Long Lasting Heat Waves: Threats of extreme heat

- Heat wave is a condition of air temperature which becomes fatal to human body when exposed. It is defined as the temperature thresholds over a region in terms of actual temperature or its change from the normal range of temperature in the region.
- In some countries it is defined through heat index based on temperature and humidity or on the basis of extreme percentile of temperature
- In recent years heat waves have broken long standing records by large margins.
- One eg. Is in spring 2021, Siberia witnessed exceptional temperatures leading to heat waves in colder countries such as Canada.

Reasons behind Heat Waves

- Heat waves are a result of trapped air. Air circles the globe in large prevailing winds, however if trapped in one region, it gets warm to uncharacteristic temperatures due to the sun light.
- The air is trapped due to high-pressure effects. These systems force the air downwards causing formation of a large cap. This trap of air is unable to rise into cooler upper atmosphere, thus preventing precipitation.
- The increase in heat waves is a result of human activities leading to high levels of carbon dioxide and other planet warming greenhouse gases into the atmosphere.
- Researches have linked an increase in heat waves to more increase in years with heating in central Pacific Ocean.
- The ocean temperatures are also rising faster resulting in longer stretches of hot days.
- Heat wave problem is exacerbated also due to (a) deforestation (b) heat-island effect (c) industrial pollution

An urban heat island effect is when the urban region experience higher temperatures than adjoining rural areas. This is attributed to buildings, roads, and other infrastructure which absorb and re-emit the sun's heat more than natural landscapes such as forests and water bodies.

Impact of heat waves on agriculture and forests

- Extreme heat waves can dry up the crops and destroy the vegetation. It can also lead to increase in cyclones, heavy rainfalls, thunderstorms, etc. as it impacts moisture content, thus impacting the productivity of crops and affecting food security.
- Heat dries the soils and vegetation, providing drier fuels that is ready to burn.
- Forests lose more water during heat waves in summers leading to fires.
- Heat Domes are frequent and act as fuel to wild fires, destroying land and vegetation and effecting the diverse biodiversity
- High temperatures lead to increased plant stress causing disease and pest attacks, hence major food grain crops yield is severely affected.
- Food production has become vulnerable to extreme weather events as is witnessed in the impact on wheat production. This year scorching temperatures swept across the country as crops planted in the winter were ripening for harvest.
- Small-scale farmers produce 50% of the world's food calories but bear the brunt of extreme weather events which destroy crops and livestock.

(Source: Excerpts from News articles The Economic Times 19 May 2022 and Economic Times 28 May 2022)

Climate Change impact on King of fruit:

No fruit in India is as universally loved and as eagerly anticipated as the mango, which, for one brief window each year, cools and sweetens the long days of summer.

Mango is the King of fruit in India. Connoisseurs argue fervently about which of India's dozens of varieties — each with a distinct flavor, color and texture — are the best.

But this year, this centuries-old ritual is imperilled. As blistering heat has struck northern India weeks earlier than usual, mango crops have been devastated, threatening a way of life for the thousands of small farmers who grow the fruit and the millions more who consume it. The heatwave is a vivid example of the challenge India faces in ensuring its food security as the effects of climate change worsen, compounding its difficulties in raising agricultural productivity to international standards to feed a growing population.

The dangers of a hotter future are achingly visible on a typical small farm in Malihabad, a prime northern mango-growing district, where grower tending

about 500 trees witnessed high temperatures in March that affected mango flowers.

India experienced its hottest March in 122 years of record-keeping, with temperatures averaging nearly 92 degrees Fahrenheit and soaring as high as 104. The intense heat of March continued into the hottest April in 50 years and then carried on into May. Climate scientists... said the chances of such a heat wave in India had increased by at least 30 times since the 19th century.

India is the world's largest mango producer, accounting for nearly 50% of the global crop. Much of it is consumed domestically, but the country exports tens of millions of dollars' worth of mangoes each year to the United Arab Emirates, Britain, Germany and the United States. Over the past decade, India has been trying to penetrate markets in other European Union countries as well.

The Malihabad district in Uttar Pradesh is known for delectable varieties like the Dasheri, which is named after a village in the area. The district is home to numerous families who have been growing the fruit for at least three generations. Most farmers in Malihabad own small plots of land and depend solely on mangoes for their livelihood. They have been witness to the vagaries of climate change and its impact on fruit yield for the first time in their lives. (Source: *Excerpts from News articles* Economic Times 28 May 2022)

Other impacts of Heat waves

- Heat wave cause ocean water to expand, increasing sea levels and melting ice sheets around the world.
- The heatwave has impact on human health leading to more hospitalisations
- Work productivity is adversely impacted, in particular among the workers exposed to heat on a regular basis.
- Heat waves increase the demand for power due to use of air-conditioners which can adversely impact grid or put pressure on energy fuel.

