Kurukshetra Summary December 2018

MODERN TECHNOLOGY IN IMPLEMENTATION OF RURAL DEVELOPMENT PLANS

- The Ministry of Rural development has been making sincere efforts to bring prosperity and well-being in the villages through its programs and schemes.
- In order to achieve the desired results of all rural development schemes great emphasis has been laid on adopting modern technology cutting-edge techniques and scientific methods in their implementation. This can be seen from the following schemes:

A. Pradhan Mantri Awas Yojana (Gramin)

- With the objective of providing **pucca houses with basic facilities by 2022** to all the eligible homeless families and the households living in dilapidated houses Pradhan Mantri Awas Yojana-Gramin was launched in November 2016.
- Under this scheme the target is to construct 1 crore residential units till March 2019 and selection is done as per the socio economic caste census 2011.
- Pradhan Mantri Awas Yojna has created employment opportunities in the country on a large scale and also catalyzed skill development in rural areas.
- The use of modern technology and new techniques in the implementation of the scheme has ensure transparency as well as helped in increasing the base of implementation process.
- In each stage of housing construction, Information Technology based **MIS-AwasSoft,** mobile based application **Awas app** and space technology are being used on a large scale for monitoring purpose. All transfer of funds to the beneficiaries are done on the basis of **electronic funds transfer order** (FTO).
- To monitor the progress of housing construction, **showing Geo-referenced photographs** with the help of mobile based application-Awas app and uploading them on awas Soft has been made mandatory. All photographs uploaded are geotagged and time-stamped. These assets can also be seen on **Geo co-ordinated Bhuvan**.
- **Off-line module** of this application has also been launched to register geotagged photograph of houses in areas where there is no network connection
- **Rural housing knowledge network (RHKN)** has being started in collaboration with IIT Delhi with the objective to prepare multilingual web portal in the public sector and to prepare comprehensive nationwide compilation of information related to business houses, institutions and practices associated with affordable and sustainable solution of rural housing.
- It can be updated from time to time and it is available on the website **www.ruralhousingnetwork.in**.

B. Pradhan Mantri Gram Sadak Yojana

- Rural connectivity is an important component of socio economic development of villagers. In India, when the year of planned development started in the year 1951, the road connectivity in the villages was negligible because only 20% of the villagers had all weather roads.
- During the **fifth five year plan**, in the year 1974, the development of rural roads was made a part of **Minimum Needs Programme**.
- Under the various programs of Central and state government pertaining to Employment generation and poverty alleviation rural roads were constructed but overall, their remained a misconception that there was no need for detailed design and engineering for rural roads.
- As a result many thousand km of roads were played without the aid of proper design and Engineering.
- The **subject of rural roads** is included in the constitution under the **state list**,
- The government had, as part of the poverty alleviation work plan meant for the assistance of the states, launched the centrally sponsored scheme of **Pradhan Mantri gram Sadak Yojana** in December 2000.
- The main objective of the scheme is **to provide all weather roads** to the habitation included in core network of planes areas not connected with two roads and having population of 500 and More (as per 2001 census)..
- **National Rural Development Agency** has been constituted for technical and managerial Assistance in the implementation of the program at the Central level where state government has constituted state rural road development agencies.
- Asian Development Bank approved technical assistant in December 2017 to emphasize on sustainability, innovative technology and anti-disaster mechanism in the development of rural roads in the country.
- The **speed of road construction** in the year 2013-14 was 75 km per day, which increase to 134 kilometres per day in 2017-18.
- **Pradhan Mantri gram Sadak Yojana II** has been started for improvement in existing rural Road network. Under this, with the aim of making road network more vibrant, selected rural roads are being upgraded by the use of modern technology and parameters and the target has been fixed to construct 50,000 km of roads.
- Now each state is required to setup simplified maintenance plan and management system to survey the actual situation of the inventory and entire Rural Road network. Data Base is available on **OMMAS** and now it is also necessary to record on the GIS platform.
- Under World Bank assisted PMGSY-Rural Road Project-II, emphasis has been laid on adopting innovative and simplified methods of maintenance of rural roads. Under this mobile application **Aarambh** has been developed which helps in collecting necessary data for preparation of inventory of roads, GIS based mapping for survey of roads surface, cost estimation and annual road maintenance plans and monitoring work.
- **National Institute of rural development** and Panchayati Raj has issued guidelines on technology initiatives for promoting cost-effective technology in the construction of rural roads using new materials, waste material and locally available material.

