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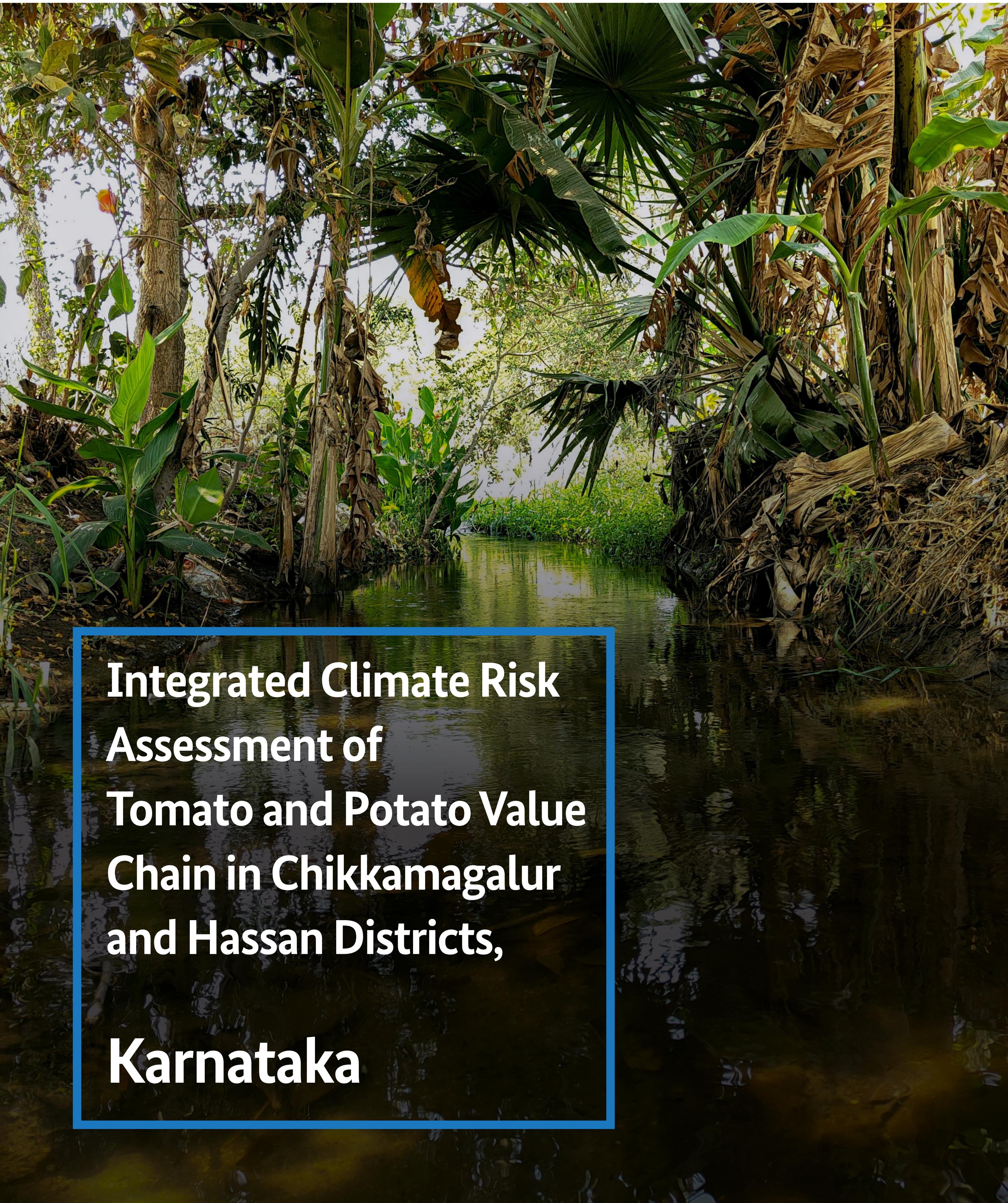

Integrated Climate Risk Assessment of Tomato and Potato Value Chain in Chikkamagalur and Hassan Districts,

Karnataka

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On behalf of the
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Bengaluru, August 2023

INTEGRATED CLIMATE RISK ASSESSMENT OF TOMATO AND POTATO VALUE CHAIN IN CHIKKAMAGALUR AND HASSAN DISTRICTS, KARNATAKA

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EXECUTIVE SUMMARY

01

Climate change has been recognised as one of the key challenges for India, with the agriculture sector being extremely vulnerable.

Smallholder farmers with high exposure to climate events are vulnerable to climate change and suffer the most due to their low resilience to such events.

Chikkamagalur and Hassan Districts in Karnataka are two potato producing clusters in the state. Potato in these Districts is primarily grown in the Kharif season under rainfed conditions. As the yield and area under cultivation have been declining over the years, farmers are forced to switch to other crops. Chikkamagalur District is also a main hub for tomato cultivation. Tomato cultivation was introduced to the district over four decades ago and is one of the commercial crops predominantly grown by small and marginal farmers with 2 acres or less per season.

The major challenges being faced by tomato growers include:

- Knowledge gaps in new and improved technologies;
- Increased incidence of leaf blight disease and Tuta pest;
- Decline of the area under production and of yields;
- High dependence on local traders;
- Highly volatile prices;
- No value addition at the farm level;
- Unseasonal and high rainfall devastating the standing crop.

The major challenges being faced by potato growers include:

- Since it is a predominantly rainfed crop, with a cropping season from May to August, it is subjected to vagaries of rainfall distribution.
- Lack modern scientific knowledge on improved technologies and mechanisation.
- Acute shortage of true potato seed tubers and they are highly dependent on suppliers from Punjab.
- *Kufri Jyothi* is the dominant variety grown for many years and there has been a very slow rate of varietal replacement.
- Increased incidence of late blight and viral diseases.
- Poor access to market information on prices and are unable to realise optimal prices due to high intermediation and cartel formation by local traders.
- Volatile prices and inadequate advisory on prices that affects the income of the farmers.
- No value addition at the farm-level.

Climate change trend

Besides the above agro-economic factors, tomato and potato crops are highly sensitive to climate change, which makes tomato growers vulnerable to climate change risks. Temperature and precipitation are two major climate perils affecting the sustainable production. Climate change analysis of past trends in temperature and precipitation for the period from 1979 to 2022 indicates that these districts:

- Are getting warmer due to climate change.
- Are getting wetter due to climate change.
- Face high temperatures and delayed monsoon during the planting season from June to August.
- Experience high intensity of rainfall during short periods from May to August/Sept, affecting tomato production.

Climate hazards:

Major climate risks for production are temperature, both high (>28°C) and low (<18°C); high and low rainfall; high and low relative humidity (RH); and high wind velocity. These climate risks directly affect crop productivity due to excess moisture or drought conditions and increased incidence of devastating diseases like late blight.

Risk exposure and tolerance:

An assessment of the tolerance capacity and availability of coping options suggest that high temperature, high rainfall, and low rainfall under the category of intolerable risks; low temperature, high RH and wind velocity fall under the category of tolerable risks; and low temperature and low RH fall under the category of acceptable risks.

The exposure to climate risk is aggravated due to poor extension services, inadequate finance, lack of access to the weather forecast, and high volatility of tomato prices.

Coping strategies:

Agronomic Practices:

The suggested coping actions are more in the form of changing agronomic practices. Adoption of agronomic practices entails an incremental expenditure of about INR ₹5000/- to INR ₹10,000/- per acre depending on the extent of vulnerability and exposure to individual growers. They may include:

Tomato

- Application of organic manure
- Cultivation of blight-resistant varieties
- Adoption of the right density of plant population
- Use of grafted seedlings
- Drip irrigation and mulching
- Pruning of leaves on the lower portion of the stems
- Foliar application of micronutrients.

Potato

- Replacement with suitable varieties resistant to late blight disease, which is virulent under favourable climate risks like high temperature, prolonged rains, high RH, and high wind speed.
- Enabling growers to commercially produce quality seed potatoes (tubers) locally through apical rooted cuttings.
- Popularising mechanical planters and boom sprayers.
- Improve drainage, soil moisture conservation, and better disease management – especially that of late blight, which is the most devastating disease and is directly correlated with rainfall patterns.

Extension support services and weather advisories:

The coping capacity of the community needs intervention and handholding support from various extension service providers such as the Department of Horticulture (DoH) in Chikkamagalur and Hassan, KVK Mudigere, the Centre of Excellence for Vegetables in Somanahallikaval and the Indian Institute of Horticulture Research (IIHR) in Bangalore and International Centre for Potato (CIP), Bangalore. These institutions can provide an efficient interface between policymakers and the farming community if adequate weather information is provided to them.

Weather advisories:

The farmer needs access to real-time weather forecasts and advisories. Therefore, it is important to strengthen the capacity of agrometeorological stations to provide customised forecasting products, undertake data management and modelling for climate impact assessment, and application of climate information at the farm level to strengthen decision-support systems.

Market access:

Enabling factors require the improved ability of farmers to discover and realise the current and future prices. Availability of storage facilities for tomato may provide better price realisation and collective marketing.

Formation of farmer collectives:

Formation and strengthening of communities through farmers' collectives like Farmer Interest Groups (FIGs) and Farmer Producer Organisation (FPOs) will promote their ability to respond to climate events and their impacts. Collectives are also required to access market, finance, and other inputs.

Source of finance:

The engagement of private enterprises, corporates, banks, and value chain participants can be leveraged to support most of the strategies. State Government support can be availed for Integrated Pest Management, vegetable sprays, drip irrigation and mulching, weather forecasts, and market interventions.

