-based various strategies and adaptation of effective and efficient measures needs to be developed taking into account and integrating all the available options to sustain the agricultural productivity. Many farmers are adopting simple measures like change of sowing dates, good plant protection practices, adjusting the harvesting date etc. to reduce the crop loss and ensure minimum assured yield and quality. Efforts can be undertaken to mitigate the effects of climate change and adapt to its consequences. Innovative agricultural practices and technologies can play a role in climate change mitigation and adaptation. Even though literature on climate change impacts and vulnerability (Lokonon et al. 2019; Shortridge 2019) is available; but limited information exists on farm-level studies based on cross-sectional data on farmers' resilience and adaptive capabilities and on the agricultural crops regarding the possible strategies and tools to understand the impact of climate change on their productivity, quality and yield. Keeping in view the above points, the proposed study was undertaken to see the vulnerability assessment of kharif onion crop to changing climatic conditions for identifying and implementing technology for its mitigation. Survey of farmers was undertaken for the vulnerability assessment regarding rainfall distribution and intensity, and temperature patterns during the cropping period of kharif onion for a period of ten years (2009 – 2018) to find out the constraints faced by them during production and post- harvest.

## 2. METHODOLOGY

### 2.1 Study Area

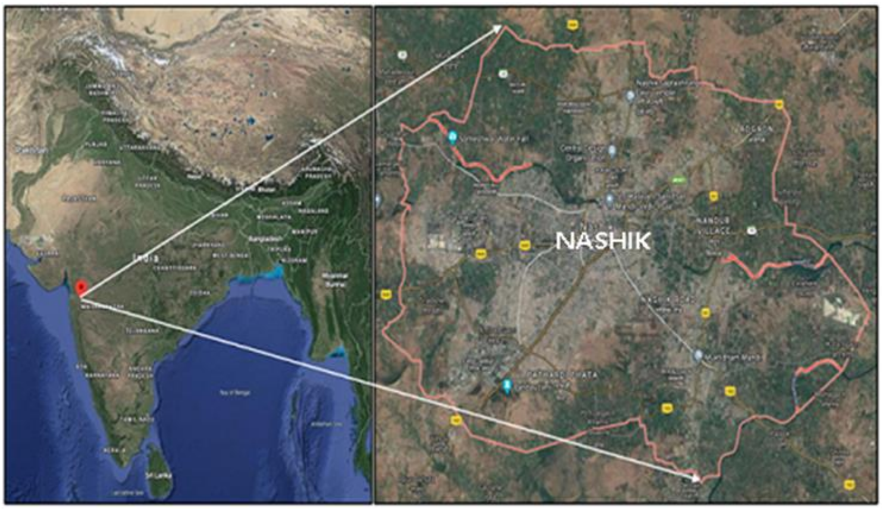


**Fig. 1. Location Map of the Nashik District (Maharashtra)**

The current study was conducted in Nashik district of Maharashtra. Nashik district is located between 18.33 degree and 20.53-degree North latitude and between 73.16 degree and 75.16-degree East Longitude partly in the upper Godavari river basin and partly Tapi river basin at Northwest part of the Maharashtra state.

It lies at 565 meters above mean sea level and being the third largest district in Maharashtra (Google Scholar) occupies an area of 15,530 sq.km and population of 6,107,187 as per the 2011 census (Ahire D., 2018).Maharashtra's 73% of the geographical area is classified as semi-arid and around 84% of the total area is under rain fed agriculture (Kalamkar, 2011).According to reports by TERI (2014), the state could face an increasing trend in rainfall variability , including droughts leading to an increased vulnerability of agriculture to climate change.

There are a total 15 tahsils in the district. The soils of the Nashik district are very fertile ranging from different shades of gray to black, red and pink color and are classified into four categories namely lateritic black soil, reddish brown soil, coarse shallow reddish black soil and medium light brownish black soil. High alumina and carbonates of calcium and magnesium are present in black soil along with variable amounts of potash, low nitrogen and phosphorus.

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The red soil is suitable for cultivation under a heavy and consistent rainfall and is less common (District survey report, 2020). The district receives an average annual rainfall between 2600 to 3000mm. Most of the rainfall is received from June to September and the relative humidity ranges from 43% to 62%. The average annual rainfall in the district is 1,034.5 mm. About 88% of the annual rainfall is received during the south west monsoon between June and September. Maharashtra accounts for one-third of the total annual onion production of India amounting to 16 million tones making it India's top onion producing state. Nashik alone contributes to more than 100,000 hectares under onion production with area under kharif onion amounting to 46,440hectares.

The unseasonal rainfall in the last few years has damaged the standing kharif crop on 37,829 hectares across Nashik district as reported in Times of India (Sep. 2020).

**2.2 Data Collection**

A survey of kharif onion growing farmers from the Nashik district of Maharashtra was undertaken for the vulnerability assessment regarding rainfall distribution and intensity, and temperature patterns during the cropping period of kharif onion for the last ten years to find out the constraints faced by them during production and post- harvest. A survey questionnaire was used as a data collection tool.

The study was conducted in two talukas of the Nashik district i.e. Chanwad and Sinnar.A total of 300 farmers from the different villages of the above two talukas were surveyed based on the randomized sampling method. All the category of the farmers was included – large farmers (> 4 ha), medium farmers (2–4 ha), and small and marginal farmers (< 2 ha). The farmers were personally interviewed in their respective villages. In addition, focused discussion comprising of 25 farmers was conducted in the above two talukas to identify key areas of action for climate change adaptation and mitigation for onion crop.

A problem assessment tree was prepared on major problems and their possible causes with possible technological measures for improving the yield of kharif onion in adverse climatic conditions.

The data was collected on the following parameters:

a. The socio-economic profile of the respondents
b. Meteorological and climatic conditions in the last ten years
c. Technology in practice and need assessment for mitigation of climate change impacts and
d. Schemes and support of the government.

**2.3 Data Analysis**

The collected data was tabulated, descriptive analysis of the data was performed in excel by applying statistical tools (frequencies) and presented in graphical form.

## 3. RESULTS AND DISCUSSION

**3.1Socio-economic profile of the respondents**

The perception of climate change is influenced by personal characteristics such as gender, age, education level and experience in farming (Omari 2010; Akinyemi 2017).

The farmer survey reveals that farming is the major source of income for farmers of the Nashik area as 96% of the respondents are engaged in farming activities with 97% being involved in kharif onion cultivation.