- Keeping in view of the use of non-conventional materials and environment-friendly Green Technologies in the construction of PMGSY roads, the Ministry of Rural development has fixed State wise target regarding the use of waste plastic and cold mix technology.
- To fulfill the objectives of e-Governance and Digital India, a new mobile application **Meri Sadak** has been launched for resolving complaints related to PMGSY roads.

C. MGNREGA

- The scheme of providing at least 100 days of unskilled manual labour to each family in the form of guaranteed employment in a financial year according to the demand in rural areas is well known as **Mahatma Gandhi National Rural Employment Guarantee Act-MGNREGA**.
- An exclusive initiative named **Geo-MGNREGA** was introduced in the financial year 2016-17 to strengthen the scheme and also to underpin transparency and monitoring mechanism in implementation. Under this initiative space technology is being used for geo tagging of all assets created through MGNREGA.
- **Secure** (Software for Estimate Calculation Using Rural Rates for Employment) is an online application, specially designed and developed to prepare online estimates of MGNREGA works.
- In the financial year 2017-18, an Android-based mobile application **Jan-MGNREGA** was launched which has a large scale feedback mechanism for the public.
- Ministry of Rural development has started the **National Electronic Fund Management System (NEFMS)** from January 1 2016 to for the simplified the fund flow system.

Conclusion:

- Use of scientific methods, state of art technology and latest techniques have greatly helped plan rural development schemes in a better way, execute qualitative work and monitor the rural schemes more effectively and with all these, it has become possible to ensure greater transparency in implementation of schemes.

Digital Health Services: Some Key Initiatives

- **mSakh**i: Is a award winning mobile phone app to help health workers in providing high-quality health care to the families in even the remotest villages in different parts of the country.
- With this app, ASHA workers can use their smartphones to update skills, stay in touch with supervisors, track and report important data about health issues in their communities.
- **Kilkari app**: It delivers free, weekly, time-appropriate 72 audio messages about pregnancy until the child is one year.
- **Mobile academy** – It is free audio training course designed to expand and refresh the knowledge base of ASHA and improve their communication skills.
- Mobile academy has been launched in Jharkhand, Madhya Pradesh, Rajasthan and Uttarakhand.
- **M-Cessation** – This programme being provided as part of any mHealth initiative, aims at reaching out to those willing to quit tobacco use and support them towards successful quitting through text

messages sent via mobile phones.

- **e-Hospital** – It is an online registration services framework portal where people can avail online services such as registration and appointment, pay fees, view diagnostics reports and check for the availability of blood in government hospitals in this portal.
- **ANM On Line (ANMOL)** – It aims to improve the quality, effectiveness and timeliness of the delivery of quality services, specially to rural populations, to ensure better healthcare for women and children.
- **Mera Aspataal** – It is a GoI initiative by the Ministry of Health and Family Welfare, to capture patient feedback for the services received at the hospitals through user friendly multiple channels such as SMS, Outbound Dialing (OBD) mobile application and web portal.

BUILDING AGRICULTURE INNOVATION SYSTEM

- In India, we have daunting challenges. They range from substantial enhancement of our productivity to dealing with challenge of climate change to managing dry land farming to rapid elimination of poverty and malnourishment. Hence, India needs to rapidly move towards **'innovation led agricultural growth'**.