(Source: *Excerpts from News articles compilations,* The Hindu 5 May'22; Economic Times 28 May'22)

Making Agriculture Climate Resilient

Climate change has become a major challenge to agricultural production. There are several projections about the varying impact of climate change on the agriculture sector in different regions. According to the Indian Network for Climate Change Assessment (INCCA) Report (INCCA, 2010), the rice crop (which is the major food grain crop), would suffer yield loss of 4–20% under irrigated conditions and 35–50% under rainfed conditions as early as 2030. The negative impact of climate change on milk production has been estimated at about 1.6 million tonnes in 2020 and more than 15 million tonnes in 2050. IPCC (2014) report indicates that climate change is occurring faster than earlier predicted. Small farm holdings, which are the main source of food, nutrition and livelihood security in India, are more prone to climate change impacts. Small farm holders, who have the least capacity to overcome the consequences, as they have fewer resources to adapt socially, technologically and financially, are likely to be the worst affected. Besides climate change, climate variability—including extreme events such as tropical storms, sudden rise and fall in temperature—is also expected to affect production of food commodities. An increase in drought intensity will lead to fall in production leading to high prices of food commodities. As per an estimate an 10% increase in drought during the monsoon period will lead to the price of rice surging by 23%, maize by 16%, sorghum and millets by 13% and tur by 10%. The higher prices of food commodities will lead to fall in demand for them—approximately 5.5% in the case of rice and 2–4% in other commodities.

Agriculture is both part of the problem and part of the

solution to climate change and sustainability. It is necessary to seize every opportunity available to move away from inefficient farm practices and towards long-term sustainability, efficiency and resilience. Of all sectors of the economy, agriculture offers the best hope for environmentally sustainable green growth. However, more targeted and detailed research is necessary to identify exact strategies. The intelligent use of climate information services and big data analytics can facilitate the efficient use and targeting of increased public and private investment in natural capital through the management of water, energy, soil quality and natural resources and climate change literacy. A bottom-up farmer level consultation is equally important, which will indicate an equitable path, going forward. More research is also needed to understand risk profiles, the implications of various agricultural service delivery models for various social groups to strengthen resilience and finally to reduce loss and damage by investing in climate proof agricultural system. There are immense opportunities in targeting climatic services, advisories, insurance and precision farming, but there is a need for sound business models in order to take these to scale. There is a growing need for right partnerships, science-based actions, policies, market/non-market incentives, investments and institutional changes. Investments in natural resources, infrastructure, knowledge and human resource and social and institutional capital, and valuing their impact for creating green jobs in these sectors and impact on various dimensions of human wellbeing are becoming imperatives in policy planning.

(Source: Excerpts from Book entitled 'Indian Agriculture Towards 2030: Pathways for Enhancing Farmers' Editors Ramesh Chand, Pramod Joshi and Shyam Khadka 2022).

JIVA- An initiative of NABARD to rejuvenate 'life' in agricultural fields

NABARD is rolling out an initiative - JIVA (life) through non-governmental organisations and other stakeholders in rural areas. Jiva is about rejuvenation of earth, creating life around the agricultural fields, using natural resources. NABARD has developed watersheds, ensuring water security to 2.5 million hectares of land. The water security is ensured and hence now the focus is on enriching the soil – through maintain the microbial activities in the soil with adopting appropriate and proper farm practices. Jiva will create a system where no harm is caused to nature.

The major goal of this programme is to effectively implement the principles of agroecology long-term sustainability and transform the social and natural capital towards efficient farming system. This agroecology-based programme is basically an amalgamation of many projects under watershed programme of NABARD and will be implemented in ecologically fragile and rain-fed areas.

Agriculture is most vulnerable to climate change. Tropical agriculture including that in arid tropics, particularly subsistence farming is vulnerable to climate change. Traditional systems that integrate soil resource adaptation through agro-forestry, agro-ecological measures, cropping pattern and crop rotation, would potentially provide options for improvement in livelihoods through simultaneous production in food, fodder and fibre as well as mitigation of the impact of climate change. While erodible soils will take longer time for rejuvenation, the low hanging fruits, in the form of agro-forestry developed land, fruit orchard (such as under TDF-wadi) and treated watershed regions, the rejuvenation and upkeep of the soil microflora will play a crucial role in providing long term solutions for sustainable farming. Hence JIVA has the key for generating more livelihood options while adhering to sustainable farming practices, bringing in its fold, expansion of vermi-composting, bio-gas programmes, better use of biomass as fuel, water conservation measures, enhanced scope for biodiversity conservation and maintaining green landscapes with better waste management. In rural parts of our country, next to land, livestock forms the most important asset of the cultivators. Traditionally cow dung as compost have been in use for sustaining soil friendly microorganisms. This practice has been exploited under organic farming and various farming methods such as natural farming, polyculture farming, companion planting, intercropping etc. These farming options can be piloted in farms for better soil use efficiency, reduce soil erosion, increased farm resilience, more stable yields etc.

A healthier eco-system in treated/completed watershed project-areas reduces the need for pesticides, fungicides, herbicides prioritizing on greater biodiversity and providing more pollinator-habitats and common pest-predators. There is need today to enrich soil with carbon through innovation based farming methods. JIVA is a knowledge and skill-intensive programme which will be implemented with an investment of Rs 50,000 per hectare in existing watershed and wadi programme across the country by NABARD. Initially collaborations with the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia, are chalked out for

simple soil water monitoring technology and with ICAR for research support for scientific validation of natural farming practices.