The data indicates that 67% of the farmers have the secondary level of education and only 3% are non-educated. Besides kharif onion, the other crops being cultivated by the farmers include soybean, maize, tomatoes, bajra, grapes, green gram, and capsicum. (Table 1)

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**Table.1.Socio-economic profiles of the respondents**

| **S. No.** | **Variable** | | **Frequency (n= 300 )** |
|---|---|---|---|
| **1** | Sex | Male<br>Female | 100<br>0 |
| **2** | Educational Qualification | Primary<br>Middle<br>Secondary<br>None | 33%<br>42%<br>67%<br>3% |
| **3** | Type of employment | Services<br>Labourers<br>Others(Farming) | 3%<br>0%<br>96% |
| **4** | Season for cultivation of onion | Kharif<br>Late kharif<br>Rabi | 97%<br>1%<br>2% |

### 3.2 Perceived impacts of climate change by the farmers on the meteorological and climatic conditions in the last ten years

Farmers are facing multitude of problems due to rainfall variability ranging from irregular and scanty rainfall causing droughts to unseasonal and heavy rainfall leading to floods, extreme rises in temperature and associated vagaries. These changes have adversely impacted seed germination, nursery raising, and transplantation to bulb maturity, harvest and post-harvest stages causing considerable losses in kharif onion crop yield (40 % to 60%) and economic losses (up to 60%).Majority of the respondents (99%) observed changes in the rainfall pattern and all of them (100%) reported the negative effect of excessive rainfall, flooding or drought on the onion crop at different stages in the last ten years. The perception of the farmers regarding increasing rainfall variability can be correlated to the annual mean (Fig.2) and seasonal mean (Fig.3) of rainfall variability trends obtained from the data collected from the Indian Meteorological Department (IMD) Mumbai for the Nashik area for a period of ten years (i.e., from 2009-2018).

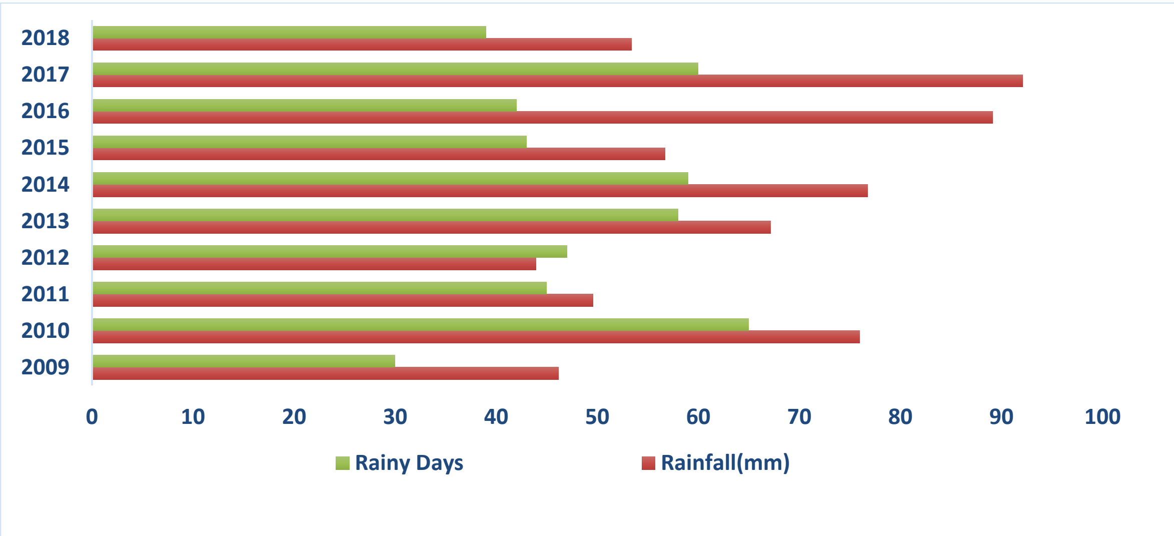


**Fig. 2. Mean Annual Rainfall variability and no. of rainy days for Nashik region from 2009-2018**

 