Plan of action for tomato and potato production:

Based on the above observations and findings of the study, the following implementation plan, with priorities, timelines, and funds indicators are proposed:

Stage	Priority	Timeline	Sources of funding
A. Planting Stage			
Application of organic manure	High	From the start of the project	Farmer's contribution
Cultivating blight-resistant varieties	High	From the start of the project	Farmer's contribution
Planting density (maintain not more than 5000-6000 plants/acre)	Medium	1-2 years from the start date	Farmer's contribution
Use of grafted seedlings on Arka Neelakant Brinjal Variety as a rootstock	Medium	2-3 years from the start date	State Government to provide 50% subsidy, balance is borne by the farmer
Drip irrigation and plastic mulching under irrigated conditions	High	From the start of the project	Farmer can avail a subsidy from the DoH; balance is borne by the farmer
Organic mulching under rainfed cultivation	Medium	From the start of the project	Farmer's contribution
Weather forecasting	Medium	From start of the project	DoH to fund 100% of the activity
B. Crop growth and Production stage			
Prophylactic spraying of plant protection chemicals to manage pests and diseases	High	From the start of the project	Farmer's contribution
Foliar spray of specials during the monsoon period	Medium	From the start of the project	Farmer's contribution; DoH provides subsidies under MIDH
Integrated Pest Management of Tuta Absoluta	Medium	From the start of the project	Farmer's contribution
Rhizobacteria application in summer	High	From the start of the project	Farmer's contribution; DoH provides eligible subsidies under MIDH
Pruning of leaves on the lower portion of the stem	High	From the start of the project	Farmer's contribution
Prophylactic spraying of plant protection chemicals to manage pests and diseases	High	From the start of the project	Farmer's contribution

Plan of action for tomato production

Stage	Priority	Timeline	Sources of funding
A. Planting Stage			
Land preparation: deep ploughing	High	From the start of the project	Farmers' contribution
Application of organic manure	High	From the start of the project	State Government to provide 50% subsidy; remainder is borne by the farmer
Replacing the Kufri Jyothi variety with Kufri Himalini	Medium	2-3 years from the start date	State Government to provide 50% subsidy; remainder is borne by the farmer
Usage of whole small seed tubers instead of cutting tubers and seed treatment	Medium	1-2 years from the start date	Farmers' contribution
Usage of Apical Rooted Cuttings (ARC) and further own-seed multi-plication by the farmers	Medium	Pilots from the start of the project, and commercial application in 2-3 years	State Government to provide 50% subsidy; remainder is borne by the farmer
Use of mechanical potato planter	High	From the start of the project	The State Government funds custom hiring centres through FPOs with a 75% subsidy; FPOs may fund the balance remaining and hiring charges are to be borne by the farmer
Drip Irrigation and plastic mulching under irrigated conditions	Medium	From the start of the project	Farmers can avail of up to 90% subsidy from the DoH; remainder borne by the farmers
Organic mulching under rainfed cultivation	Medium	From the start of the project	Farmers' own contribution
Weather forecasting	High	From the start of the project	DoH to fund 100% of the activity
B. Crop growth and production stage			
Prophylactic spraying of plant protection chemicals to manage pests and diseases	High	From the start of the project	Farmers' own contribution
Foliar spray of micronutrients and vegetable specials	Medium	From the start of the project	Farmers' contribution. Department of Horticulture provides a subsidy of INR ₹1000/acre
Earthing up during tuber formation and growth stage	Medium	From the start of the project	Farmers' own contribution

Crop insurance	High	From the start of the project	State Government to subsidise the 50% risk premium
C. Harvesting, post-harvesting management, storage and marketing			
Harvesting stage	High	From the start of the project	Non-monetary action
Curing of tubers after harvesting	High	From the start of the project	Non-monetary action
Storage and Marketing	Medium	From the start of the project	Farmers to meet the storage rentals

BACKGROUND

02

Chikkamagalur and Hassan Districts in Karnataka are two potato producing clusters in the state. Potato in these Districts is primarily grown in the *Kharif* season under rainfed conditions.

As the yield and area under cultivation have been declining over the years, farmers are forced to switch to other crops. Potato cultivation was introduced to Hassan over five decades ago and is one of the commercial crops predominantly grown by small and marginal farmers having one to two acres of land. Chikkamagalur District is also a main hub for tomato cultivation. Tomato cultivation was introduced to the district over four decades ago and is one of the commercial crops predominantly grown by small and marginal farmers with 2 acres or less per season The production technology in terms of varieties and agronomic practice have changed drastically over the last 15 to 20 years.

Temperature and precipitation are two major climate perils affecting the sustainable production of tomatoes and potatoes Climate change analysis of past trends in temperature and precipitation for the period from 1979 to 2022 indicates that both districts faces high temperatures and delayed monsoon during the planting season from June to August and experiences high rainfall during the period from May to August/ Sept, affecting tomato production. Tomato crop is highly sensitive to climate change, which makes tomato growers vulnerable to climate change risks. These climate risks also directly affect potato crop productivity due to excess moisture or drought conditions and increased incidence of devastating diseases like late blight.

Smallholder farmers with high exposure to climate events are vulnerable to climate change and suffer the most due to their low resilience to such events. Adaptation options must be de-veloped for these farmers in the face of the increasing intensity, frequency, and variety of cli-mate risks. This will require consideration of agriculture value chains, their vulnerabilities, and their adaptation potentials. These adaptation options build sustainable resilience by creating assets and institutional linkages for farmers.

The aim of this document is to provide a comprehensive climate risk assessment and specific recommendations for managing both the current and future risks of the potato value chain in the Chikkamagalur and Hassan Districts in Karnataka and future risks of the tomato value chain in Chikkamagalur District. It is based on the Climate Risk Management (CRM) Framework developed by developed by GIZ projects 'Global Programme on Risk Assessment and Management for Adaptation to Climate Change' and 'Climate Change Adaptation in Rural Areas of India', commissioned by German Federal Ministry for Economic Cooperation and Development (BMZ), in collaboration with KPMG India and IIASA, and published by National Institute of Disaster Management, and and is an outcome of the desk review and the field survey conducted on climate hazards (nature, frequency, intensity, risk and magnitude) vis-à-vis resilience capacity (sensitivity) of tomato and potato value chain participants to determine their relative vulnerability to climate change.

Climate trend projections are based on the Bangalore Climate Change Initiative – Karnataka (2011) which is based on Karnataka's climate trends and made projections, in most cases based on a coupled atmosphere-ocean general circulation model known as HadCM3 and further downscaled using regional climate model PRECIS.

Under GIZ India, this is supported by the Indo-German development cooperation projects 'Green Innovation Centres for the Agriculture and Food Sector - India (GIC India)', 'Climate Adaptation and Finance in Rural India (CAFRI).' GIC India is part of a larger global programme under the Special Initiative "Transformation of Agricultural and Food Systems" by the German Federal Ministry for Economic Cooperation and Development (BMZ).

CLIMATE CHANGE

03

3.1 Temperature and rainfall in Chikkamagalur District

Past (long-term) trends in temperature and precipitation

Climate change analysis of past trends in temperature and precipitation for the period from 1979 to 2022 (source: meteoblue.com) in Chikkamagalur District is shown below:

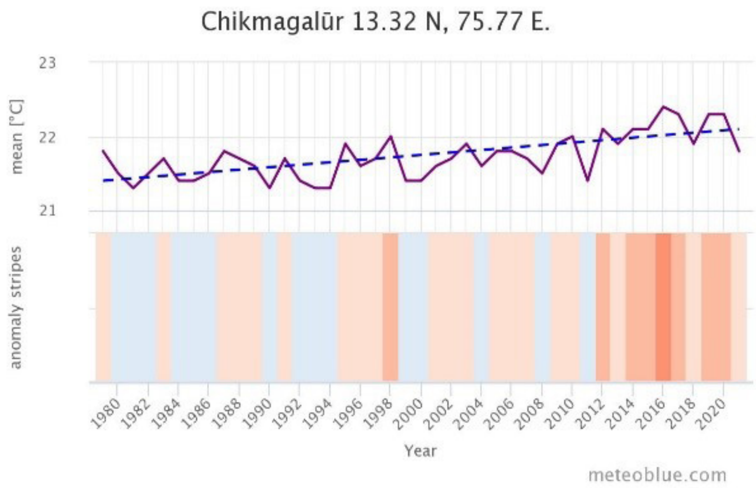

Figure 1: Mean yearly temperature trend

Figure 1 shows a continuous increase in the mean annual temperature for the larger region of Chikkamagalur. Chikkamagalur District is getting warmer due to climate change. In the lower part, the graph shows the so-called warming stripes. Each coloured stripe represents the average temperature for a year - blue for colder and red for warmer years. It is clear that in the last two decades, the warmer periods have grown longer.

According to the SAPCC, during the period from 1901 to 2008, there has been an increasing trend in the amount of precipitation received by the district. The distribution trend of monsoon was 5% during the pre-monsoon rainfall (January – May), 88% during the southwest monsoon (June – September), and 7% during the northeast monsoon (October – December).

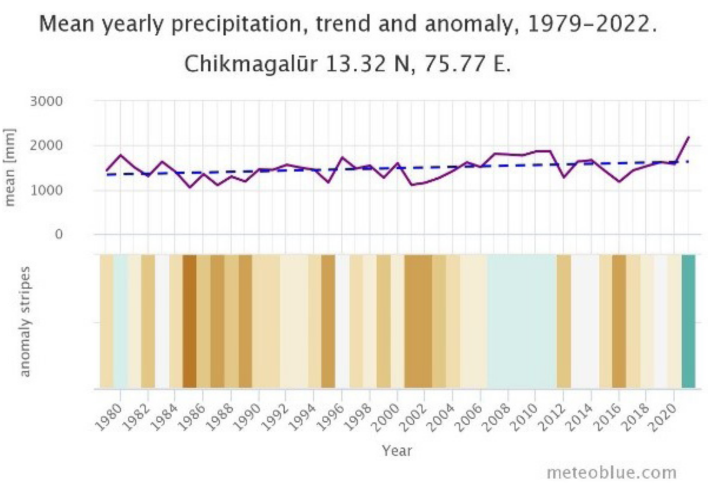

Figure 2: Mean yearly precipitation trend

The graph in Figure 2 shows an estimate of the mean total precipitation for the larger region of Chikkamagalur. The blue dashed line is the linear climate change trend. The trend line is going up from left to right, indicating that the precipitation trend is positive, and it is getting wetter in Chikkamagalur due to climate change. In the lower part, the graph shows the so-called precipitation stripes. Each coloured stripe represents the total precipitation of a year - green for wetter and brown for drier years. The intensity of precipitation is increasing over the years.