Rainfall plays an important role in natural resource management, especially it is observed that with decrease in rainfall the productivity of arable crops and grasses decline as do the tree and shrub density. Therefore, the platform of treated watershed and wadi regions with JIVA programme will boost the biodiversity while reducing the dependency on chemical-use in agriculture. Innovations for better natural resource management, community participation and use of technology, especially digital based farming will play a key role in enhancing climate resilience agriculture.

NABARD has placed much significance on the program which is being piloted in 11 states covering five agro-ecological zones in the country. The best practices piloted in 200 hectares in each of the project, will demonstrate and proselytise to the farming community the advantages of JIVA. Bankers too will play pivotal role in enhancing credit flow to integrated farming based systems. Training programme to sensitise stakeholders have been initiated, in particular in the watershed treated and TDF-Wadi programme in the country.

(Source: NABARD website; Banking Finance volume XXXV)

National Innovations in Climate Resilient Agriculture (NICRA) Project: ways to minimise climate change impacts on agriculture

Today the need to enhance the resilience of Indian Agriculture to Climate Change is felt more strongly than before in our country. The extreme weather events like floods, droughts, heat waves and erratic monsoon spells are increasing day by day. Improved technologies coupled with new policies are key to enhance resilience. NICRA project is an effort to develop and promote climate resilient technologies in agriculture which will address vulnerable areas in the country. Accordingly, the Government of India has accorded high priority on research and development to cope with climate change in agriculture sector through various initiatives, projects and programmes. Key among which is the implementation of NICRA project.

NICRA or National Innovations on Climate Resilient Agriculture, is a network project of the Indian Council of Agricultural Research (ICAR) launched in February 2011 with an outlay of Rs.350 crores. ICAR with its large network of agricultural research and education institutes is facilitating critical research on climate change adaptation and mitigation that covers crops, livestock, fisheries, and natural resource management projects. The project consists of four components namely (i) Strategic Research (ii) Technology Demonstration (iii) Capacity Building and (iv) Sponsored/ competitive grants. Under the programme, through competitive bidding for the grants - research is undertaken in critical areas under climate change in R & D institutions of excellence, which can be within or outside the National Agricultural Research System (NARS). Some important features of the project:

1. NICRA project includes comprehensive field evaluation of new and emerging approaches of crop cultivation such as aerobic rice, conservation agriculture practices etc., for their impact or reducing the GHG emissions.
2. It lays emphasis on livestock and fishery sectors including aquaculture by identification and characterisation of adaptive traits in the indigenous resilient breeds.
3. Demonstration plots of climate resilient package of practices and adoption of such practices by farmers.
4. Promotion of the following practices have been identified under the project:

(a) in situ moisture conservation

(b) biomass mulching

(c) residue incorporation instead of burning

(d) brown and green manuring

(e) water harvesting and recycling for supplemental irrigation

(f) improved drainage for flood prone areas

(g) conservation tillage where appropriate

(h) artificial ground water recharge

(i) water saving irrigation methods

5. The project would enhance resilience through the following measures

(a) Promote drought/temperature tolerant varieties

(b) Advancement of planting dates of rabi crops in areas with terminal heat stress

(c) Water saving paddy cultivation practices (SRI, aerobic, direct seeding)

(d) Frost management in horticulture through fumigation

(e) Staggered community nurseries for delayed monsoon

(f) Custom hiring centres for timely completion of farm operations

(g) Location specific intercropping systems having high sustainable yield index

6. The institutional interventions that will bring in the resilience include the following:

(a) Strengthening existing institutions

(b) Initiating new institutions on various aspects/ parameters to address the challenge

(c) Community seed bank

(d) Fodder bank

(e) Commodity groups

(f) Custom hiring centres

(g) Collective marketing groups

(h) Weather index based insurance

(i) Climate literacy through a village weather station

(j) Promoting an enabling mechanism at village level for continued adoption of sustainable practices to enhance resilience

7. Sharing of experiences under NICRA project through effective dissemination to concerned departments for Upscaling the interventions across the country

8. Capacity building of farmers and their training institutions on the following

(a) Resilient practices and technologies

(b) Location specific mitigation strategies

(c) Location specific adaptation strategies

(d) Use of farm machinery

(e) Seed bank

(f) Fodder bank

9. In rainfed farming and in the vulnerable regions the NICRA project will show the approach to enhance resilience through smart technologies

10. Innovations can emerge from the NICRA study and rural youth/educated youth would require handholding and the right ecosystem to flourish.

(Source: NICRA www.nicra-icar.in)

Water Management Challenges: India's Irrigation sector

- Irrigation is the main consumer of fresh water and accounts for more than 90% of groundwater draft in our country.
- Growing population coupled with food security has put pressure on water resources.
- While the demand for water from various sources of our economy is increasing – the supply of fresh water is constant. This is also causing water crisis in irrigation sector.
- Some of the concerns in irrigation sector owing to water crisis are as follows:

1. **Depletion of water Table:** Heavy investment in the canal irrigation has been made, however the canal irrigated area has decreased by 38 lakh hectares. This is due to the age of the infrastructure, unreliable water supply, lack of incentives etc. This has led to ground water depletion. The key is that there is widening gap between irrigation potential created and actually utilised.