New System:

- We have benefited from our established 'Indian Agriculture Research System'. However, we need to understand that any National Agricultural Research System is **activity based**. Agricultural Knowledge and Information system are **output based**. National agricultural innovation system (NAIS), however, are **outcome** based.
- This new emphasis means that rather than just supporting research and research organizations, or supporting the generation of outputs, such as agricultural knowledge and information, emphasis has to be now placed on supporting **outcomes** that lead to sustainable development and growth.
- In the new National Agricultural Innovation System, we must move to total innovation, involving technological and institutional innovations throughout the production, marketing, policy research and enterprise domains.
- Farmer's role **no more will be confined** to learning adopting and conforming. They must become **co-creators of knowledge**, **process and innovation**. We must move from 'funding for research and research infrastructure' to 'strengthening' the systemic capability for 'total innovation', backed up by an enabling policy environment that fosters innovations.
- The combination of scarcity and aspiration had helped India develop its own brand of innovation-getting **more from less for more people**- not just for more profit. This was called the **MLM paradigm**, i.e., 'More from Less for More'.
- The challenge for the Indian Agriculture Innovation System will be also to get 'more from less for more'. This means getting more output or productivity by using less resource to create benefits for more and more people, not just more and more profit.
- Indian demand for food grains would increase from 192 million tones in 2000 to 342 million tones in 2030.

- Diversion of arable lands for urbanization, industrialization and also for producing bio-fuels will mean less availability of land for agriculture. Availability of 'Less land' is also due to degradation caused by soil erosion, soil salinity and water-logging problems. Available estimates show that over 120 million hectares of land is degraded.
- Furthermore, in India, agriculture is dominated by small farmers, with small landholdings. The average size of the landholdings decreased from 2.30 ha (1970) to 1.32 (2000) and is likely to be reduced to 0.68 ha (2020) and then to 0.32 ha (2030).
- Despite this **'less' land per capita**, we have to get '**more' income** for our farmers. This means developing technological innovations that suit less land holding, or developing affordable implement or involving these small land holders innovatively in agrisupply chain through institutional innovations.

Getting More From Less

- Using the power of new technology, such as information and communication technology, nanotechnology, space technology, modern biotechnology, etc can help. However, a robust policy level innovation is a must to achieve this.
- We could have innovation through **technology-enabled supply chain** through the use of RFID, advanced GIS/GPS, tracing and traceability systems.
- **Precision agriculture** could be achieved with the use of advanced GIS/GPS and sensors can guide planting/irrigation, monitor yields, find tune inputs and achieve 'more from less' by improving yields as well as reduce the use of water and fertilizer.
- Farmers can have real time market information by using mobile communications, voice based call centers, and expert systems for real time price discovery, weather information and cultivation trends.
- Again we can achieve 'more from less' by using leakage-free public system, which uses computerized allocation of food grains, GPS/SMS monitoring, verifiable digital identify and web portal for public grievances.
- Finally, we can have technology enabled crop insurance.
- The **second powerful way** of getting 'more from less' is to **empower more and more farmers with more and more knowledge**. This can happen if the farmer understands the soil that he is sowing his sees in (soil health card).
- The **third way** of getting 'more from less' is by using the **power of 'collective intelligence'**. We must have more innovators becoming active players in the Indian agricultural innovation ecosystem going beyond our formal research and innovation systems.
- National Innovation Foundation (NIF) recognizes such grass roots innovators across India. For example, Dadaji Khobragade from Nanded was one such as 'grassroots innovator'. NIF indentified him and honored him.
- The improved paddy variety, HMT, developed by him has now diffused to several states covering more than one lakh acres. It has been included as a standard reference for thinness by **Protection of Plant Variety and Farmer's Right Variety (PPVFRA)** also!

- The **fourth strategy** is that more 'collective intelligence' of the innovators must be used in enhancing the productivity of the workers in agriculture, while reducing or removing the drudgery in their fields.
- Women comprise over fifty per cent of the total work force in tea gardens in India. Plucking of tea leaves manually involves a lot of drudgery. Can we not develop a tea leaf plucking device?