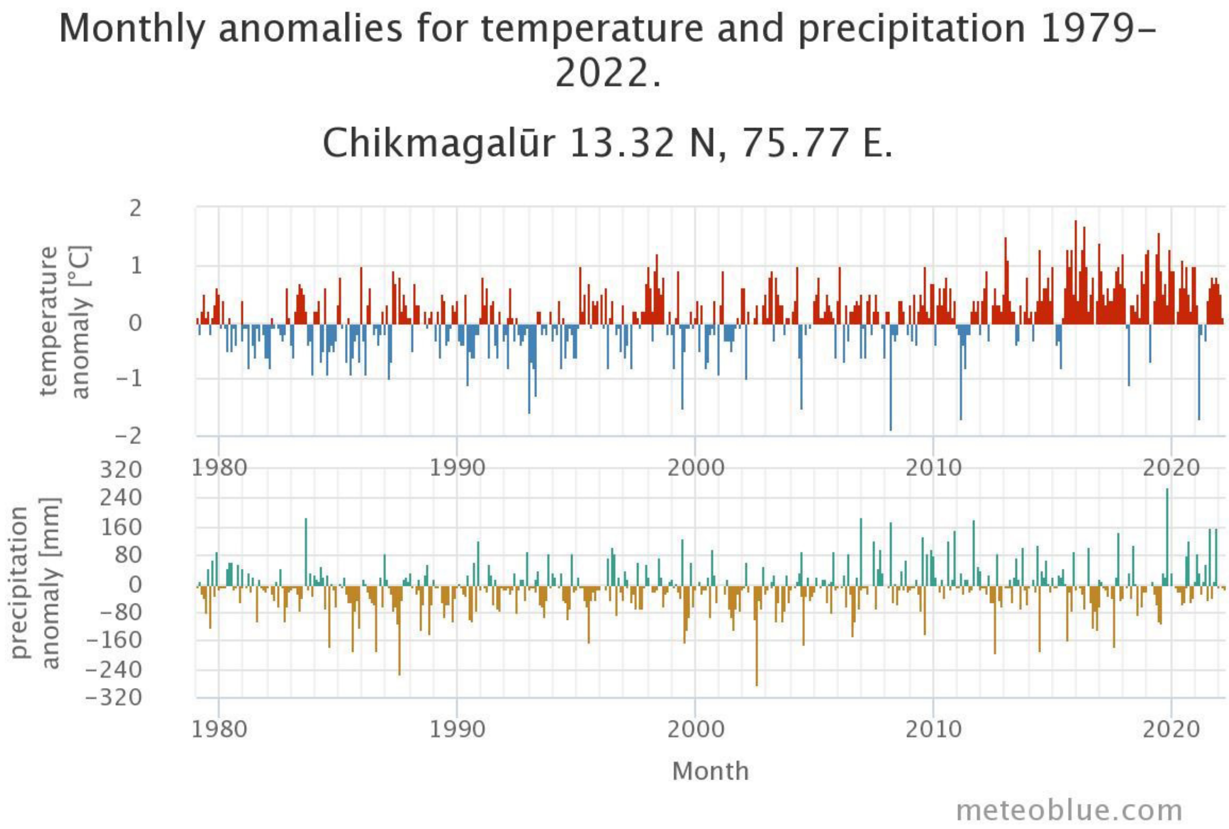

Figure 3: Monthly anomalies of temperature and precipitation

The first graph in Figure 3 shows the temperature and precipitation anomaly for every month from 1979 upto 2022 and illustrates the frequency of months warmer or colder than the 30-year climate mean of 1980-2010. Thus, red months were warmer and blue months were colder than normal. The number of warmer months has increased substantially over the years, reflecting the global warming associated with climate change.

The second graph in Figure 3 shows the precipitation anomaly for every month from 1979 upto 2022. The anomaly shows whether a month had more or less precipitation than the 30-year climate mean of 1980-2010. Thus, green months were wetter and brown months were drier than normal.