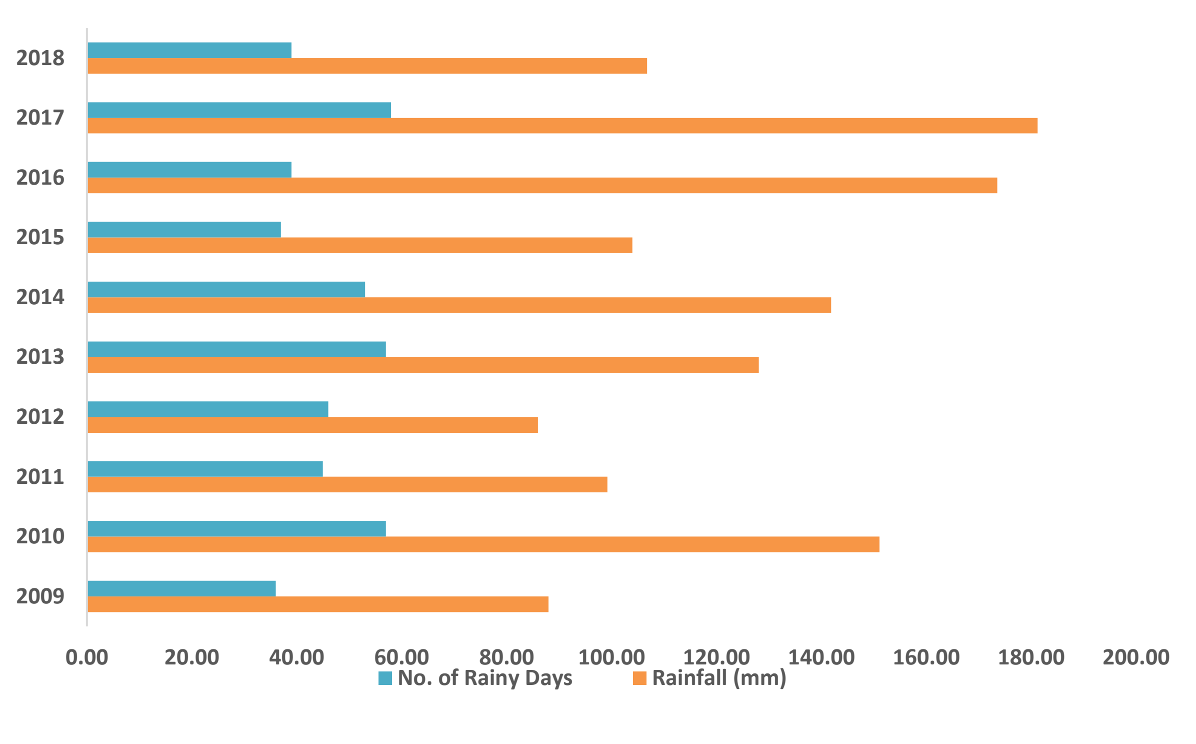


**Fig. 3 Kharif season rainfall variability (Mean) and number of rainy days for Nashik region from 2009 to 2018**

### 3.3 Impacts of climate change on crop parameters

Germination failure from 40% to 70% and poor seedling establishment due to excessive rainfall (flooding) was reported by 84% and 34% of the farmers respectively whereas germination failure (40 % to 70%) due to drought and poor seedling establishment (40% to 60%) was reported by 72% and 65% of the farmers respectively. The majority of the farmers (77%) reported reduction in crop growth from 40% to 60%. A 30% to 40% reduction in the storage quality of the onion bulb due to flooding (62% respondents) and from50% to 60% due to drought (36%respondents) was also observed. A 40% increase in the incidence of occurrence of pests and diseases due to flooding (37%respondents) and drought (20% respondents) was indicated by the farmers. Considerable reduction in crop yield was reported due flooding (40% to 50%) by 51% of the respondents whereas yield reduction from 40% to 60% owing to drought was observed (80%of the respondents) (Fig.4) .85% of the farmers reported up to 80% reduction in market price due to flooding and up to 60% reduction owing to drought (72%farmers) (Table 2). The primary cause of the crop loss worldwide is drought which is a major problem in arid and semi-arid regions. It leads to more than 50% crop loss worldwide (Siva Kumar et al., 2016). The seed germination is adversely affected by drought conditions in vegetable crops like onion and okra and sprouting of tubers in potato (Arora et al., 2010). Another important abiotic stress posing serious problem for the growth and yield of vegetable crops is flooding specially to flood sensitive (Parent et al., 2008). Onion is also sensitive to flooding and yield loss up to 30-40% is reported during bulb development. Daymond et al., (1997) reported that the duration of onion gets shortened due to high temperature leading to reduced yields. Increase in temperature above 40 ºC reduced the bulb size of onion and increase of about 3.5ºC above 38ºC reduced yield as shown by Lawande et al., (2010) in their studies.

**Table. 2. Perceived impacts of climate change by the respondents on rainfall distribution and rise in temperature and their effect on crop parameters**

| Impact | Frequency(n=300) | Percentage |
|---|---|---|
| **Changes in rainfall pattern** | 296 | 99% |
| **Crop spoilage due to excessive rainfall, flooding and drought** | 300 | 100% |
| **Germination failure due to flooding (40% to 70%)**<br>**drought (40 to 70%)** | 252<br>216 | 84%<br>72% |
| **Poor seedling establishment due to flooding (40%to 60%)**<br>**drought (40% to 60%)** | 185<br>195 | 62%<br>65% |

  

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| | | |
|---|---|---|
| **Increased occurrence of pests and diseases due to flooding (40%)**<br>**drought (40%)** | 112<br>59 | 37%<br>20% |
| **Poor crop growth due to flooding (40%to 60%)**<br>**drought (40%to 60%)** | 232<br>233 | 77%<br>77% |
| **Reduced storage quality of bulb due to flooding (30% to 40%)**<br>**drought (50% to 60%)** | 185<br>107 | 62%<br>36% |
| **Low market price due to flooding (40%to 80%)**<br>**drought (50% to 60%)** | 227<br>216 | 85%<br>72% |
| **Extreme rise in temperature**<br>**Effect on Crop Parameters:**<br>**1. Germination failure (40% to 60%)**<br>**2. Poor seedling establishment (40% to 50%)**<br>**3. Increased incidence of occurrence of pests and diseases (30 % to 60%)**<br>**4. Poor crop growth (40% to 60%)**<br>**5. Reduced storage quality of bulb (40% to 60%)**<br>**6. Decrease in crop yield (40%to 60%)**<br>**7. Economic losses (40% to 60%)** | 294<br><br>212<br>167<br>264<br>232<br>`169<br>267<br>244 | 98%<br><br>71%<br>55%<br>89%<br>77%<br>57%<br>88%<br>82% |
| **Rise in soil temperature** | 255 | 85% |
| **Loss in soil moisture** | 261 | 87% |
| **Changes in soil quality** | 298 | 99% |
| **Reduced moisture** | 164 | 55% |
| **Reduced fertility** | 81 | 27% |
| **Changes in water holding capacity** | 49 | 16% |

Along with the changes in rainfall, the extreme rise in temperature as a key parameter of climate change was perceived by 98% of the respondents. Majority of the farmers (71%) believe that extreme rises in temperatures is leading to germination failure (40% to 60%), poor seedling establishment (55%), increased incidence of occurrence of pests and diseases (89 %), poor crop growth (77%), reduced storage quality of bulb (57%), decrease in crop yield (88%), economic losses (82%) in kharif onion crop (Fig.4). These results are supported by Milius (2017) who reported that shifting weather patterns affects agriculture through changes in average temperatures, increased rainfall variability, and climate extremes (e.g. heat waves); changes in pests and diseases, fostering their spread and evolution of new strains of insect pests; fungal, bacterial and virus diseases; changes in atmospheric carbon dioxide and ground-level ozone concentrations; changes in the nutritional quality of some foods and changes in sea level (Hoffmann, 2013).
Other changes perceived by the respondents include rise in soil temperature (85% respondents) and changes in soil quality (87% respondents). The reduction in soil moisture was reported by 55% of the respondents whereas decrease in soil fertility (27%) and changes in water holding capacity (16%) was also observed (Fig.4).
The survey results showed that 81% of the farmers made use of the sources of climate forecasting to reduce production risks. The main sources of climate forecasting system employed by 51% of the respondents included local weather forecasting system. For other sources of information, 68% of the respondents rely on the government institutions and only 20% of the respondents gave credit to voluntary organizations.