The Way Forrward

- The decade of 2010-20 was declared as the Indian Decade of Innovation.
- India's ranking among 143 nations has slipped from 62(2011) to 81(2015). However, in the subsequent years, it has steadily improved, 66 (2016), 60 (2017) and 57 (2018).
- Global Innovation Index is largely based on technological innovation. Other countries appear to be speeding faster than India in technological innovation. But India **excels in non-technological innovations** such as business model, system delivery, workflow, organizational, institutional innovations, etc. It also **excels in grassroots innovation**. The Global Innovation Index must be redesigned to account for all this.
- We must build our own Indian **Agriculture Innovation Index**. It is important to do so, because what cannot be measured, cannot be monitored.
- If we do this with determination, then we will achieve the dream of moving rapidly from **'green revolution'**, too much needed '**evergreen revolution'** and '**nutritional revolutions'**.

KRISHI VIGYAN KENDRA: PROMOTING SCIENTIFIC TEMPER

- The diffusion of science, technology and innovation in agriculture is rather the key to increase agricultural production in a sustainable manner.
- In order to draw true potential of farmers towards the state of the art technologies for the betterment of agriculture, Indian government has set up a big chain of over 700 Krishi Vigyan Kendras (KVKs) across the country.
- KVKs are emerging as the regional knowledge hubs and gaining trust of the farmer community. KVKs are the integral part of the national agricultural research and extension system.
- KVKs conduct training and emphasize on learning by doing.

Origin, Philosophy & Objectives of KVK:

- The concept of Krishi Vigyan Kendra was given by **Dr. M.S. Swaminathan**, initiator of green revolution in India and the father of Indian agricultural research.
- Its objective was to cater activities such as technology assessment, refinement and demonstration of technology product.
- The Government of India established first KVK in **Pondicherry during 1974** with the financial support and guidance of Indian Council of Agriculture Research. In **Kapgari Village** of West Medinipur district, the first KVK in West Bengal and second in India was established in the year 1976.
- Presently, around 695 Krishi Vigyan Kendras are existing in different district of India.

- The objectives cum activities of Krishi Vigyan Kendras can be summarized as below :

  (1) **On Farm Testing of new Technologies:**

  (2) **Frontline Demonstration Centre:** It organizes programmes to show the efficacy of new technologies on farmer fields.

  (3) **Capacity Building:**

  (4) **Multi sector Support and Advisory Services:** Krishi Vigyan Kendras offer support to various private and public initiatives through its local network and expertise.

- The study found that KVKs are playing a prominent role in transforming new technology at field level with beneficial impacts.
- This study predicts a better future of KVKs. It exhibits that through KVKs, agriculture related technological development is getting momentum and the final outcome of this expedition is to support national development through a scientifically tempered approach.

Conclusion:

- Krishi Vigyan Kendras provide requisite knowledge through trainings and other activities to improve the skill and attitude of the people particularly farmers towards new technology and approach in farming, provide groper guidance to solve any problem faced by the farming community in agriculture and allied fields.

New Scheme to Promote young Entrepreneurs in Cooperatives

- To cater to the needs and aspirations of the youth, the **National Cooperative Development Corporation (NCDC)** has come up with a youth-friendly scheme **'Yuva Sahakar-Cooperative Enterprise Support and Innovation Scheme**" for attracting them to cooperative business ventures.
- The scheme will be linked to Rs. 1000 crore 'Cooperative Start-up and Innovation Fund (CSIF) created by the NCDC. The scheme envisages 2% less than the applicable rate of interest on term loan for the project cost up to Rs 3 crore including 2 years moratorium on payment of principal. All types of cooperatives in operation for at least one year are eligible.
- NCDC, has also embarked on **Sahakar 22**, a Mission for Doubling Farmer's Income by 2022.
- The NCDC has the unique distinction of being the sole statutory organization functioning as an apex financial and developmental institution exclusively devoted to cooperative sector. It supports cooperatives in diverse fields apart from agriculture and allied sectors.