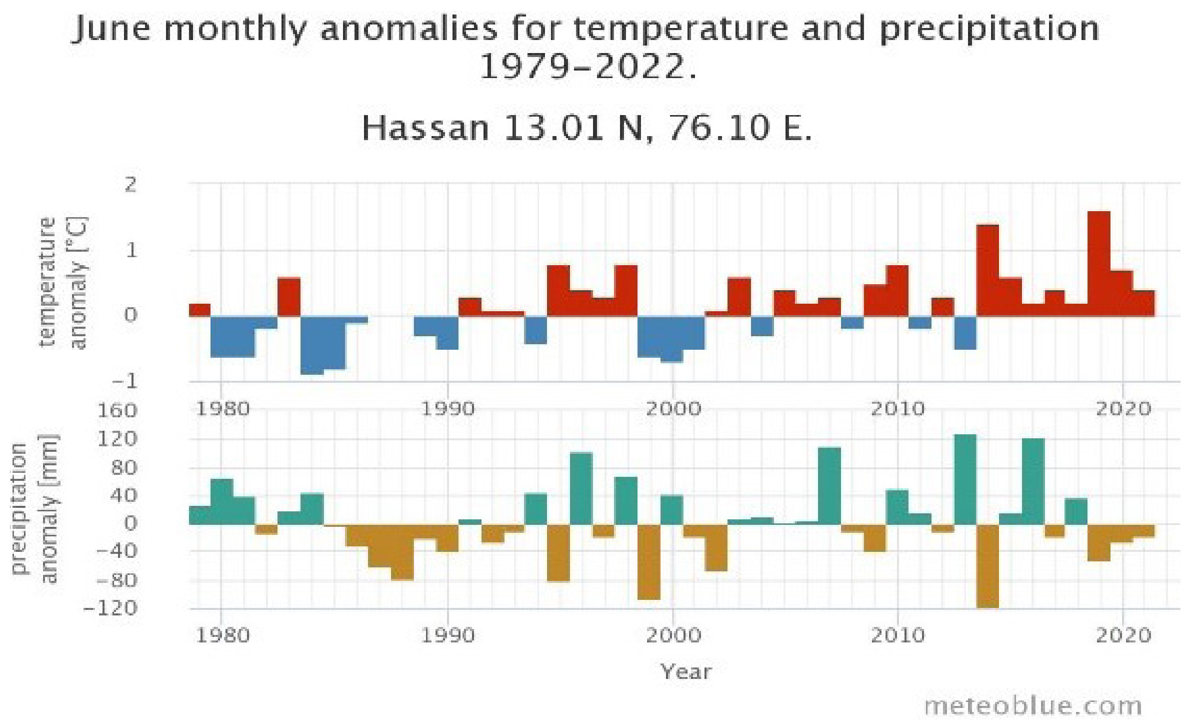

Figure 4: Past temperature and precipitation anomalies in June

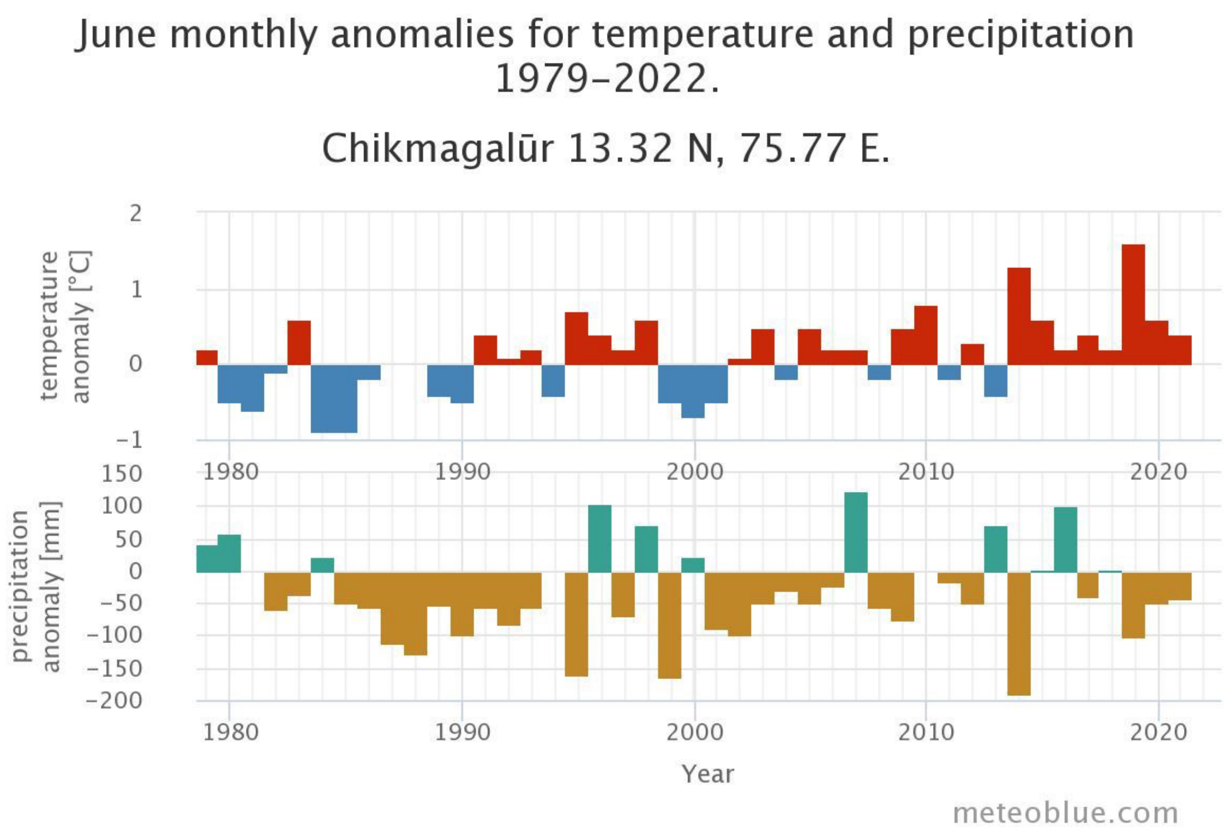

Figure 5: Past temperature and precipitation anomalies in July

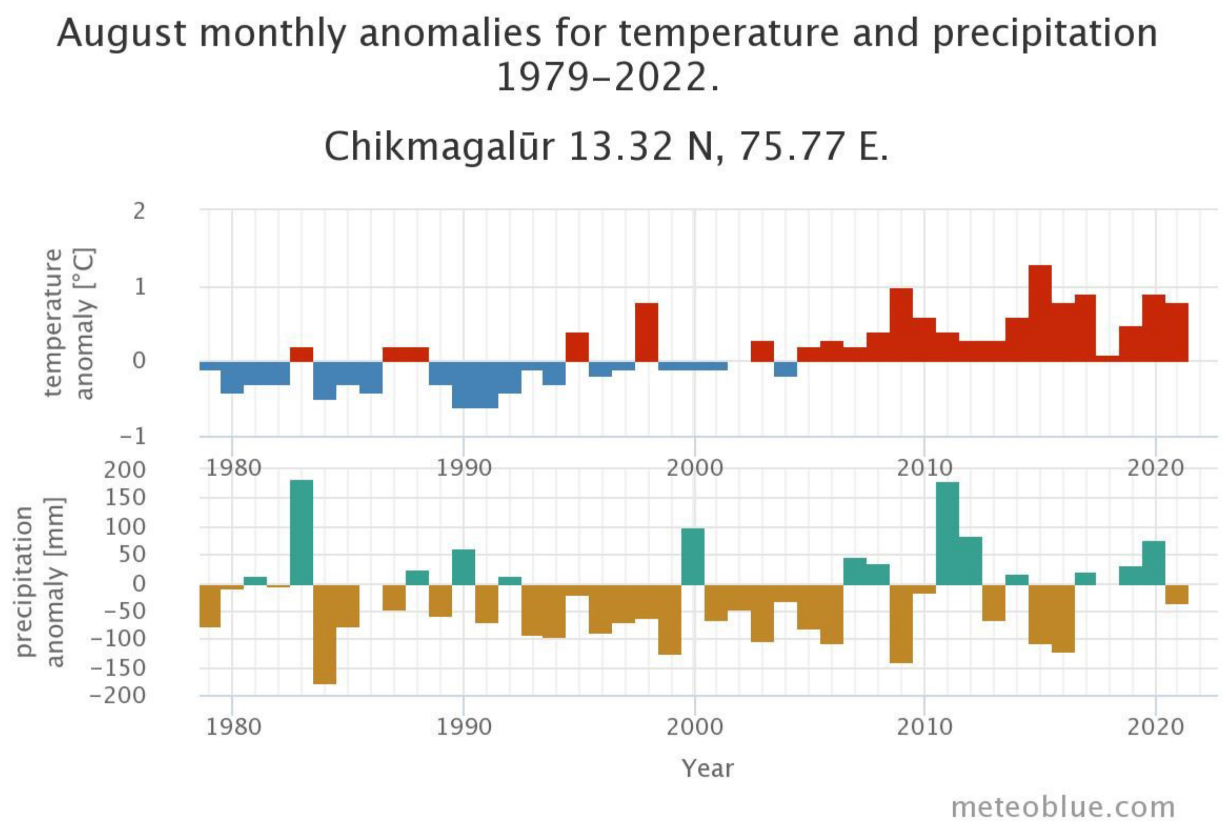

Figure 6: Past temperature and precipitation anomalies in August

The graphs above depict temperature and precipitation anomalies during June, July and August, spanning the tomato-growing season. They show a general increase in temperature and precipitation during these three months over the years.

3.2 Extreme weather events in Chikkamagalur District

As per the District Disaster Management Plan, 2019-20, by the Chikkamagalur District Disaster Management Cell, the month-wise highest and lowest temperature recorded, and month-wise average rainfall recorded in the Chikkamagalur District are given in Table 3.

Sl. no.	Month	Average Rainfall (mm)	Minimum Temp(° C)	Maximum Rainfall (mm)
1	January	0.22	8.0	35.1
2	February	3.65	6.6	37.9
3	March	35.12	9.4	39.0
4	April	66.62	15.6	40.6
5	May	247.98	16.7	39.4

Sl. no.	Month	Average Rainfall (mm)	Minimum Temp(° C)	Maximum Rainfall (mm)
6	June	492.76	16	34.8
7	July	631.52	16.8	33.6
8	August	543.00	17	30.9
9	September	111.08	13.2	36.2
10	October	115.55	9.1	35.7
11	November	27.31	8.30	35.5
12	December	9.54	8.00	37.6

Table 3: Extreme temperature and precipitation in Chikkamagalur District (2008-18)

High rainfall during the period from May to August/September affects tomato production.

The Bangalore Climate Change Initiative – Karnataka (2011) studied Karnataka's climate trends and made projections, in most cases based on a coupled atmosphere-ocean general circulation model known as HadCM3[2] and further downscaled using the regional climate model PRECIS.

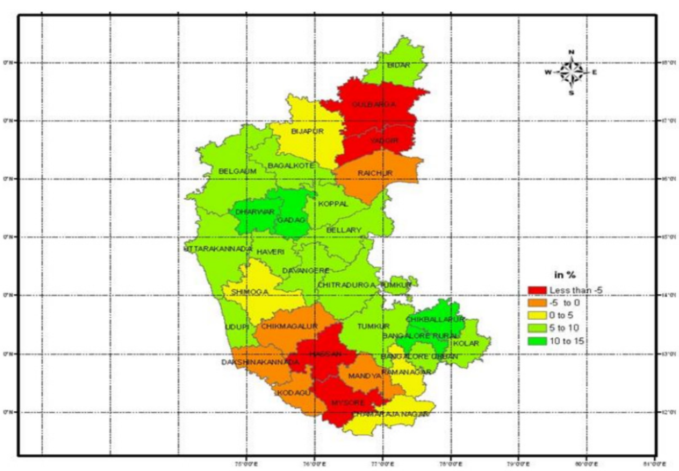

Figure 7: Projected change in annual rainfall (2021-50 – A1B)

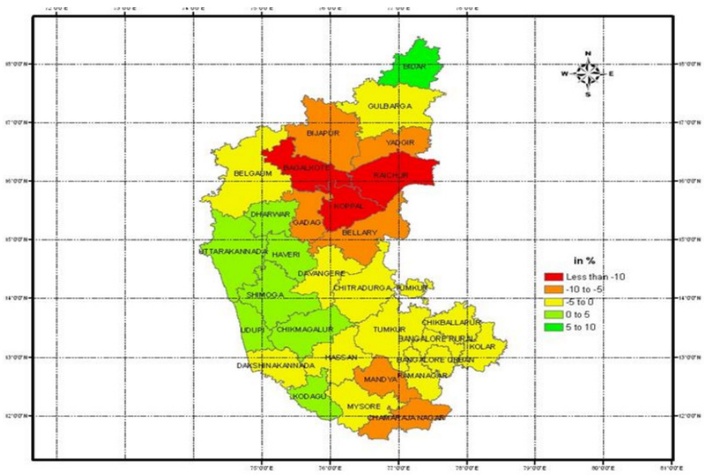

Figure 8: Projected change in June, July, August, and September rainfall for the period 2021-50 (A1B)

The projected change in annual rainfall for 2021–50 (A1B), compared to the baseline of 1961-90 is a 3.62% increase. However, the month-wise distribution of the projected change in mean annual rainfall in Chikkamagalur District is -44.13% (January – February), 2.86% (March – May), 0.14% (June – September), and 11.63% (October – December). According to the SAPCC (BCCI-K, 2011), during the period 2021-50, the projected change in average

2 Hadley Centre Coupled Model, Version 3 developed by the Hadley Centre, Met Office, United Kingdom

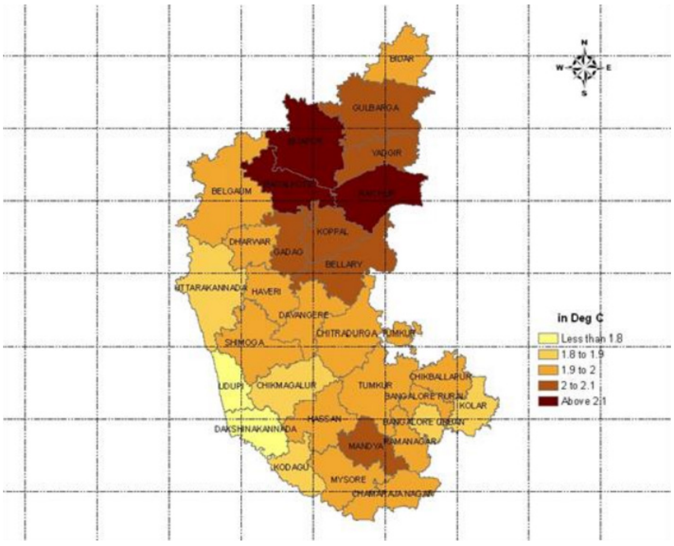

Figure 9: Projected increase in annual minimum tem-perature for 2021-50 compared to 1975 (A1B)

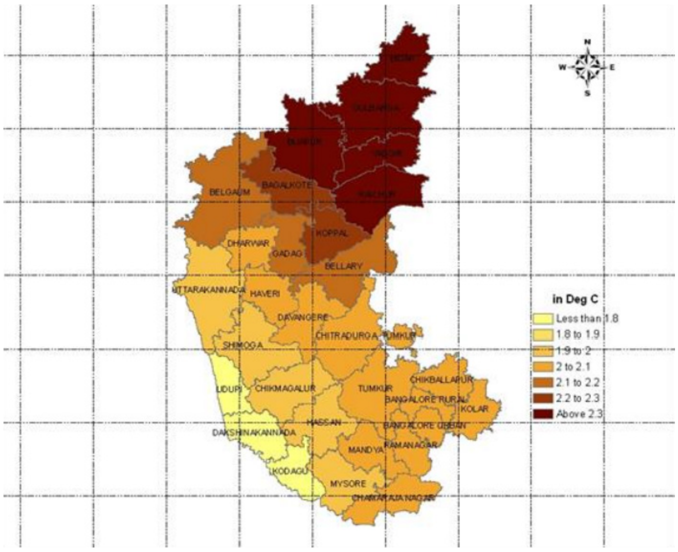

Figure 10: Projected increase in annual maximum temperature for 2021-50 compared to 1975 (A1B)

temperature in Chikkamagalur District is 1.98 ° C, whereas the projected change in the minimum and maximum temperature are 2.06 ° fC and 1.91 ° C respectively.

Farmers report a decline in area due to crop failure, glut in production, and climate change. Prolonged rains and high rainfall are major perils affecting production in Kadur.