2. **Deterioration of Groundwater Resources**: Ground water resource deterioration due to technology and policy led shifts such as cropping pattern shifts (paddy), irrigation source (towards ground water) and energy source.

3. **Poor irrigation efficiency:** Inadequate infrastructure and its maintenance lead to poor irrigation efficiency eg. unlined canal and farm channels. Overall the average irrigation efficiency is around 38% which is much below the desired level of 70%. Thus there is scope to improve efficiency through appropriate infrastructure and its upkeep.

4. **Frequent Droughts and overuse of groundwater:** The frequency of drought years is increasing in the country. The period between 1950 to 1989 had 10 drought years, but in the past 16 years, since 2000, the nation has witnessed 5 droughts. Rich ground water resources help in coping during critical drought conditions. However the resulting ground water overuse and quality deterioration during such droughts is a cause of concern.

5. **Potential created and utilised**: The major reason for non-utilisation of created potential are delay involved in the development of on-farm works identified as follows:

(a) Construction of field channels

(b) Land levelling or shaping

(c) Adoption of warabandi system

(d) Time taken by farmers to switch over from dryland farming to irrigated farming

(e) Finance required for use of micro-irrigation and

(f) Shifting to new cropping patterns, impacting cropping intensity, crop diversification etc.

6. **Imbalance in Rainfall and water availability:** Rainfall and water availability in India have huge regional imbalance. There is huge temporal and spatial variation in rainfall and water availability. While average rainfall is 1170 mm, some parts of the country (NER) get around 10000 mm per year, while parts of Rajasthan get only 100 mm.

7. **Interstate water disputes and development of water resources:** Interstate water disputes and development of water resources is planned by states individually based on specific regional needs. All major rivers are inter-state in nature. This leads to differences on aspects such as storage, priorities and use of water among the states. Rigid outlook of the distribution of water supply require negotiations to arrive at win-win situation at regional level.

(Source: Excerpts and compilations from (i) The Hindu, 10.3.22 (ii) Irrigation in India, status, challenges and options, *Journal of soil and water conservation* 18(4), Dec.'2019; Jain et al)

ESG: Evolving an sustainable inclusive economy

The term ESG was first coined in 2005 in a landmark study by the United Nations titled *Who Cares Wins*. Environmental, social and Governance refers to the three core themes for bringing-in sustainability and societal impact of an investment in a company. Our country though is the third largest carbon emitter in the world, the emissions are low in per capita terms. A well structured plan for Net Zero 2070 is essential which will influence the ESG issues. The environmental issues range across climate change, carbon emission concerns, waste management and pollution of natural resources. Social issues cover labour issues, under-the table sourcing practices, products and processes that affect lives and livelihoods, privacy concerns, data security etc. While Governance issues broadly cover business ethics, corporate culture, organisational practices, decisions of the Board, risk frame work, transparency in disclosures etc. The ESG adoption requires to be brought-in in an organisation's culture. There is much scope to discuss these aspects for smooth and quick transition along with educating and capacity building of key stakeholders, decision makers, investors and public at large. In our country ESG is being considered with concern by the stakeholders.

According to a recent report by think-tank Climate Risk Horizons, banks in India are not prepared to adapt to climate change. They have yet to factor in climate related financial risks into day to day decision making and assessments. Some of the critical criteria used to assess the banks include commitment to phase out investments in coal, disclosing and verifying direct and indirect emissions, sanctioning green loans and funding climate mitigation and net zero targets for various emissions alongwith action plan for implementing them. The report is critical that the banks have not tested the resilience of their portfolios in the face of climate change.

Green lending or green finance sector is presently in a nascent stage in the country. Banks in the country have been slow in green financing in general. The approach of banks needs to move quickly from traditional lending to assessing sustainable businesses. Green financing is a business opportunity for banks. A crucial input for Net Zero is a well developed and functional green finance sector, which will enable mobilising of required capital. A study by Climate Policy Initiatives (CPI) brought out that under climate investments in 2018 only $ 18 billion was mobilised as against the annual requirement of $160 billion.

As a policy push to encourage low carbon sectors and to share the national goal of net zero 2070, a number of steps are being considered. The regulator RBI joined the network for greening of the financial systems, a group of central banks working in developing financing to help transition to renewable projects and sustainable businesses.

(Source: BW Business World, "In Depth," May 2022)

India's strategies for new 2030 and net zero targets: where we stand!

Our nation has been severely impacted by COVID 19 during 2021, which has further reduced the resilience of climate change vulnerable populations already at risk of displacement by storms, floods, droughts and other climate disasters. The government had then responded to the pandemic led economic crisis by unveiling one of the largest stimulus packages in the world, equating to a share

of around 11% of the country's GDP in 2019. India's overall COVID recovery stimulus package mainly supports activities related to industries. However this was likely to have a negative impact on the environment since the package includes increasing the use of fossil fuels.