KNOWLEDGE MANAGEMENT THROUGH DIGITAL TECHNOLOGIES

- A knowledge based society and knowledge sharing environment can make the development process sustainable and accelerate the process of achieving the development goals.
- Reaching-out right knowledge to the right people at right time is always a challenge, owing to various reasons including accessibility and authenticity of information and knowledge from different

sources. Adopting a suitable knowledge Management system or combination of systems and tools is important to reach-out the target audience with intended information and knowledge.

Concept of knowledge management:

- Knowledge Management (KM), a process of leveraging collective knowledge in a particular domain/institution/organization, traditionally includes four processes, i.e, **knowledge creation, knowledge storage retrieval, knowledge transfer and knowledge application**.
- Traditional Knowledge Management systems including classroom teaching and distance mode programs in rural in '**knowledge push'** and very less scope for interactivity. These systems are more 'process-centric' rather than 'people-centric'. But, rapid technological developments over the years, have made the knowledge management process more interactive and people centric.
- The recent trends in ICT have made 'Knowledge Sharing' more efficient and timely.

Different Digital Technologies:

A. Web Portal: A powerful Knowledge Management tool

- Web portals are specially designed single access points to information collected from diverse sources. The information is arranged in portlets in a uniform way for users to access.
- Web portals can be classified as **horizontal** (providing broad range of content for general user) or **vertical** (targeted offering for niche users), also called vortal. Web portals designed for rural advisory services are generally of the second type.
- Some of the key web-portals hosting credible information on Rural Development in India, include – Vikaspedia (www.vikaspedia.in), India Panchayat Knowledge Portal (www.panchayatgyan.gov.in), India Portal (www.india.gov.in), Ministry of Rural Development Portal (www.rural.nic.in), NIRD & PR portal (www.nird.org.in), Panchayat Enterprise Suit (www.pnachayatonline.gov.in), Digitla India Portal (www.digitalindia.gov.in) and DISHA Portal monitoring 42 National Flagship Schemes (www.socialcops.com).
- In India, most of the websites (76%), particularly Government websites, are available only in English and about 24% of the website host bilingual content (hindi/regional language).
- These website are largely institute websites that have a greater focus on organization related aspects. The only predominantly available user centric information is that of policies and schemes of that particular institution.
- Limited scope for the user to share their experiences and knowledge with others and interact with experts or peers.

B. Social Media: A cost effective tool for Knowledge sharing

- Rural Development process demands continuous interaction among multiple stakeholders and learning to take collective action. These services have been called upon to be less 'top-down' and more interactive, and social media can be a potentially powerful tool in this regard.
- Social media is the best knowledge management tool as on today to reach-out the target group in rural areas in shorter time and more effectively.
- Sustainability depends upon the ability of the members to feed the content, add value to content, and support purposeful online engagement. Social media sustainability depends on the capacity of

the stakeholders to address the dynamic information needs of clients and create networking opportunities with peers.

C. Smart Phones: Dynamic power house of Knowledge

- As on 31st August 2018, the total number of mobile users in India were 1167 million (91% of total population), including 519 million subscribes from rural areas, as estimated by Telephone Regulatory Authority of India (TRAI).
- The success and failure of mobile based services broadly on the target group, demand driven content, mode of delivery and sustainability model. Some of the successful mobile based services implemented in India, is listed below:
    - **Rural Development:** *DISHA, Gram Samvad, Awaas App (PMAY-G), Mission Antyodaya App,*
    - **Agriculture and allied sectors:**
    - **Banking:** *BHIMApp, PhonePe, PayTm, FreeCharge, Airtel Money, Idea Money*
    - **Health:** *mSWASTHYA, MOTHER, Indian Blood Donors, Blood4India, eMamta, eAushadhi, Sanjeevani, 1mg App, mTIKKA.*
- Government of India has launched 'Mobile Seva' initiative for mainstreaming mobile governance in the country.