3.3 Temperature and precipitation in Hassan District

Climate change analysis of past trends in temperature and precipitation for the period from 1979 to 2022 (source: meteoblue.com) in the Hassan district is shown below:

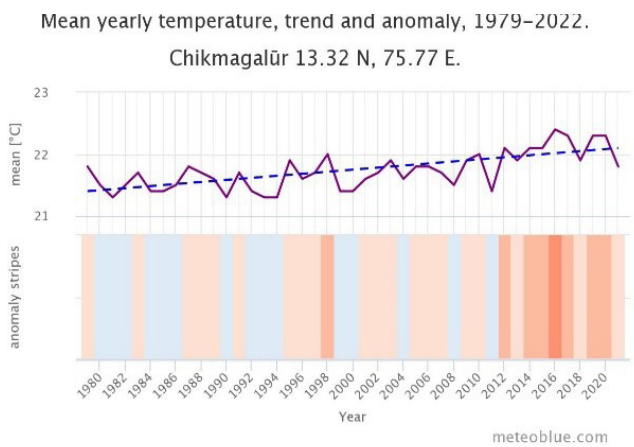

Figure 1: Mean yearly temperature trend

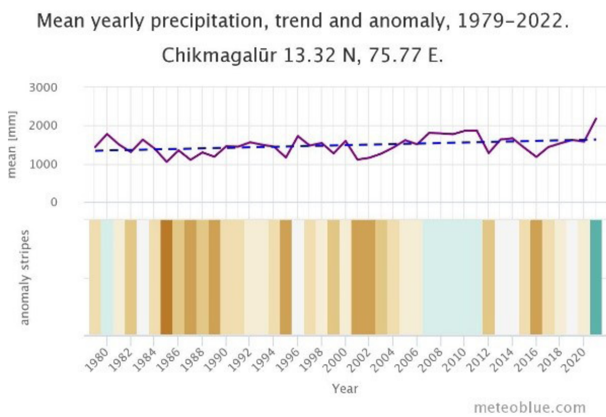

Figure 2: Mean yearly precipitation trend

Figure 2 shows a continuous increase of the mean annual temperature for the larger region of Hassan; the district is getting warmer due to climate change. In the lower part, the graph shows the so-called warming stripes. Each coloured stripe represents the average temperature for a year - blue for colder and red for warmer years. It is clear that in last two decades, the warmer periods have been growing extended.

According to the SAPCC, during 1901-2008, there has been an increasing trend in the amount of precipitation received by the district. The distribution trend of monsoon was 7% during the pre-monsoon rainfall (Jan – May), 76% during the southwest monsoon (June – September), and 15% during the northeast monsoon (October – December).

The graph in Figure 2 shows an estimate of the mean total precipitation for the larger region of Hassan. The dashed blue line is the linear climate change trend. The trend line is going up from left to right, meaning that the precipitation trend is positive and it is getting wetter in Hassan due to climate change. In the lower part, the graph shows the precipitation stripes. Each coloured stripe represents the total precipitation of a year - green for wetter and brown for drier years. The intensity of precipitation is increasing over the years.

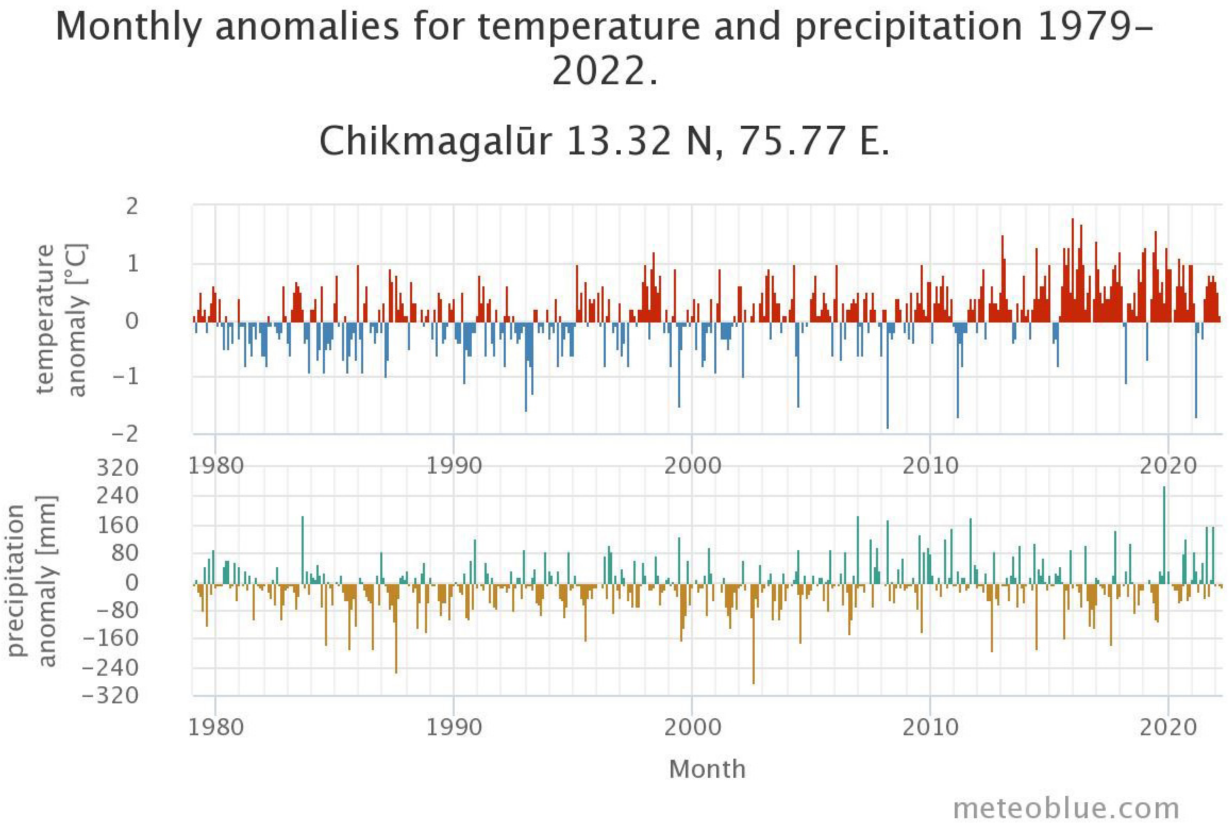

Figure 3: Monthly anomalies of temperature and precipitation

The first graph in Figure 3 shows the temperature anomaly for every month from 1979 up to 2022 and illustrates the frequency of months warmer or colder than the 30-year climate mean of 1980-2010. Thus, red months were warmer and blue months were colder than normal. The number of warmer months has increased substantially over the years, reflecting the global warming associated with climate change.

The second graph in Figure 3 shows the precipitation anomaly for every month from 1979 up to 2022. The anomaly tells if a month had more or less precipitation than the 30-year climate mean of 1980-2010. Thus, green months were wetter and brown months were drier than normal.