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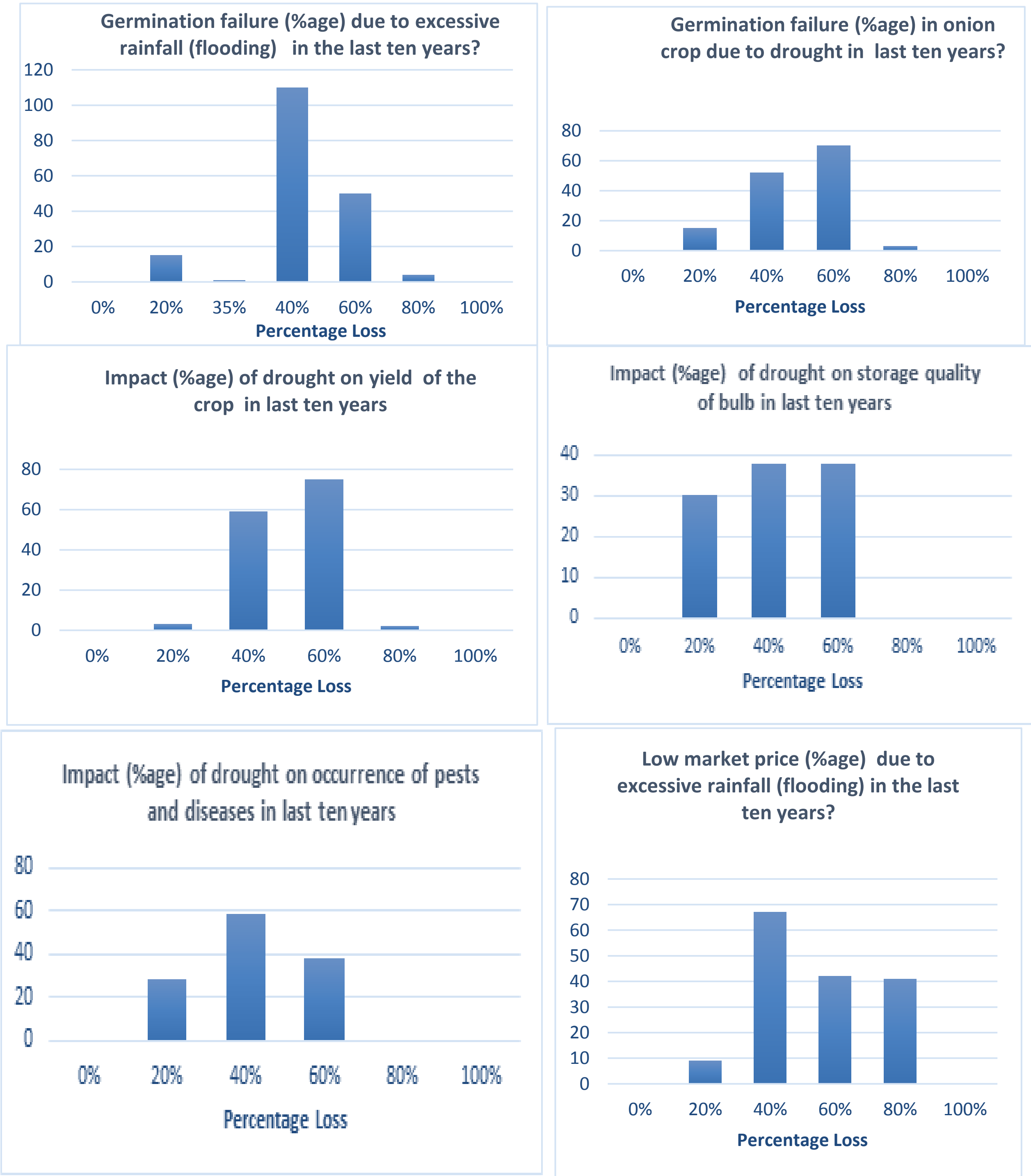
78%respondents were of the view that the government provided subsidies/loans/other facilities in case of loss of agricultural produce are not enough. Whereas absence of any training programmes by the government to improve the farmers ‘skills was also reported by 92% of the respondents.

**Fig. 4. Perceived impacts of climate change by the respondents on rainfall distribution and rise in temperature and their effect on crop parameters**



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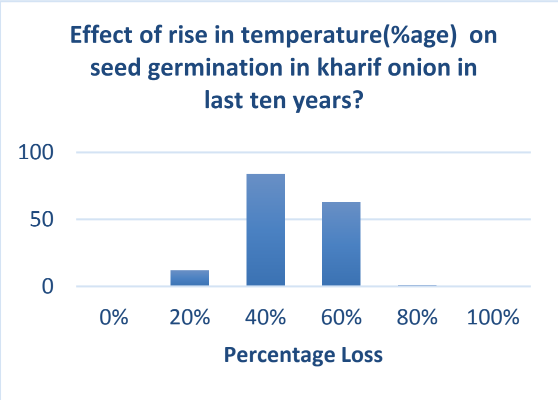