D. Expert System: A virtual expert tool providing solutions for common problems

- An Expert System is basically a software application that attempts to reproduce the performance of an expert in a particular domain. It adopts artificial intelligence to solve a particular problem with the help of pre-set conditions in the software application.
- There are expert systems available in Agriculture and allied sectors developed by Indian Council of Agricultural Research (ICAR) and are widely used in Krishi Vigyan Kendras (KVKs) and other organizations working in remote villages.
- **'Plantix'** is a mobile based plant disease diagnostic tool getting popular in recent days.

E. E-Learning: A solution for large scale capacity building

- Technology Enabled Learning (TEL) including online courses, remote classrooms, video conferencing etc. plays a major role in rural knowledge management.
- E-Learning platforms could be used for offering online course for focused groups in a convenient and consistent manner, providing opportunity for anytime-anywhere learning for the community.
- Massive online open courses (MOOCs) are recent trends which include, SWAYAM (MHRD, Government of India), Coursera, edX, Khan Academy, Udacity and Future Learn.

F. Community Radio:

- Community Radio is a broadcasting system established by the efforts of a specific community, operated by them for the purpose of the community's welfare. These stations are collectively owned by the community, trust or foundations in total locality.
- As on today, there are 186 Community Radio stations operational in India, including 40 in rural areas. The **'Sangam Radio'** started in 2008, by Deccan Development Society (DDS) in Telangana,

is the first NGO operated Community Radio, successfully operated by women's collectives for the past 10 years.

- Unlike other countries, Community Radios are not too successful in India, owing to many reasons including lack of funding, program skills, technology and licencing issues. Government intervention is required to resolve these issues and promote setting-up of more community Radios in rural areas.

INNOVATIVE TECHNOLOGY FOR HIGHER PRODUCTIVITY

- India has achieved a remarkable growth in production and productivity of various agricultural commodities over the last five decades. Major changes in agricultural production took place in mid-1960s with introduction and adaptation of new production technologies which is known as "Green Revolution" technology.
- The agriculture sector observed spectacular growth of over 4% per annum during 1980 to 1990. However, this growth rate did not sustain during 1990s due to several reasons including slowdown in public investment, low yield growth, decline in food productivity, declining water table and environment led stress problems, climate changes etc.

Importance of Agriculture

- Agriculture is still the main livelihood of approximately half of the rural households in India and contributing over 16% to its gross domestic product (GOI, 2018).
- It is estimated that in the year 2035 the total domestic food grains demand will be 398.6 mt and milk 237.8 mt against 264 mt and 132.44 mt respectively in 2013-14. To meet the estimated demand, the yield level over the base period yield (1994-95) is required to be enhanced by more than 50%. It is pertinent to mention here that these targets are to be achieved in a scenario of several odd factors which will constraints the sustainable development of agriculture.
- Agricultural development will have to be therefore guided not only by the compulsion of improving food and nutritional security, but also by the concerns for eco-restoration including conservation ad harnessing of biodiversity, long-term sustainability and profitability under the pressure of global climate change scenario.
- This can be done through two methods: A) Innovations in efficient Input Resources Utilisation and B) System based technologies for increasing resources use efficiency.

A. Innovations in efficient Input Resources Utilisation:

- Site-specific input management which is based on the spatially and temporally variable conditions, have proved tangible yield gain, along with higher efficiency, profits and better soil health. Precision farming technologies have now been developed to spatially vary nutrients within a field based on various information sources.

1. Site-specific Nutrient Management (SSNM):

- Integration of SSNM with GIS based spatial variability mapping is much more useful technique as it provides an opportunity to assess variability in the distribution of native nutrients. It also helps in

assessing other yield limiting/improving soil parameters across a large area and thus aids in developing appropriate nutrient managements strategies leading to better yield and environmental.