Temperature and precipitation anomalies in the potato-growing season

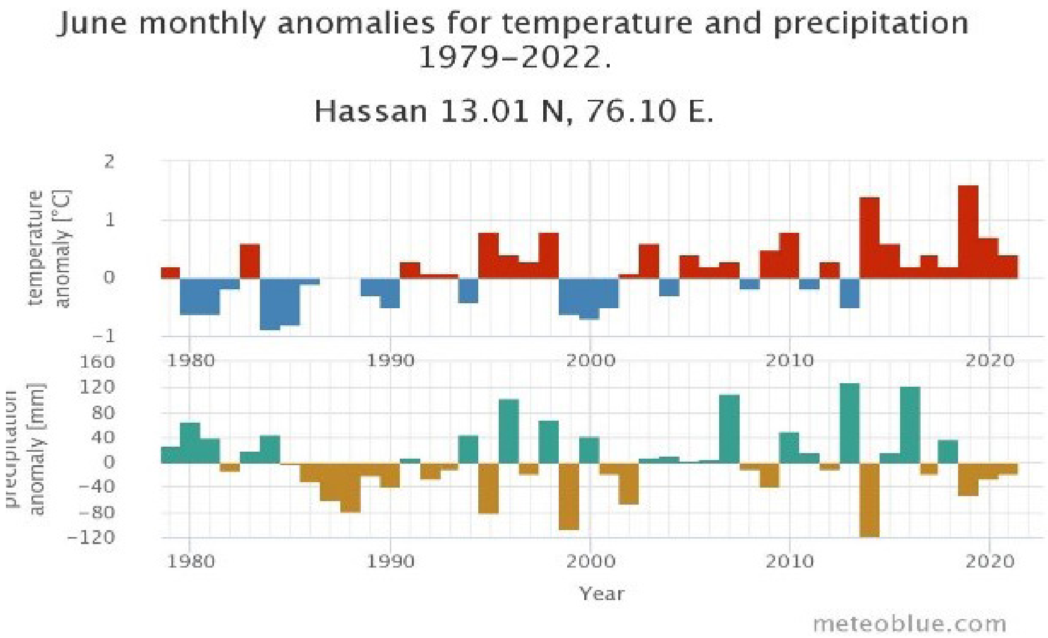

Figure 4: Past temperature and precipitation anomalies in June

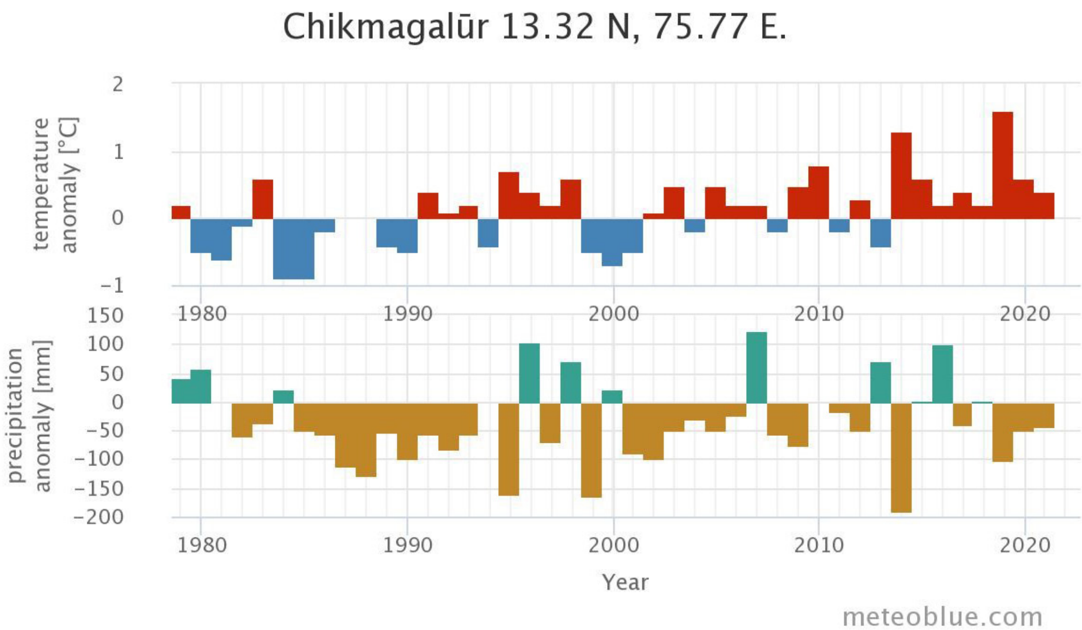

Figure 5: Past temperature and precipitation anomalies in July

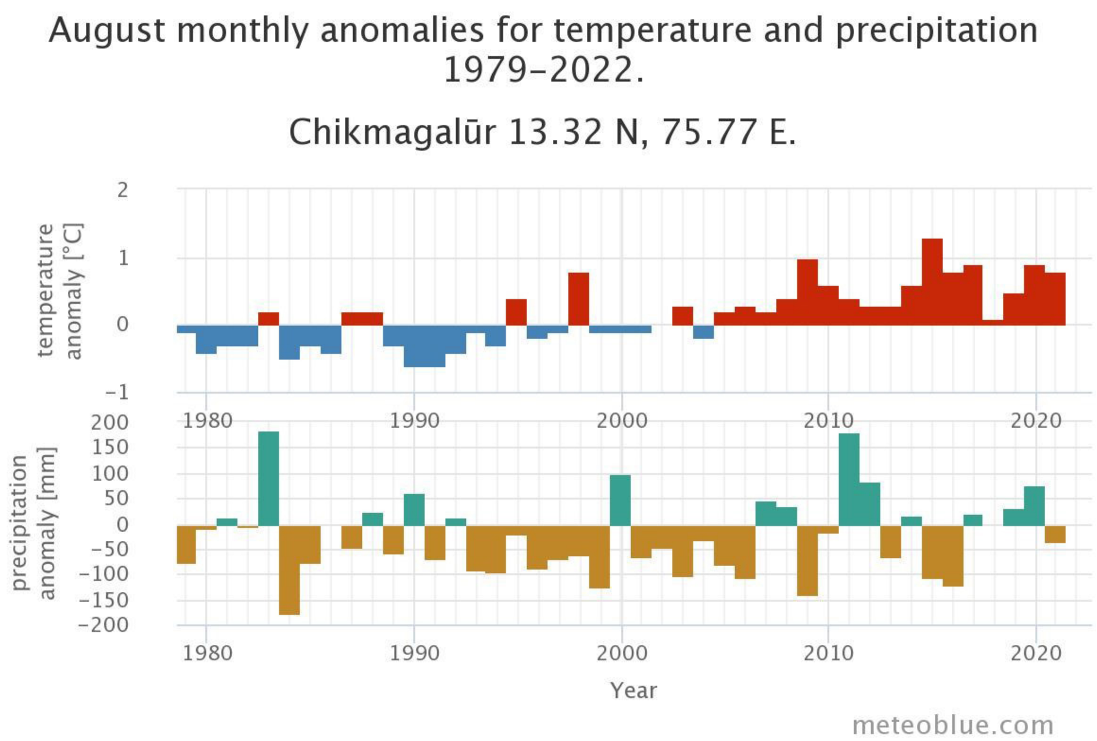

Figure 6: Past temperature and precipitation anomalies in August

The graphs above depict temperature and precipitation anomalies during June, July and August, a period that spans the potato-growing season.

They show a general increase in temperature and precipitation during these three months over the years.

The extreme range of temperature and precipitation

As per the District Disaster Management Plan, 2019-20, prepared by the Hassan District Disaster Management Cell, extreme temperature and precipitation events in the Hassan District from 2008 to 2018 are given below. High rainfall during the period from May to August/ September affects potato production.

#	Taluk	Month / Year	Min. Temp (°C)	Month / Year	Max. Temp (°C)	Max. Rainfall (mm)
1	Alur	Jan 2008	11.68	Apr 2016	35.08	591.3 in Jul 2009
2	Arkalagudu	Jan 2018	14.45	Apr 2016	37.41	333 in May 2018
3	Arasikere	Jan 2018	14.02	Apr 2016	37.87	313.5 in Sept. 2017
4	Belur	Jan 2008	11.68	Apr 2016	36.61	500.2 in July 2009
5	Channarayapatna	Jan 2008	13.10	Apr 2016	39.07	252 in Sept. 2017
6	Hassan	Jan 2018	13.59	Apr 2016	36.75	365 in May 2018
7	Holenarasipura	Jan 2018	13.54	Apr 2016	38.95	295 in Sept.2017
8	Sakaleshapura	Jan 2008	11.68	Apr 2016	34.34	1211 in July 2009

Figure 6: Past temperature and precipitation anomalies in August

Climate change projections

The Bangalore Climate Change Initiative – Karnataka (2011) studied Karnataka's climate trends and made projections, in most cases based on a coupled atmosphere-ocean general circulation model known as HadCM3[3] and further downscaled using regional climate model PRECIS.

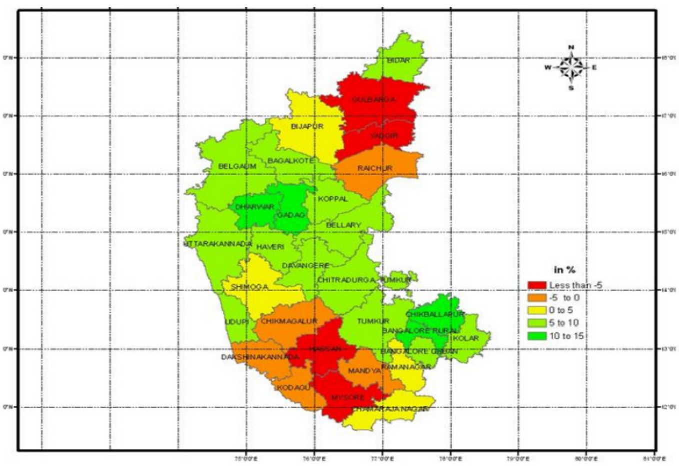

Figure 7: Projected change in annual rainfall (2021-50 – A1B)

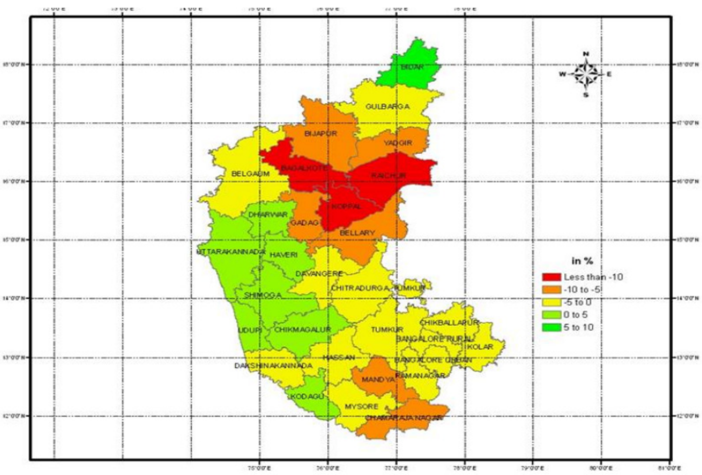

Figure 8: Projected change in June, July, August, and September rainfall for the period 2021-50 (A1B)

The projected change in annual rainfall for 2021-50 (A1B), compared to the baseline of 1961-90 is a 2.45% increase. However, the months-wise distribution of the projected change in mean annual rainfall in Hassan District is -53.02% (Jan – Feb), -3.39% (March – May), -3.72% (June – September), and 11.94% (October – December).

3 Hadley Centre Coupled Model, Version 3 developed by the Hadley Centre, Met Office, United Kingdom

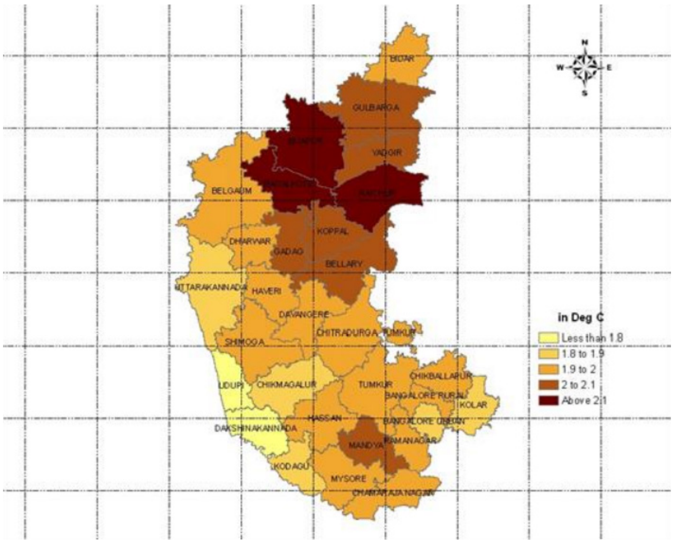

Figure 9: Projected increase in annual minimum tem-perature for 2021-50 compared to 1975 (A1B)

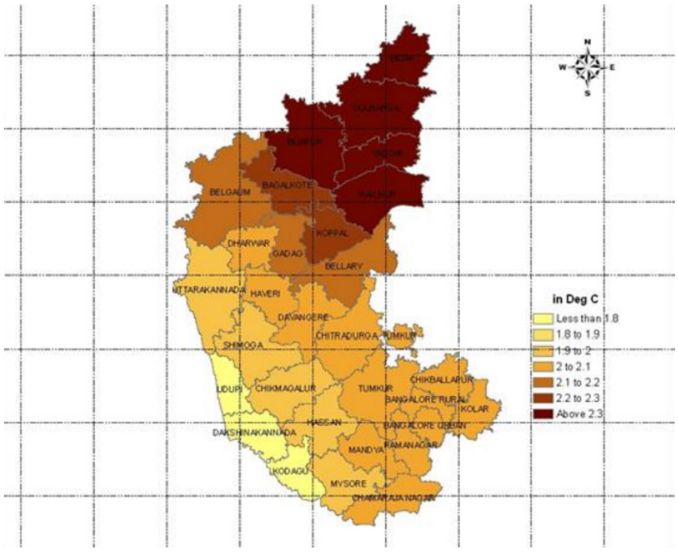

Figure 10: Projected increase in annual maximum temperature for 2021-50 compared to 1975 (A1B)

According to the SAPCC (BCCI-K 2011), during the period 2021-50, the projected change in average temperature in Hassan District is 1.92°C, whereas the projected change in the minimum and maximum temperature are 1.96˚C and 1.95ºC respectively.

3.4 Impact of climate change on tomato and potato production

Based on the feedback from scientists working for the NICRA project at IIHR and a review of literature on the subject, the impacts on tomato production due to climate changes are listed below in Table 5.