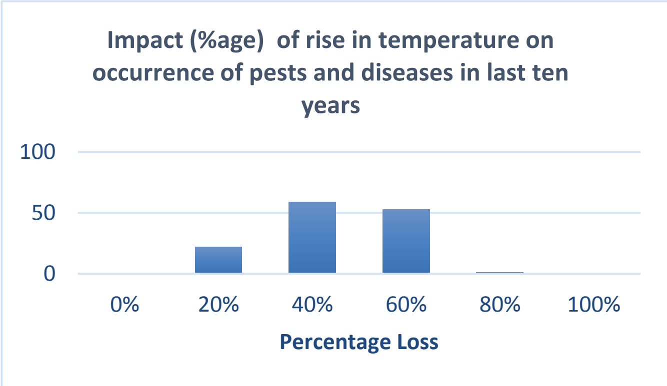


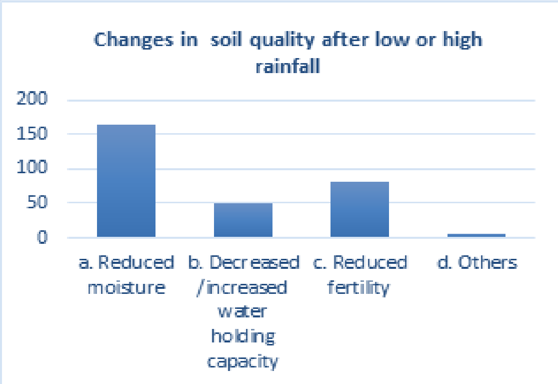


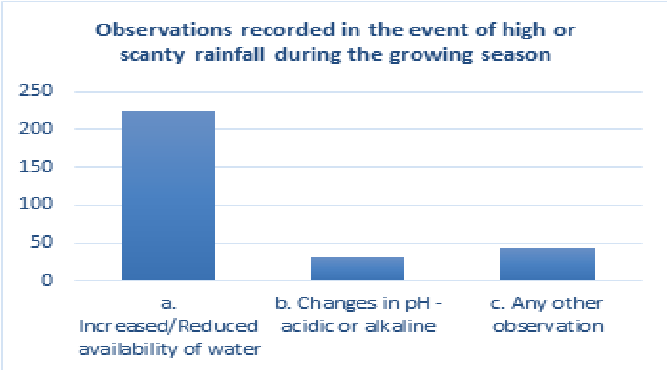


**3.3 The adaptation strategies and technology in practice by the farmersfor the mitigation of climate change impacts**

Focused discussion with selected farmers revealed the key areas of action for climate change adaptation and mitigation for onion crop. In addition to the above-mentioned impacts, the other major problems faced by the farmers as comprehended from the focused group discussions include poor yield of kharif onion due to poor sapling quality attributed to irregular rainfall pattern, changes in cropping dates, poor soil mineralization, poor nutrient availability, poor aeration and water holding capacity of the soil, high occurrence of pests and diseases besides the other reasons cited above. Majority of the farmers are unaware of the climate resilient technologies (i.e., bio- fertilizers, organic fertilizers, raised bed technology, flood and drought resistant varieties)along with poor utilization of some technologies especially raised bed during flooding, use of bio-fertilizers and organic manures for soil quality improvement, role of bio-fertilizers in pest and disease control and are not exposed to climate resilient training programmes for crop improvement under adverse climatic conditions.(Fig.5)

 

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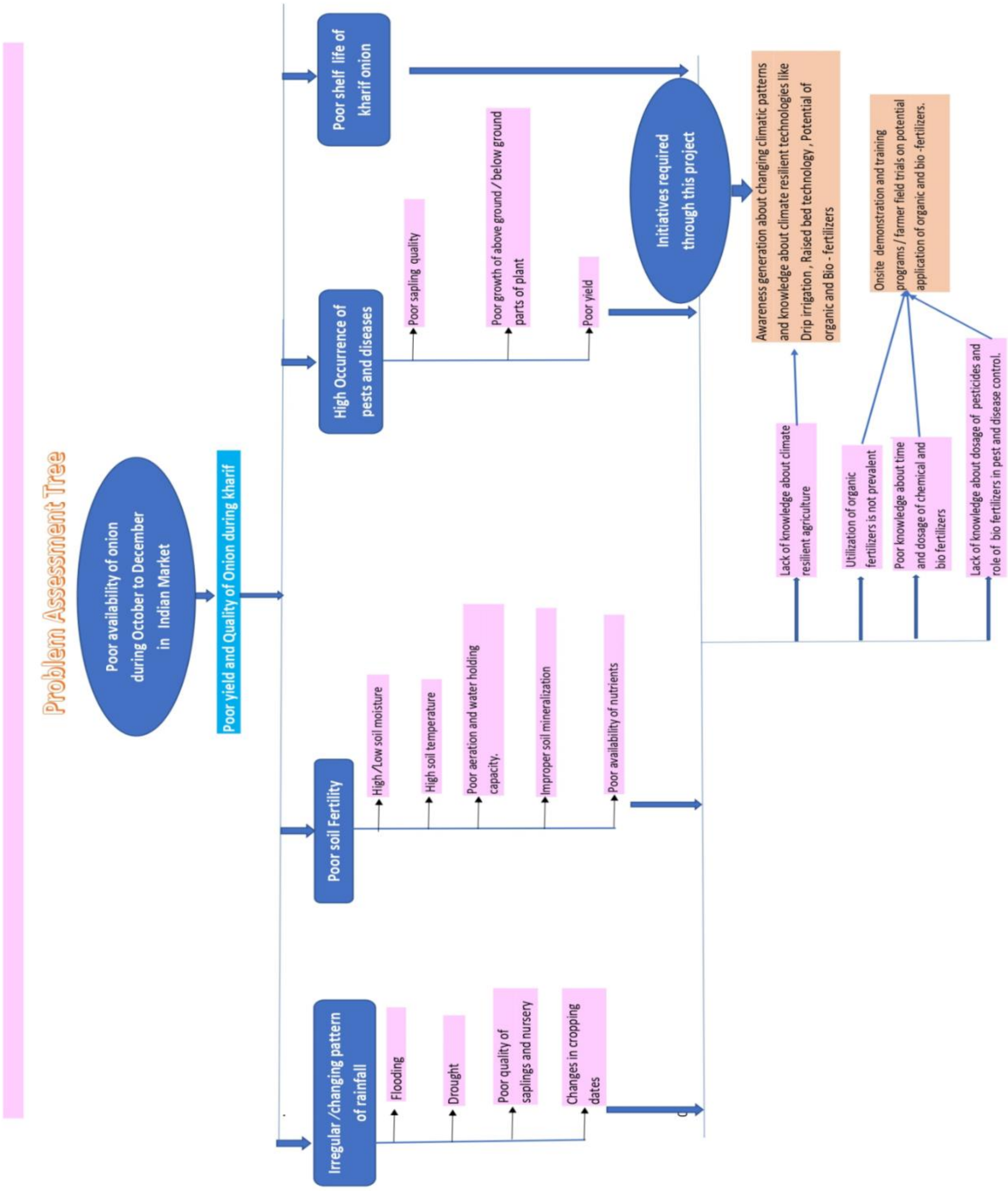


**Fig. 5. Problem Assessment Tree**

### 3.4 Technology in practice and strategies adopted by the farmers

Different strategies are in practice by the farmers of the Nashik region to adapt to changing climatic conditions and reduce the risks posed by the climatic vagaries. The process of climate change necessitates that the farmers initially perceive the climatic variability followed by the identification of the necessary adaptations that are required to be implemented (Mustapha et al. 2012). Majority of the farmers (89%) have adapted to strategies like changes in sowing dates to tide over the unfavorable weather conditions of excessive or scanty rainfall during the cropping period. In the event of less rainfall or drought, 70% of the farmers use drip irrigation as a climate resilient technology to irrigate the crops whereas others employ methods like bore well (32%) and artificial ponds by rainwater harvesting (16%). The farmer's survey indicated that 53% of the farmers adopted broad bed furrow (BBF) practice whereas 35% planted on ridges and furrows to prevent water - logging and erosion following heavy rainfall along with broadcast method being employed by majority of the farmers (75%) for fertilizer application. Changes in the cropping pattern as an adaptive strategy was also employed by 84% of the respondents. Crop rotation was followed as an alternate practice for