2. **Real-time Nitrogen supply:**
   - Synchronization between crop Nitrogen demand and the available N supply is an important key to improve N-use efficiency. Crop N requirements are closely related to yield levels, which is turn are sensitive to climate, particular solar radiation and the supply of nutrients and crop management practices.
3. **Use Decision Support System (DSS):**
   - Use of software based skills like- Nutrient, Experts, Crop manager etc, have proved to be useful.
4. **Improving water productivity**
   - Water productivity defines as the output of goods from the unit of water. The productivity of water irrespective of environment will be governed by those factors which minimize the water losses from the soil system and improve the transpiration water use by the crops.
   - The alternatives for increasing water productivity are changing of *crop varieties, crop substitution, deficit, supplement and precision irrigation, improved water management practices* and improving non-water inputs.
   - Reallocation of water from low value to higher value uses would generally **not help in any direct water savings** but may increase the economic productivity of water.
   - On individual farms, higher productivity requires selection of appropriate crops and cultivars and proper soil and water management technology, improved planting methods. Pressure irrigation system along with fertilizer application (fertigation) resulted in remarkably high-water use efficiency and yield and thus high productivity of water.
5. **Sustained adoption of Micro-irrigation**
   - Several efforts and economic gains, micro-irrigation area in India remains insignificant proportion of its potential.
   - The most important determinants of micro-irrigation adoption include access to groundwater, the prevailing include access to groundwater, the prevailing cropping pattern, level of education, financial resources, the social stratum of the household, and the wealth or poverty status of the farmer.
   - Subsurface drip is a highly efficient irrigation system that uses buried drip tubes or drip tape to meet crop water needs. Since the water is applied below the soil surface (as opposed to surface irrigation or traditional drip irrigation), the effects of surface infiltration, such as crusting, saturated condition of ponding water, and water losses via evaporation and surface run-off (including soil erosion) are eliminated.
   - Water is applied directly to the root zone of the crop as opposed to the soil surface where most weed seeds hibernate. As a result, germination of annual weed is reduced. Furthermore, some crops may benefit from the additional heat provided by dry surface conditions, and produce more biomass.
6. **Nanotechnology**

- Application of nanotechnology has gained momentum to mitigate biotic and abiotic stress as well as other constraints causing low crop yields.
- Some of the main applications of nanotools are:
    - Increase productivity using Nano-pesticides & Nano-fertilizers e.g. Nano zinc particles.
    - Improves soil quality using Nano-zeolites and hydrogels
    - Stimulate plant growth with nanomaterials (e.g. SiO_2, TiO_2 and carbon nano-tubes).
    - Provide smart monitoring using Nano-sensors by wireless communication devices.

B. System based technologies for increasing resources use efficiency

I. Crop diversification

- In general, crop diversification refers to the shift from the regional or temporal dominance of one crop to production of a number of crops, to meet ever increasing demand for cereals pulses, vegetables, fruits, oilseeds, fibres, fodder and fuel, etc.
- Crop diversification has become an important option to attain the following goals:
    - Natural resources sustainability
    - Ecological balance
    - Employment generation
    - Output growth and adequate buffer stocks
    - Risk coverage and reducing the magnitude of risk due to mono-cropping
    - Higher profitability
    - Resilience/stability in production.
    - Attaining self-sufficiency in some crops and earning exchange from others.
- Crop diversification is two types, first one is horizontal diversification which includes the diversification through crop substitution and crop intensification.
- Second one is vertical diversification approach in which farmers and others add value to products processing, regional branding, packaging, merchandizing, or etc to enhance the marketable access of the product.

II. Integrated Farming Systems:

- One of the best approaches in building farm resilience is through spreading risks and creating buffers.
- Integration of livestock rearing with crop production gave higher economic returns compared to crop production alone for both marginal and small farmers.
- Under irrigated areas, the following IFS models are most suitable to maintain soil fertility and productivity.

III. Conservation Agriculture (CA):

- Conservation agriculture refers to the system of raising crops without tilling the soil while retaining crop residues on the soil surface.

- Conservation agriculture permits management of soils for agricultural production without excessively disturbing the soil, while protecting it from the processes that contribute to degradation.
- Three key features of conservation agriculture are: i) Minimum soil disturbance by adopting no-tillage and reduced traffic for agricultural operations, ii).
- Maximum soil covers by leaving and managing the crop residues on the soil surface, as cover/mulch and iii) Adopt spatial and temporal crops sequencing/crop rotation to derive maximum benefits from inputs and minimize adverse environmental impacts. The main advantages of CA are reduction in cost of production, reduced incidence of weeds, saving in water and nutrients, increased yields, environmental benefits, crop diversification opportunities, improvement in resource-use efficiency, etc.