However in 2021 the country's most recent stimulus is more climate-friendly, with two-thirds of the resources targeted towards a green recovery, including roughly USD 3bn in battery development and solar PV. While the additional stimulus is a positive step, economic recovery would continue to use coal, with fresh loans to many thermal power projects, thus undermining a green recovery.

Emissions to 2030 will rise less than in pre-COVID 19 projections, mainly because of the pandemic's impact on the economy. Today, the country is continuing to expand coal capacity, as many projects are under construction and several more have been announced. The utilisation rate of coal power plants is falling, thus affecting profitability.

Based on current coal expansion plans, the coal capacity would increase from current levels of over 200 GW to almost 266 GW by 2029-2030. The coal-fired power plant pipeline is the second largest in the world and is one of the few to have increased since 2015. A recent move to increase domestic coal production has opened coal mining to private investors. To get on a 1.5°C emissions pathway, it is important to phase out old, high-capacity power plants existing in the country. These power plants are having low efficiency and high emissions.

The coal subsidies in absolute terms have remained largely same since 2017, however they are about 35% higher than subsidies for renewables. Hence there is a need to increase subsidy support for non-fossil energy sources.

Our nation has ambitious renewable energy policies. The ambitious 2022 renewable energy capacity target of 175 GW, as of July 2021, has reached to almost 100 GW mark. The new renewable energy capacity installed as of July 2021 to be precise is 98.9 GW. The country is geared to achieve current NDC target with current policies. Strategically speeding up renewable energy sources can provide access to affordable power at scale. Falling auction prices for wind and solar, and increasing cost of coal-fired power generation will hasten the availability of affordable, renewable energy.

To be aligned with the Paris Agreement 1.5°C limit, the country has to phase out coal use from power sector by 2040. The National Electricity Plan (NEP) in 2018 is projected to add more than 45 GW of coal-fired capacity by 2027.

The initial NDC has three main elements:

- An emissions-intensity target of 33%–35% by 2030 below 2005 levels;
- To increase the share of non-fossil-based energy resources to 40% of installed electric power capacity by 2030 with support;
- To create an additional (cumulative) carbon sink of 2.5–3 $GtCO_2e$ through additional forest and tree cover by 2030.

Moving forward with mitigation efforts, new five targets have been put in place which are:

(1) Non fossil energy capacity to 500 GW by 2030

(2) 50% of energy requirement will be met from renewable energy by 2030

(3) Reduce Carbon emissions by one billion tonnes from 2021 to 2030

(4) Reduction of Carbon intensity of economy by less than 45% and

(5) Achieve Net Zero by 2070

This target can be achieved through innovations and inventions with more youthful energy to tackle the ills of climate change and through multi-pronged approach based on leading research, development and extension efforts. In addition it will require international support to be consistent with the Paris Agreement's 1.5°C temperature limit.

(Source: Excerpts from Climate Action Tracker, climateactiontracker.org, India)

Green Bond

Key facts of Green Bonds are as follows:

- Green bonds work like regular bonds with a key difference: the money raised from investors is used exclusively to finance projects that have a positive environmental impact, such as renewable energy and green buildings
- With nations around the world stepping up efforts to reduce Carbon emissions, the market for green bonds is booming. This rapid growth was highlighted in October 2021, when the European Union issued inaugural green bonds raising about 12 billion euros ($13.8 billion), which is largest

ever deal. This money raised is for supporting projects such as Research platform for energy transition and wind power projects.

- For the first time Green Bonds were issued in 2007.
- The market grew slowly for a decade, now it is growing steadily. Global green initiatives such as the Paris Agreement on climate change and the UN SDGs have helped spur this expansion.
- Strong demand for green bonds is also driving growth, with major investors from asset managers to insurers and pension funds keen to promote them. The EU deal shows that orders exceeded the securities available by 11 times. This shows the great demand and hence it can cost less to issue green bonds than the conventional ones.

(Source: Climate Bonds.net & OECD.org)

Crop Diversification: An Option for Climate Change Resilience

Extreme temperature, frequent and intensive flood, cyclone and other natural disasters due to climate change have become acute and would be more severe in near future. At the same time, crop diversification could be an effective adaptation option under such situations, as it protects natural biodiversity, enhances ability of agro-ecosystems to respond to such stresses, minimises environmental pollution, reduces risk of total crop failure, reduces incidence of insect pests, diseases and weed problems and secures food supply besides providing farmers alternative income generating opportunities. The rice-wheat system is a main food security system of India. It provides food, income and employment to the masses. The changing climate and increase in intensity and frequency of climate disaster events is the cause of decline in rice and wheat productivity. The excessive use of chemical fertilisers, weed control and pest control are affecting soil health. This in turn poses threat to the environment causing ecological imbalance. Some of the issues of concern emerging as threat to sustainability of rice-wheat systems are:

Agricultural Issues: Degrading soil structure and health coupled with residue management are a cause of concern in the Rice-wheat pattern prevalent in the Indo Gangetic States, namely, Punjab, Uttar Pradesh, Haryana, Bihar and West Bengal. The Rice-wheat cropping system is water, energy, capital and labour intensive as transplanting, spraying and harvesting require intense labor, in particular for paddy. Labour shortage is an emerging issue in the rice-wheat belt. Dr. M.S. Swaminathan reported declining crop response and marks it as the major reason for decline in land productivity. Intensive cultivation of rice-wheat patterns is also affecting underground water levels. This has resulted in submersible pumps replacing the centrifugal pumps which lift up water from the deeper levels requiring more energy. Declining underground water table alongwith outbreak of insects-pests diseases and weed pressure leads to low productivity. The above issues can be briefly enlisted as follows:

1. Over mining of nutrients and decreasing response to nutrients from soil
2. Disturbed soil aggregates due to peddling in rice
3. Declining ground water table
4. Outbreaks of diseases/pests and of *Phalaris minor*
5. Low input use efficiency in north western plains
6. Low use of fertiliser in eastern and central India
7. Lack of appropriate varietal combination

Sustainable Cropping Pattern

Ground water depletion affecting the rice-wheat belt growing regions requires immediate interventions in the form of land, water and crop management programmes. The shift to less water intensive traditional crops is key to address this growing challenge. The wheat cultivated after rice in North West parts of the country, study shows that it suffers from manganese deficiency. In rice-wheat cropping sequence, decline in wheat yields due to boron deficiency is observed. Selenium toxicity is an emerging issue in the Rice-Wheat cropping pattern, however under Maize-Wheat Cropping rotation no selenium toxicity was observed. The issue of micro-nutrient deficiencies such as iron and zinc in rice and in wheat- the manganese deficiency and selenium toxicity makes it impertinent to shift or change the cropping pattern.

Diversification of Cropping Pattern: Diversification strategies in agriculture is increasingly being considered as a panacea for many ills in agriculture development in the country, it is being looked up for (a) risk management practices (b) increase farm income (c) increase self-sufficiency (d) mitigate negative externalities associated with monocropping. Thus the crop-pattern changes are outcome of the interactive effect of many factors, broadly categorised into the following five groups:

1. Resource: irrigation, rainfall and soil fertility
2. Technology: Seed, fertiliser, water technologies, storage, processing and marketing
3. Investment capacity for farmers namely self-sufficiency on account of fodder etc.
4. Input/output Price: Output and input prices as well as trade policies and other economic policies that have impact on them
5. Infrastructure and institutional support: farm size and tenancy arrangements, research, extension and extant policies etc.
6. These factors are inter-related and hence no water tight approach is required to address the prevailing situation

Major constraints in crop diversification are:

1. Over 63 percent of the cropped area in the country is completely dependent on rainfall
2. Sub-optimal and over-use of resources like land and water resources have adverse impact on environment and sustainability of agriculture
3. Fragmentation of land holding an impediment on modernisation and farm mechanisation
4. Lack of adequate and appropriate infrastructure in power, connectivity, extension etc.
5. Inadequate post-harvest technologies and inadequate infrastructure for post-harvest handling of perishable produce
6. Lack of adequate agro-based industry
7. Lack of appropriate research-extension-farmer linkages
8. Inadequately trained human resources coupled with persistent and large illiteracy among farmers
9. Increase in diseases and pests affecting most crops
10. Poor database for horticulture crops
11. Gap in investments in the agriculture sector over the years.

Government policies and strategies for crop diversification

The steps taken by the Government favouring crop diversification are as follows:

1. Technology mission for integrated development of horticulture in the North Eastern Region.
2. Operationalising technology mission on cotton
3. Programmes on Watershed development
4. Infrastructure support for horticulture development with emphasis on post-harvest management
5. Strengthening institutional and agricultural finance
6. Strengthening agri marketing through the e-NAM scheme launched in 2016
7. Viability gap funding for warehouses
8. Steps for strengthening cooperatives
9. Agriculture export policy
10. Public investment in irrigation, comprehensive measures for water stressed districts
11. Farm insurance scheme such as PMFBY
12. Programmes for encouraging organic farming, natural farming, use of less chemicals etc.
13. Facilitate contract farming and Farmer-producers organisations
14. Framework set up for development, management and conservation of marine fishery resources
15. Sustainable cropping patterns
16. Incentivise use of technology

Hence the recent developments, policies and enabling ecosystem would bring in direct benefits for all the farmers, inclusive of the small and marginal farmers.

Global warming is the new challenge faced by the agriculture sector and mitigating its adverse effects are being promoted through Research and extension wings. Rice–wheat cropping systems produce huge crop residues which is generally burnt at field for timely sowing of the wheat crop. Flaming of farm residues generates greenhouse gases and aerosols and other hydrocarbons into the atmosphere affecting the air quality. Research shows that nearly, 70%, 7%, 0.66 % of Carbon gets released in the atmosphere, as CO2, CO and CH4 upon burning of rice straw. These gases then lead to localised increase in the levels of aerosols and acid depositions. Hence different techniques that can be developed and adopted at large scale in the region which could reduce the production of the GHGs inclusive of Resource Conservation techniques are as follows:

(a) direct drilling of wheat seeds in standing rice stubbles using "Happy Seeder", direct seeding etc.