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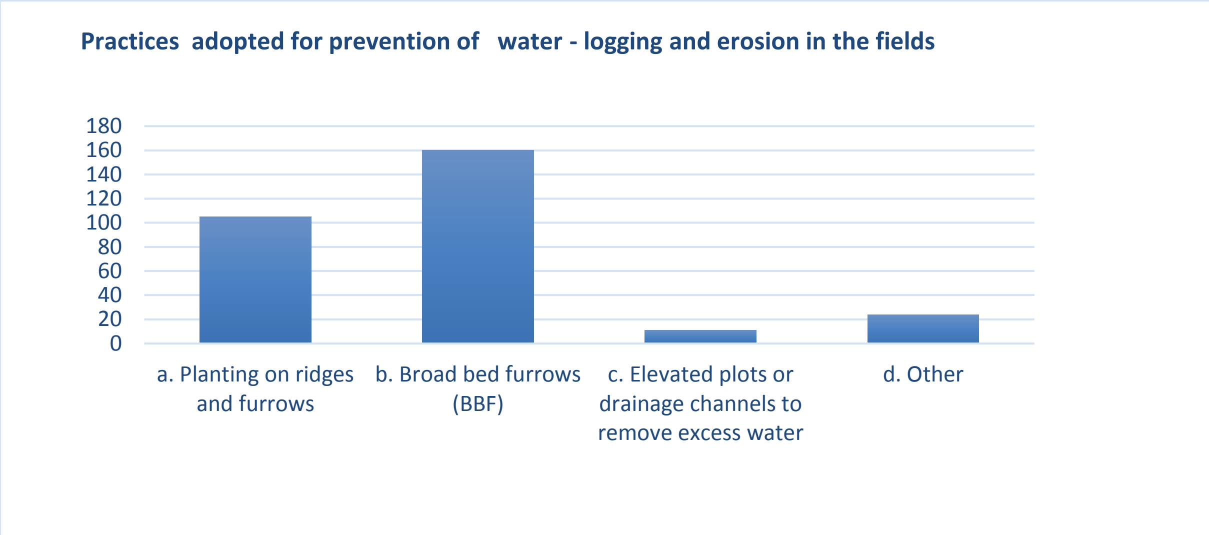
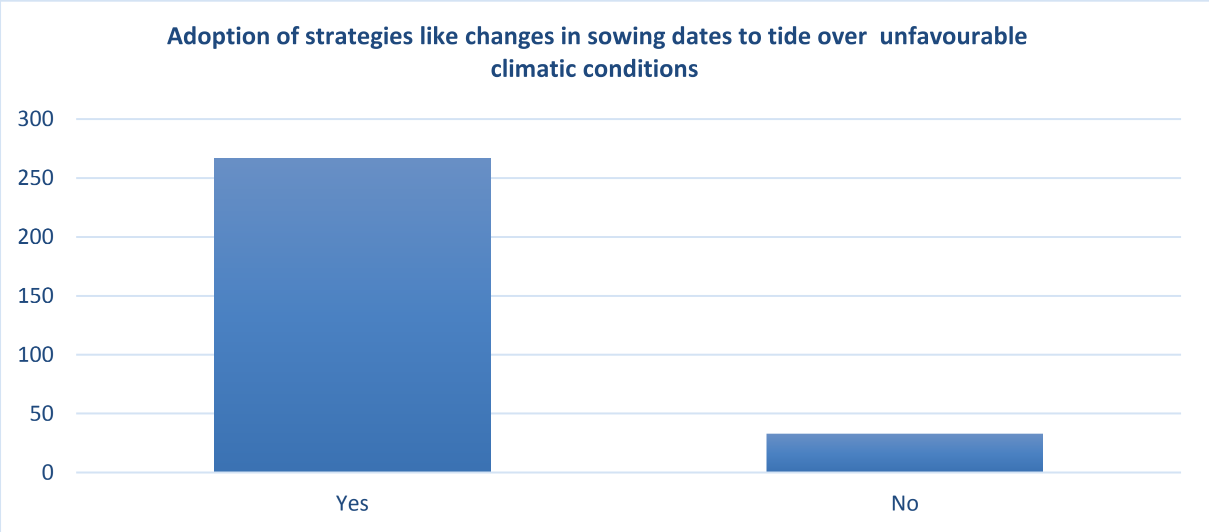
maintaining soil fertility by majority of the farmers (65%).80%of the farmers are using only nitrogen fixing bio-fertilizers whereas 88% use compost as an organic fertilizer for the improvement and maintenance of soil fertility (Fig.6) .Changing the sowing date, use of efficient technologies like drip irrigation, developing heat and salinity stress resistant cultivars , developing flood soil and moisture conservations measures, fertilizers management through fertigation, use of grafting techniques, use of plant regulators, protected cultivation, improving pest management are the effective adaptations strategies for reducing the impact of climate change (Devi etal., 2017). Gadge, et al. (2011) reported an increase in productivity of kharif grown onion planted in raised bed (20-25 tons/ha) using drip or sprinkler irrigation and micro-irrigation as per DOGR recommendation against the regular practice of planting in flat beds (10-12 tons/ha yield).