Table 5: Climate change risks and impact on tomato value chain

Climate risk	Impact on tomato production	Probability of impact	Losses (monetary/ non-monetary)
High temperature	• Affects pollen viability and fruit set • Poor colour development • Increases incidence of sucking pests like aphids and mites • Increases incidence of viral diseases • Increases the incidence of bacterial wilt	Medium	Monetary
Low temperature	• High incidence of late blight resulting in a drastic reduction in yield • High Incidence of Tuta Absoluta pest	Low	Monetary

Climate risk	Impact on tomato production	Probability of impact	Losses (monetary/ non-monetary)
High rainfall	• High incidence of late blight • High incidence of bacterial wilt • Leaching of soil nutrients out of the root zone	High	Monetary
Low rainfall	• Reduced fruit set and yield • Reduced fruit size and quality	High	Monetary
High relative humidity	• Wilting of Plants • Fruit rot and fruit drop	Medium	Monetary
Low relative humidity	• High RH (85-90%) during day and night increases the incidence of late blight	Low	Monetary
Wind velocity	• Affects the fruit set and fruit size	Medium	Monetary

The Horticulture Research Centre, Somanahallikaval, Hassan, is working exclusively on potato and has identified the following impacts due to climate change on potato production, given in Table 6.

Table 6: Climate change risks and impact on the potato value chain

Climate risk	Impact on tomato production	Probability of impact	Losses (monetary/ non-monetary)
High temperature	• Affects initiation resulting in a decline in yield • Hollow heart in tubers • Potato Tuber Moth damage • Increases incidence of sucking pests like aphids and mites • Increases incidence of viral diseases • Increases the incidence of bacterial wilt	Medium	Monetary
Low temperature	• High incidence of late blight resulting in a drastic reduction in yield	Low	Monetary

Climate risk	Impact on tomato production	Probability of impact	Losses (monetary/ non-monetary)
High rainfall	• Soil erosion leads to a higher percentage of green tubers • High incidence of late blight • High incidence of bacterial wilt • Leaching of soil nutrients out of the root zone • Rotting of tubers at the time of harvesting	High	Monetary
Low rainfall	• Delayed sowing (missing ideal season) • Reduce tuber size (unmarketable size) and declined yield	High	Monetary
High relative humidity	• High RH (85-90%) during day and night increases the incidence of late blight	Medium	Monetary
Low relative humidity	• Affects the tuber formation and reduces the number of tubers	Low	Monetary
Wind velocity	• Faster spread of late blight	Medium	Monetary

As a majority of the area under potato and tomato cultivation is rainfed in Hassan and Chikkamagalur Districts, changes in rainfall and temperature play a very critical role in the success of crop production. Mitigation of these two climate perils by modification of agronomic practices, varietal changes, and so on is the need of the hour to make potato cultivation in the district sustainable in the future. Apart from the climate change risks, price volatility is also a critical factor affecting the income of the growers.

A study to profile climate change adaptation strategies of potato cultivators in Karnataka by Philip Kuriachen et al. (2020) identified socio-economic factors governing farmers' adaptations to climate change. Farmers of different size classes differed in their adaptation behaviour, with large farmers adopting more crop- and water-centric adaptation practices and small farmers opting for alternative livelihood options like diversifying income through dairy management and non-farm employment. Ordinal logistic regression analysis was used to identify factors governing farmers' adaptation to climate change. Access to credit, membership in farmers' groups, contact with extension agencies, size of land holding, number of livestock owned, and returns from farm enterprise were found to increase the likelihood of a farmer belonging to a higher adopter category.

From the study, it is clear that the small farmers look for alternative livelihood options for sustaining their income in the event of loss of income from their cash crops, like tomato and potato, to climate changes. The promotion of integrated farming systems among tomato/potato growers may enhance and secure the farm income. Lack of financial support and lack of knowledge of cost-effective and sustainable climate change risk mitigation measures may also be discouraging factors for the small growers in the adoption of climate change risk mitigation measures.

RECOMMENDATIONS

04

4.1 Coping and Adaptation Strategy Potato

Table 7: Coping and Adaptation Strategy Potato

Stage	Priority	Timeline	Sources of funding
A. Planting Stage			
Land preparation: deep ploughing	High	From the start of the project	Farmer's contribution
Application of organic manure	High	From the start of the project	State Government to provide a 50% subsidy; the balance is borne by the farmer
Replacing the *Kufri Jyothi* **variety with** *Kufri Himalini*	Medium	2-3 years from the start date	State Government to provide a 50% subsidy; the balance is borne by the farmer
Usage of whole small seed tubers instead of cut tubers and seed treatment	Medium	1-2 years from the start date	Farmer's contribution
Usage of Apical Rooted Cuttings (ARC) and further own seed multiplication by the farmers	Medium	Pilots from the start of the project and commercial application in 2-3 years	State Government may provide a 50% subsidy; the balance is borne by the farmer
Use of Mechanical Potato Planter	High	From the start of the project	State Government may fund custom hiring centres through FPOs with a 75% subsidy; FPOs may fund the balance and hiring charges to be borne by the farmer
Drip Irrigation and Plastic mulching under irrigated conditions	Medium	From the start of the project	Farmers can avail of upto a 90% subsidy from the DoH; the balance is borne by the farmer

Expected outcome/climate risk mitigation	Cost of intervention
• The improved drainage system in the event of high rainfall • Prolonged field moisture availability during drought conditions	An incremental tractor hiring cost of INR ₹1000/- per acre.
• Improved soil health and fertility • Improved moisture holding capacity • Higher resistance to pests and diseases • Improved yield with a higher grade of quality tubers	Considering 50% organic manure is met from own sources, the incremental cost would be INR ₹2500/- per acre.
• High resistance to a late blight during prolonged rainfall and high relative humidity • Less incidence of late blight and crop failure Increased yield	No additional cost is involved.
• Improved germination in the event of delayed or deficit rain • Less incidence of tuber rot diseases • A higher percentage of germination and density of plants	This involves an incremental cost of about INR ₹2000/- for 400 kg of tubers required per acre.
• All the advantages of using whole seed tuber and • Virus-free seeds • Own production of seeds Faster multiplication of new varieties	No incremental cost is involved as this is the same as the cost of whole seed tubers. No seeds cost if farmers start using their seeds.
• Improved drainage during high rainfall • Less incidence of late blight • Less percentage of green potato Higher yield, improved grades, and quality	No incremental cost is involved as this technology saves manual labour cost.
• Improved irrigation efficiency and ideal for precision farming • Protects crops during high and prolonged rains • Less incidence of blight • Less percentage of green potatoes	This involves a capital investment of about INR ₹20,000/- per acre for drip irrigation and INR ₹10,000/- for plastic mulch; the DoH

Stage	Priority	Timeline	Sources of funding	
A. Planting Stage				
Organic mulching under rainfed cultivation	Medium	From the start of the project	Farmer’s contribution	
Weather Forecasting	High	From the start of the project	DoH to fund 100% of the activity	
B. Crop growth and Production stage				
Prophylactic spraying of plant protection chemicals to manage pests and diseases	High	From the start of the project	Farmer’s contribution	
Foliar spray of micronutrients and vegetable specials	Medium	From the start of the project	Farmers' contribution. The DoH provides a subsidy of INR ₹1000/- per acre	
Earthing up during tuber formation and growth stage	Medium	From the start of the project	Farmer’s contribution	
Crop insurance	High	From the start of the project	State Government to subsidise 50% of the risk premium	

Expected outcome/climate risk mitigation	Cost of intervention
• Protects crops during high and prolonged rains • Prolonged soil moisture during deficient rain • Maintain ideal temperature for tuber formation • Less incidence of blight • Less percentage of green potatoes • Higher yield, improved grades, and quality	Low or no additional cost is involved if farmers can use their agro-waste as mulching.
• Rain forecast and synchronising planting operations shall mitigate the risk of delayed rain and poor sprouting and rotting of the seed potato planted Also helps in effective peat and disease management during the crop growth stage	No incremental cost is involved. Varuna Mitra Call Centre by Karnataka State Natural Disaster Management Cell at Bangalore provides real-time weather forecasting. There is a need for a facility to reach out to more farmers and sensitise the farmers on the benefits of following weather forecast information.
• Control serious diseases like late blight affecting the crop production when the rainfall is in excess or prolonged • Control of sucking pests and viral disease when the temperature and wind velocity is high Effective pest and disease management leads to higher productivity	No incremental cost is involved. Framers can save cost by adopting prophylactic measures with the use of wright type of plant protection chemicals with wright dose.
• Supports healthy growth of plants and also develops resistance to pests and diseases Increased productivity and quality of tubers	The incremental cost would be about INR ₹1000/- per acre.
• When rainfall is high, soil erosion at the plant base leads to exposure of tubers and an increased percentage of greens that are unmarketable; earthing up leads to minimising the percentage of the green	No additional cost is involved; farmers only need to be educated on the appropriate timing of earthing up.
• Since potato is rainfed in the district, farmers can benefit under the scheme covering the risk of crop failure due to excess or deficient rainfall	Farmers have to bear the insurance premium on actuarial rates decided by the State Government.

Stage	Priority	Timeline	Sources of funding
C. Harvesting, post-harvesting management, storage and marketing			
Harvesting stage	High	From the start of the project	Non-monetary action
Curing of tubers after harvesting	High	From the start of the project	Non-monetary action
Storage and marketing	Medium	From the start of the project	Farmers to meet the storage rentals

4.2 Coping and Adaptation Strategy Tomato

Table 8: Coping and Adaptation Strategy Tomato

Stage	Priority	Timeline	Sources of funding
A. Planting stage			
Application of organic manure	High	From the start of the project	Farmer's contribution
Cultivating blight-resistant varieties	High	From the start of the project	Farmer's contribution
Planting density (maintain not more than 5000-6000 plants/ acre)	Medium	1-2 years from the start date	Farmer's contribution
Use of grafted Seedlings on Arka Neelakant Brinjal Variety as a rootstock	Medium	2-3 years from the start date	State Government to provide a 50% subsidy; the balance is borne by the farmer

Expected outcome/climate risk mitigation	Cost of intervention
The right stage of harvesting helps in better curing of tubers before marketing and spoilage is minimal in case of excess rainfall at the time of harvesting	No incremental cost is involved.
• Improves the keeping quality and storage life of tubers Better price realisation	No incremental cost is involved.
• Farmers need to be sensitised about the befits of storage and realisation of higher prices, and minimise storage losses FPOs can play the role of aggregators and help growers in higher price realisation, promote contract farming of varieties suitable for processing, and so on.	Small incremental storage costs are involved, which can be recovered from the higher price realisation.