(b) short duration varieties

(c) precision land levelling

(d) direct seeded rice

(e) tensiometers based irrigation

(f) alternate wetting and drying practices

(g) mechanical transplanting to improve land and irrigation water productivity

Conservation agriculture:

The sustainability threats in farming can be addressed through adoption of Conservation agriculture. Reduced labour, fuel costs and better moisture regimes are key drivers responsible for adoption of Conservation agriculture. Precision farming are providing further scope for improvement in facilitating Conservation agriculture. Broadly Conservation farming is based on following three principles:

(1) Diverse rotations: rotation of crops changes the rhizosphere affected soil area which gets replenished with its continuous practice. For an eg. shifting to maize in place of rice increases the sustainability and productivity of natural resources of the rice–wheat cropping pattern

(2) Reduced till system: reduced or no tillage sequesters higher fractions of Carbon, thus improving soil quality.

(3) Mulching: mulching is key practice which is helpful in conservation of the soil moisture, maintains the soil temperature and improves water productivity.

Conservation agriculture coupled with other technologies such as earlier sowing and better weed control have the potential to increase yield. Management options viz. mulching, no-tillage etc. represent the evolution and pragmatic integration of Conservation agriculture principles to local conditions and balance resource protection in the long-term with shorter-term productivity imperatives.

(Source: Excerpts from International Soil and Water Conservation Research 2016, Vol.4, Issue 1, 64-74, R.Bhatt et al and Review paper on Crop Diversification: An option for climate change resilience, Trends in Biosciences 10(2), 2017)

Indian Economy during the Pandemic: agriculture the bright spot

The good monsoon and the relentless works of the Government, RBI, NABARD and the Banking sector saw a continuous positive growth trajectory of agriculture sector to the Indian Economy in 2021. In this the part played by the farmer is key to success coupled with the multipronged approaches and programmes of the Government- both the state and central Governments have churned out several strategies to reach out to rural citizen. One of the many programmes launched by the GoI to mitigate the ill-effects of climate change on crop production is the PMFBY, a brief on this yojana is as follows:

1. Pradhan Mantri Fasal Bima Yojana (PMFBY)

- During Kharif 2021, a total of 484.6 lakh farmers applications have been enrolled over an area of 244.7 lakh hectare for a sum insured of Rs.99368 crore.
- Against the budget provision of Rs.16000 crore, Rs.9719.24 crore has been utilised/released during 2021-22.
- Government has announced for augmentation of micro-irrigation fund corpus created in NABARD of Rs.5000 crore by another Rs.5000 crore and continuation during 15th Finance Commission for expanding area of micro-irrigation in country.
- An area of 59.37 lakh hectare has been covered under Micro irrigation in the country from 2015-16 till date under PMKSY-per drop more crop programme.
- Out of the partial claims of Rs.11148 crore for the year 2020-21, claims of Rs.10385 crore have been paid to 110.7 lakh farmer applications.

Salient features of the PMFBY scheme

- The Pradhan Mantri Fasal Bima Yojana (PMFBY) is the world's largest crop insurance scheme and it covers crop damage due to a wide range of climate related risks.
- The scheme launched on 18 February 2016 is having the following main objectives:
  a. Provide insurance coverage and financial support to the farmers in the event of failure of any of the notified crop.
  b. The crop damage as a result of natural calamities, pests & diseases is covered.
  c. Stabilise the income of farmers to ensure their continuance in farming.
  d. Encourage farmers to adopt innovative and modern agricultural practices.
  e. Ensure flow of credit to the agriculture sector.
- **Crops and Notified Area:** The features of crops and notified area covered under the scheme is as follows:
  (a) All Crops with past yield data, grown during the notified season, in a Notified Area
  (b) Crops with yield estimation at Notified Area level - based on requisite number of Crop Cutting Experiments (CCEs) being a part of the General

Crop Estimation Survey (GCES).

(c) Notified Area is the Unit of Insurance decided by the State Govt. for notifying a Crop during a season. The size of the Unit of Insurance shall depend on the area under cultivation within the unit.

(d) For major crops, the Unit of Insurance shall ordinarily be Village/Village Panchayat level and for minor crops could be at a higher level so that the requisite number of CCEs could be conducted during the notified crop season.

(e) States may notify Village / Village Panchayat as insurance unit in case of minor crops too if they so plan.

(f) All farmers growing notified crops in a notified area during the season are eligible.

(g) Insurance is compulsory for farmers in the notified area who possess a Crop Loan account/KCC account (called as Loanee Farmers) to whom credit limit is sanctioned/renewed for the notified crop during the crop season.

(h) Voluntary coverage for all farmers inclusive of Crop KCC/Crop Loan Account holders whose credit limit is not renewed.

- Risks Covered: Following risks leading to crop yield loss (standing crops, on notified area basis) are covered under the scheme:

(a) Comprehensive risk insurance is provided to cover yield losses due to non-preventable risks, such as (i) Natural Fire and Lightning (ii) Storm, Hailstorm, Cyclone, Typhoon, Tempest, Hurricane, Tornado etc. (iii) Flood, Inundation and Landslide (iv) Drought, Dry spells (v) Pests/ Diseases etc.