**Fig. 6. Strategies adopted by the farmers to tide over the impacts of climate change**



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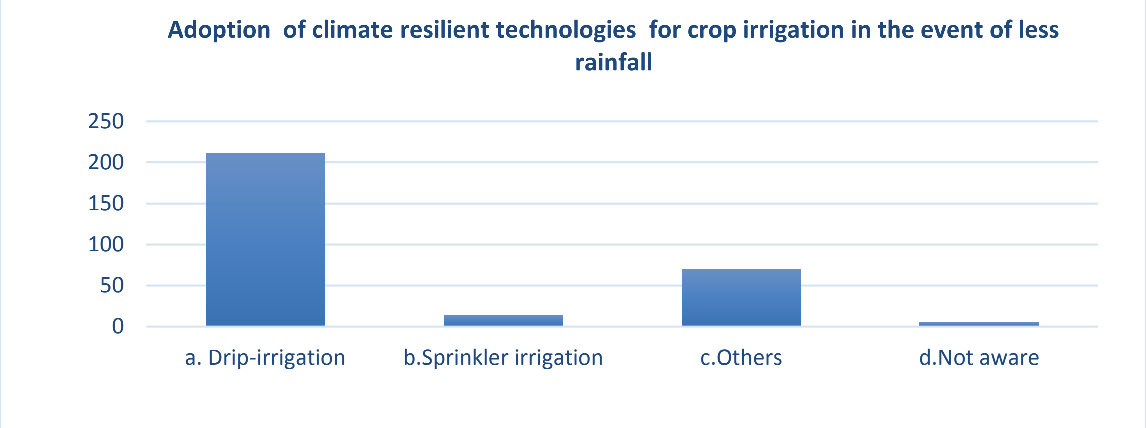
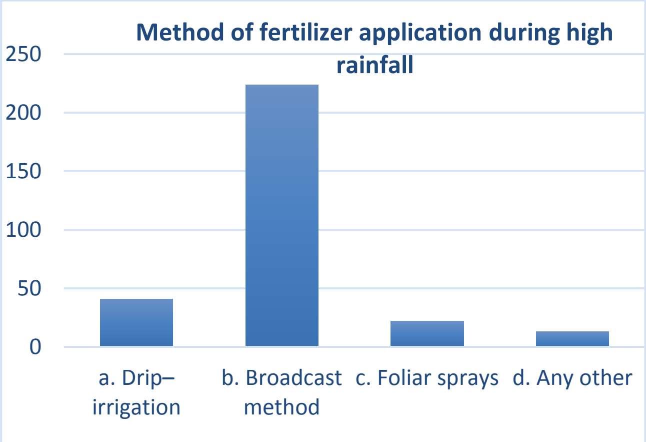
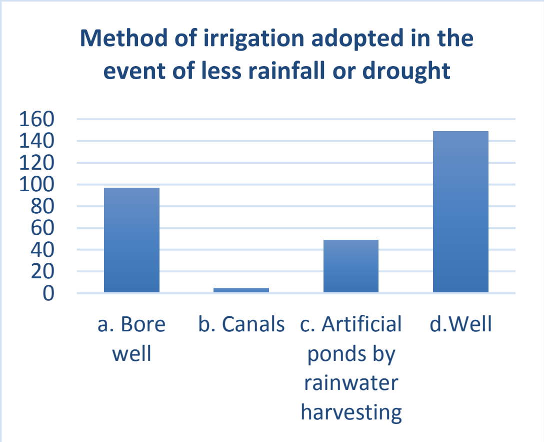
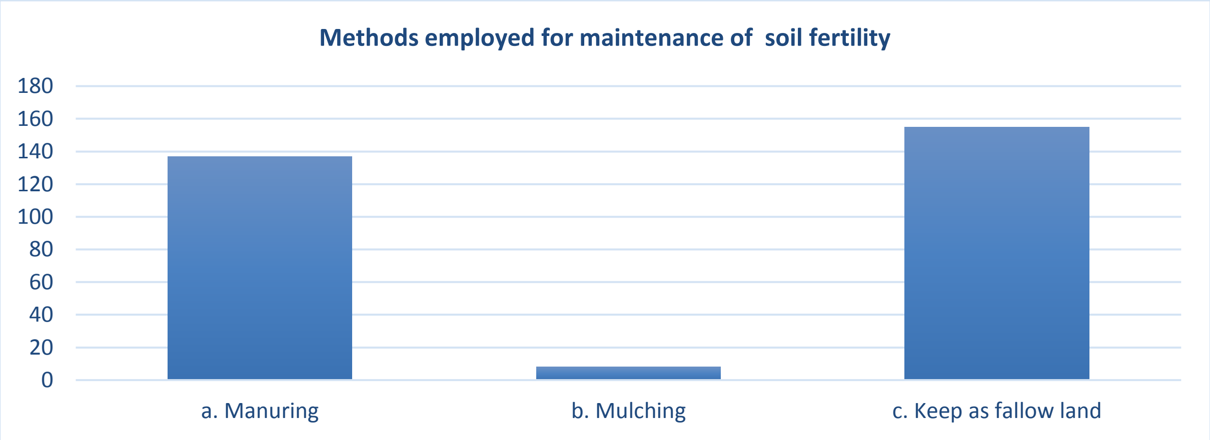
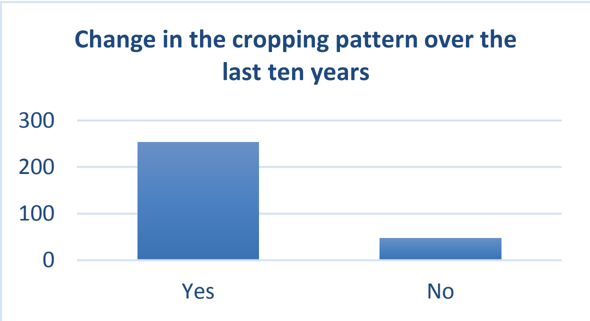