Expected outcome/climate risk mitigation	Cost of intervention
• Improved soil health and fertility • Improved moisture holding capacity • Higher resistance to pests and diseases Improved yield with a higher grade of quality fruits	Considering 50% organic manure is met from own sources, the incremental cost would be INR ₹2500/- per acre.
• High resistance to a late blight during prolonged rainfall and high relative humidity • Less incidence of late blight and crop failure Increased yield	No additional cost is involved.
• Improved aeration and gaps between rows to minimise peat and disease build-up Improved quality of fruits with good colour development	Reduces the seedling and staking costs by about INR ₹2500/- to 3000/- per acre.
• Tomato plants are unaffected by 6 to 7 days' water stagnation and prolonged rainfall Grafts are resistant to bacterial wilt during prolonged and heavy rains	Incremental cost of about 5000 per acre. IIHR can train progressive farmers or nursery owners to produce grafted seedlings on a commercial scale.

Stage	Priority	Timeline	Sources of funding
A. Planting stage			
Drip irrigation and plastic mulching under irrigated conditions	High	From the start of the project	Farmers can avail of up to 90% subsidy from the DoH; the balance is borne by the farmer
Weather forecasting	Medium	From the start of the project	DoH to fund 100% of the activity
B. Crop growth and production stage			
Prophylactic spraying of plant protection chemicals to manage pests and diseases	High	From the start of the project	Farmer's contribution
Foliar spray of vegetables specials during the monsoon period	Medium	From the start of the project	Farmer's contribution; the DoH provides eligible subsidies under MIDH
Integrated Pest Management of Tuta Absoluta	Medium	From the start of the project	Farmer's contribution
Rhizobacteria application in summer	High	From the start of the project	Farmer's contribution; the DoH provides eligible subsidies under MIDH
Pruning of leaves on the lower portion of the stem	High	From the start of the project	Farmer's contribution
Prophylactic spraying of plant protection chemicals to manage pests and diseases	High	From the start of the project	Farmer's contribution

Expected outcome/climate risk mitigation	Cost of intervention
• Improved irrigation efficiency and ideal for precision farming • Protects crops during high and prolonged rains • Less incidence of blight and wilt Higher yield, improved grades, and better quality	A capital investment of about INR ₹20,000 per acre for drip and INR ₹10,000 for plastic mulch would be required. The DoH provides a subsidy for these investments.
• Rain forecast and synchronising planting operations will mitigate the risk of delayed rain and poor sprouting and rotting of tomato seeds planted Will help in effective peat and disease management during the crop growth stage	No incremental cost is involved. Varuna Mitra App by Karnataka State Natural Disaster Management Cell provides a weather forecast through a mobile app and manages the Kisan Call Centre to provide instant weather information. The facility needs to reach out to more farmers and raise awareness on the benefits of following weather forecast information
• Control of serious diseases like late blight affecting crop production when rainfall is excessive or prolonged • Control of sucking pests and viral disease when the temperature and wind velocity is high Effective pest and disease management leads to higher productivity.	No incremental cost is involved. Farmers can save money by adopting prophylactic measures with the use of the right type and right dose of plant protection chemicals.
• Supports the healthy growth of plants and the development of resistance to pests and diseases Increased productivity and quality of fruits	The incremental cost would be about INR ₹1000/- per acre.
• Using pheromone tarps and integrated pest management helps to reduce incidences of the dreaded Tuta pest Increased yield and reduced percentage of Tuta-damaged fruits	The incremental cost would be about INR ₹1500/- per acre.
Helps good growth of plants and improved productivity	The incremental cost would be about INR ₹1500/- per acre.
This operation reduces the incidence of late blight during high rainfall and reduces other pests and diseases	No additional cost is involved. Farmers only need to be educated on the appropriate stage and techniques of pruning.

4.3 Adaptation partnerships

Table 9: Adaptation partnerships

Stakeholder	Roles and Responsibilities
Potato	
Department of Horticulture	• Sensitising and creating awareness among potato growers on climate risk mitigation and adaptation measures • Providing extension services on good agricultural practices • Subsidise the production and distribution of Apical Rooted Cuttings for seed potato multiplication locally • Regulate and certify the quality of seed potato multiplication • Provide subsidy for the purchase of potato mechanical planters • Provide subsidy for the purchase of boom sprayers • Promote cultivation of varieties suitable for processing through contract farming • Promote and strengthen the FPOs in the district
Horticulture Research and Extension Centre, Somanahallikaval	• Standardise agronomic practices for climate change risk mitigation and adaptation • Training of farmers on climate risk mitigation and adaptation measures for sustainable production of potato • Screening of varieties adoptable for climate change in Chickmagalur • Multiplication through tissue culture and supply of hardened Apical Rooted Cuttings to nurseries and other approved entities for commercial multiplication
Centre of Excellence for Vegetables, Somanahallikaval	• Training of farmers on improved package of practices for potato production • Multiplication and supply of Apical Rooted Cuttings and micro seed tubers to potato growers
KVK, Hassan	• Training of farmers on improved package of practices for potato production • Multiplication and supply of Apical Rooted Cuttings and micro seed tubers to potato growers • Demonstration of climate risk mitigation and adaptation measures for the sustainable production of potato in Chickmagalur • Weather forecasting and crop advisories through the mobile app or other mass communication modes
International Centre for Potato, Bangalore	• Multiplication through tissue culture and supply of hardened Apical Rooted Cuttings to nurseries and other approved entities for commercial multiplication • Training of nurseries and progressive farmers on commercial multiplication of Apical Rooted Cuttings and micro seed tubers

Stakeholder	Roles and Responsibilities
Tomato	
Department of Horticulture	• Sensitising and creating awareness among tomato growers on climate risk mitigation and adaptation measures • Providing extension services on good agricultural practices • Subsidise the production and distribution of grafted seedlings and support the commercial production of grafted seedlings • Provide subsidy for the purchase of tomato mechanical planters • Provide subsidy for integrated pest management, integrated nutrient management, and other components under MIDH • Promote cultivation of varieties suitable for processing through contract farming
IIHR, NICRA	• Standardise agronomic practices for climate change risk mitigation and adaptation • Training of farmers on climate risk mitigation and adaptation measures for the sustainable production of tomato • Screening of varieties adaptable for climate change in Chickmagalur • Training farmers and nurseries in the commercial production of grafted seedlings
Centre of Excellence for Vegetables, Somanahallikaval	• Training of farmers in an improved package of practices for tomato production • Multiplication and supply of grafted seedlings
KVK, Mudigere	• Training of farmers in an improved package of practices for tomato production • Demonstration of climate risk mitigation and adaptation measures for the sustainable production of tomato in Chickmagalur • Weather forecasting and crop advisories through mobile apps or other mass communication modes

References

Adapting to Climate Change: A Case Study of Potato Cultivators in Karnataka (2020): Philip Kuriachen, A. Suresh, D.R. Singh, G.K. Jha, P. Venkatesh, and Biswajit Sen, Division of Agricultural Economics, ICAR-Indian Agricultural Research Institute.

Adapting to Climate Change: A Case Study of Tomato Cultivators in Karnataka (2020): Philip Kuriachen, A. Suresh, D.R. Singh, G.K. Jha, P. Venkatesh, and Biswajit Sen, Division of Agricultural Economics, ICAR-Indian Agricultural Research Institute.

Alugadde Beleyelli Adhunika Besaya (Kannada Publication) by H Amaranajundeswar, Dr. Mahesh Y S, and others. Horticulture Research Station and Extension centre, Somanahallikaval, Hassan

An overview of heat stress in tomato (Solanum Lycopersicum L.) (2021): Muhammed Alsamir, Tariq Mahmood, Richard Trethowan, Nabil Ahmad Plant Breeding Institute, Faculty of Agriculture and Environment, University of Sydney.

Climate Risk assessment and management in agriculture (2012): Ramasamy Selvaraju Climate, Energy and Tenure Division, FAO, Rome

Climate Risk Management (CRM) framework for India: Addressing Loss and Damage (L&D) (2019): NIDM and GIZ.

Climatic change and its impact on tomato (Lycopersicon esculentum l.) Production in plain area of Nepal (2021): Roshan Bhandari, Nilhari Neupane, Danda Pani Adhikar.

District Disaster Management Plan for Chikkamagalur district (2019-20): District Disaster Management Authority Chikkamagalur District, Karnataka

District Disaster Management Plan for Hassan district (2019-20): District Disaster Management Authority Hassan District, Karnataka.

Heat Tolerance in tomato (2012): Faruq Golam, Zakaria Hossain Prodhan, Arash Nezhadahmadi, Motiur Rahman, Institute of Biological Sciences, Faculty of Science, University Malaya.

How to do Climate change risk assessments in value chain projects (2015): IFAD.

Potential Linked Credit Plan of Chikkamagalur District (2022-23): NABARD Karnataka Regional Office.

Potential Linked Credit Plan (2022-23) of Hassan District: NABARD Karnataka Regional Office

Review on the Effect of Climate Change on Tomato (Solanum Lycopersicon) Production in Africa and Mitigation Strategies (2018): Wakuma Biratu Ethiopian Institute of Agricultural Research, Mehoni Agricultural Research.

List of Abbreviations

APMC	Agriculture Produce Marketing Committee
BMZ	German Federal Ministry for Economic Cooperation and Development
°C	Degree Celsius
CAS	Coping and adaptation strategies
CCA	Climate Change Adaptation
CRM	Climate Risk Management
DoA	Department of Agriculture
DoH	Department of Horticulture
DEST	Department of Environment, Science & Technology
FIG	Farmer Interest Group
FPC	Farmer Producer Company
FPO	Farmer Producer Organisation

FSG	Farmer Study Group
GIC	Green Innovation Centre for the Agriculture and Food Sector
GoI	Government of India
KVK	Krishi Vigyan Kendra
NFSM	National Food Security Mission
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MoAFW	Ministry of Agriculture and Farmers' Welfare
MoEFCC	Ministry of Environment, Forest and Climate Change
MIDH	Mission for Integrated Development of Horticulture
MT	Metric Ton
NABARD	National Bank for Agriculture and Rural Development
PMPBY	Pradhan Mantri Phasal Bhima Yojana
RKVY-RAFTAAR	Rashtriya Krishi Vikas Yojana - Remunerative Approaches for Agriculture and Allied Sector Rejuvenation scheme
SAPCC	State Action Plan for Climate Change
SC/ST	Scheduled Caste or Scheduled Tribe
SHG	Self-Help Group

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