(b) Prevented Sowing (on notified area basis), in cases where majority of the insured farmers of a notified area, having intent to sow/plant and incurred expenditure for the purpose, are prevented from sowing/planting the insured crop due to adverse weather conditions, shall be eligible for indemnity claims upto a maximum of 25% of the sum-insured.

(b) Post Harvest Losses (individual farm basis), will get coverage upto a maximum period of 14 days from harvesting for those crops which are kept in "cut & spread" condition to dry in the field after harvesting, against specific perils of cyclone / cyclonic rains, unseasonal rains throughout the country.

(c) During local calamities (individual farm basis), loss / damage resulting from occurrence of identified localized risks i.e. hailstorm, landslide, and Inundation affecting isolated farms in the notified area.

(d) Exclusions - Risks and Losses arising out of perils such as war & kindred perils, nuclear risks, riots, malicious damage, theft, act of enmity, grazed and/or destroyed by domestic and/or wild animals, Post–Harvest losses where the harvested crop bundled and heaped at a place before threshing, other preventable risks are excluded from the scheme.

- Premium Rates: The Premium Rate would be charged under PMFBY from farmers as follows:

(a) Kharif season: 2% of sum insured

(b) Rabi season: 1.5% of sum insured

(c) Kharif & Rabi for annual and horticulture crops:5 % of sum insured

(d) The premium for all the notified crops and seasons shall be charged on actuarial rate or as percentage of sum insured (as indicated for notified crops in notified area) whichever is less.

(e) The difference between the premium rate and the rate of insurance charges payable by farmers shall be shared equally by the Centre and State.

- Use of Innovative technology: The scheme promotes cutting edge technology for good quality, timely and reliable yield data. The CCEs may take long time, hence for addressing this problem, video/image capture of crop growth at various stages and transmission thereof with CCE data on a real time basis utilizing mobile communication technology with GPS time stamping improves the data quality, / timeliness and supports timely claim processing and payments. States and insurance companies to utilise this technology.

(Source: data compilation from agricoop.nic.in and pmfby.gov.in/guidelines)

2. Trade and exports from agriculture sector

- The exports and Agri and allied commodities during 2020-21 were Rs. 310811.44 crore as compared to the same period during 2019-2020 thus indicating an increase of 22.86%. The commodities which posted significant growth in exports were wheat, other cereals, rice (other than basmati), soya meal, raw cotton, fresh vegetable and processed vegetables etc.
- Wheat and other cereals posted huge growth over past year with increase to Rs.444.20 crore from Rs.417.08

crores and Rs.1454.72 crore to Rs.5198.42 crore respectively.

- Our nation has witnessed tremendous growth of 839.46 % for wheat export.
- There is significant growth in export of Other Than Basmati Rice that witnessed 147 % increase.
- Export of Other-Than Basmati Rice has gone up from Rs.14400.33 crore in 2019-20 to Rs.35557.04 crore in 2020-21.
- Raw Cotton, Fresh Vegetables and processed vegetables also registered significant increase in export in 2020-21 as compared to corresponding period in 2019-20.
- This increase in exports, during 2020-21 compared to 2019-20 for raw cotton, fresh vegetables and processed vegetables was by 85.27%, 16.69% and 42.41% respectively.
- In terms of actual exports made during 2020-21 for raw cotton, fresh vegetables and processed vegetables stood at Rs.13968.38 crore; Rs. 5388.03 crores and Rs 3150 crore, respectively.
- Despite the pandemic, balance of trade in agriculture has favourably increased during 2020-21 to Rs.156300.23 crore as against Rs.105530.25 crore during the same period in 2019-20.

(Source: data compilation from the Hindu businessline 13 June' 21 and gov.in; agricoop.nic.in)

Eunice Newton Foote

Eunice Newton Foote was an American scientist, inventor and women's rights campaigner. **She is the first scientist who experimented on the warming effect of sunlight on different gases**. She published a paper *Circumstances affecting the Heat of the Sun's Rays*, which was presented at the American Association for the Advancement of Science (AAAS) conference in 1856, **Foote theorized that changing the proportion of carbon dioxide in the atmosphere would change its temperature**. Foote conducted a series of experiments that demonstrated the interactions of sunlight on different gases, namely on carbon dioxide (CO_2), air, and hydrogen.

Of the gases she tested, Foote discovered that CO_2 trapped the most heat, reaching a temperature of 125 °F (52 °C). She concluded that CO_2 gas became got much heated, more than the other gases and it took longer time in cooling. She based on the history of the Earth, theorized CO_2 gas would cause high temperature if it increased in the atmosphere.

Foote was praised in the September 1856 issue of *Scientific American* titled "Scientific Ladies." Impressed with how her findings were backed up by her experiments, stating, "this we are happy to say has been done by a lady". Foote's work for the first time reported that the heating effect of sunlight was affected by CO_2 and water vapour in the atmosphere – thus demonstrating the existence of greenhouse gases. Foote had been the first to propose a connection between carbon dioxide and climate change.

(Source: Wikipedia, the free encyclopaedia 2022)

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