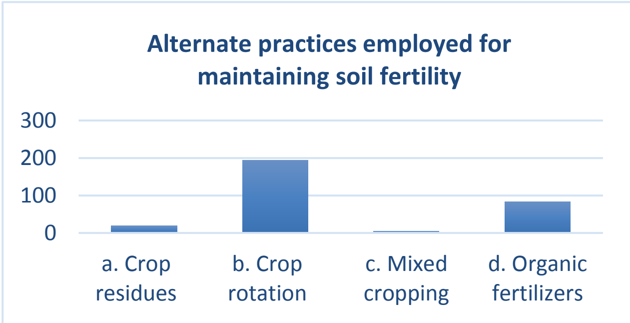



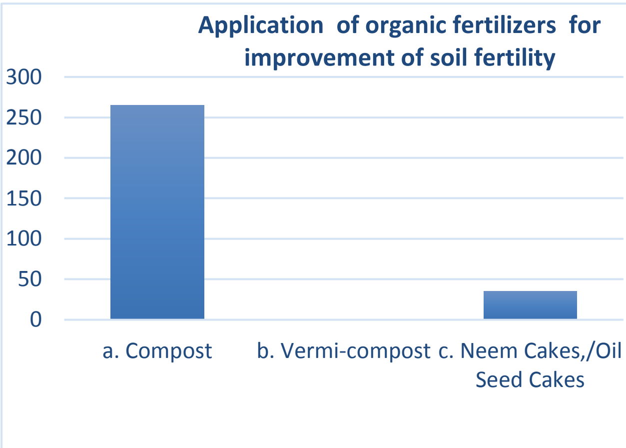



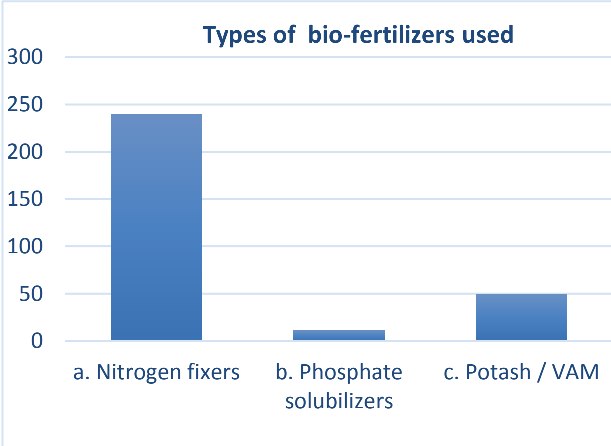



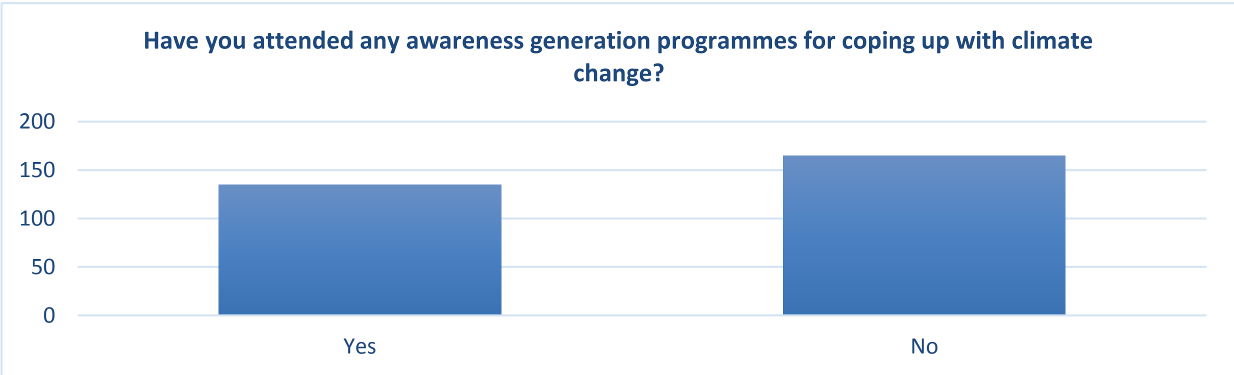
**Strategies adopted by farmers to tide over the impacts of climate change**




**3.5 Other practices employed by the farmers**

| Practices employed | Frequency | Percentage |
|---|---|---|
| Use of chemical manures for maintaining soil fertility | 250 | 83% |
| Use of organic manures | 49 | 16% |
| Use of green manures (Legumes) | 46 | 15% |
| Use of chemical products for disease & pest management practices | 297 | 99% |
| Use of beneficial micro-organisms for improving crop performance under stress conditions | 26 | 9% |
| Use of cover crop for maintaining soil fertility and soil moisture retention | 28 | 9% |
| Non usage of flood and drought resistant varieties | 0 | 100% |
| Increase in application of dosage of fertilizer and pesticides as per changing climatic conditions | 82 | 27% |
| Absence of foliar nutrition as a climate resilient technology | 205 | 68% |

From the data obtained, it was inferred that majority (83%) of the farmers used chemical manures for maintaining soil fertility and all of them used chemical products for disease & pest management practices. Only 16% of the respondents

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used organic manures whereas only 9% planted cover crop for maintaining soil fertility and for soil moisture retention Knowledge about the use of beneficial micro-organisms for improving crop performance under stress conditions was limited to only 9% of the respondents and was unaware of the flood and drought resistant varieties of onion crop. Majority (68%) did not employ foliar nutrition as a climate resilient technology and only a few (27%) made changes in the dosage of fertilizer and pesticides as per changing climatic conditions. Malhotra and Srivastava (2015) and Srivastava et al., (2014) suggested modifying the application of fertilizers for enhancing the nutrient availability and nutrient uptake by the soil and use of soil amendments to improve soil fertility.
Below are some of the adaptation Measures for Climate Change in onion crop as also suggested by Gadge, et.al., (2011).

- Shifting of sowing dates to escape periods of high or scanty rainfall. (Welbaum ,2015)
- Planting on broad bed furrow (BBF) instead of traditional flat beds to reduce losses from flooding and prevent the seedling damage from Anthracnose disease in the kharif season.
- Growing crops on raised beds for reduction of excessive build-up of soil moisture due to heavy rains (La and Huges, 2007).
- BBF planting coupled with drip irrigation to overcome drought and salinity conditions.
- Irrigation by micro-sprinklers to reduce high temperature effect on bulb development.
- Integrated pest management system control measures.
- Introduction of water saving techniques such as irrigation coupled with fertigation. Studies showed savings of 40% water, 30% labour, 30% nitrogen with yield increase of 15% by drip irrigation (NRCOG, 2003).
- Mulching with organic waste and bicolor polythene for soil moisture conservation and maintenance of soil temperature.
- Good drainage facilities in cropped field (both inside and on the border of the field).
- Improved varieties/hybrid
- Improved post-harvest infrastructure technologies

## 4. CONCLUSION

The study highlighted the impacts of the climate change as perceived by the farmers along with an insight into the various adaptation strategies and commonly employed practices by the kharif onion growing farmers of the Nashik district. Climate change is clearly perceived by the farmers with lack of access to information regarding climate resilient technologies, lack of knowledge about other adaptation options and their proper method of implementation, insufficient access to inputs and improper knowledge about timings and dosage of bio-fertilizers for increasing the resilience of onion crop to climatic vagaries among other constraints faced by them.

➢ Climate change effects are comparatively more on small and marginal farmers, particularly who are mainly dependent on vegetables (FAO, 2009). The adaptive capacity of poor farmers is limited since their education is of low level and because of subsistence agriculture. Therefore, simple, adaptation strategies which are economically viable and culturally acceptable need to be developed and implemented.

➢ There is a need to transfer the knowledge and provide access to social, economic, institutional, and technical resources and which should be integrated within the existing resources of farmers.

➢ Conduction of awareness generation programmes on new and improved climate resilient technologies for the growers and farmers, modification of present vegetable production practices and greater use of greenhouse technology are some of the solutions to minimize the effect of climate change.

➢ Conduction of training programmes to improve farmers' skills to innovate the refined agricultural technologies to fit into the socio-economy of the farms.

➢ Priority of education to various farmers for implementing the technology at the grass root levels is the need of the hour. Thus, policy issues, adaptation strategies and mitigation technologies could be worked out.

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