IV. Climate Smart Cropping

- In changing climate scenario, developing cultivars resistance to climate change may become important adaptive mechanism for maximizing resource-use efficiency. For example, crop varieties those are resistant to lodging (e.g., short rice cultivars), may withstand strong winds during the sensitive stage of crop growth, are viable alternative.
- Such adaptation measures like change in crop calendar to reduce the negative effects of increased climatic variability in arid and semi-arid tropics proved advantageous to avoid extreme weather events during the growing season.

V. Integrated Crop Management (ICM):

- ICM suggests the use of good agricultural practices (GAP) which is an alternative system of crop production, which conserves and enhances natural resources while producing quality food on an economically viable and sustainable foundation.
- It combines the best of traditional methods with appropriate modern technology for balancing the economic production of crops with positive environmental management. ICM is particularly beneficial for small and marginal farmers because it aims to minimize dependence on purchased inputs while utilizing on-farm resources.

TECHNOLOGY INTERVENTIONS IN SANITATIONS

- The Swachh Bharat Mission, launched in 2014, is a unique programme that has brought focus on the cleaning up of our cities and villages, in addition to the elimination of open defecation.
- Every year, about 55 million tones of municipal solid waste (MSW) and 38 billion litres of sewage aer generated in the urban areas of India.

Waste can be broadly classified into:

i) Urban/Rural Waste – Municipal Solid Waste, sewage and Faecal Sludge.

ii) Industrial Waste – Hazardous and non-Hazardous

iii) Biomass Waste

iv) Biomedical Waste

Different technologies for waste disposal:

A. Waste to Energy:

- It also called by the term energy-from-waste (EfW) is the process of generating energy in the form of electricity or heat from the primary treatment of waste material.

B. Incineration:

- Incineration, the combustion of organic material with energy recovery is the most common *Waste to Energy* method.
- It entails burning waste to boil water, which powers stream generators that generate electric energy and heat to be used where required. These processes need to meet strict emission standards, including those on nitrogen oxides (NO_x), Sulphur dioxide (SO_2), heavy metals and dioxins. Further, emission of fine particulate, heavy metals, trace dioxin and acid gas, and proper management of residues like toxic fly ash, are matters of concern that have to be handled properly.
- There are arguments that incinerators destroy valuable resources and reduce incentives for recycling, howeve use of incinerators in many places is often done to avoid landfilling.

***C.* Other technologies:**

- These technologies include the following:
    - **Thermal Technologies**
    - **Gasification:** producing combustible gas, hydrogen, synthetic fuels.
    - **Thermal depolymerization:** producing synthetic crude oil, which can be further refined.
    - **Pyrolysis:** producing combustible tar/bio-oil and chars.
    - **Plasma arc gasification or plasma gasification process (PGP):** producing syngas including hydrogen and carbon monoxide usable for fuel cells or generating electricity and other products.
    - **Non-Thermal Technologies**
    - **Anaerobic digestion:** producing Biogas rich in methan.
    - **Fermentation production:** Takes biomass and creates ethanol, using waste cellulosic or organic material. e.g. ethanol, lactic acid, hydrogen.
    - **Esterification –** the result of this process is biodiesel.
    - Mechanical biological treatment (MBT)

India: Waste to Energy Potential

- The Ministry of New and Renewable Energy (MNRE), is actively promoting technology options available for energy recovery from urban and industrial wasters.
- According to the MNRE, there exists a potential of about 1700 MW from urban waste and about 1300 MW from industrial waste.
- Indian Renewable Energy Development Agency (IREDA) estimates indicate that India has so far realized only about 2% of its waste-to-energy potential.

- To promote biofuels in the country, a **National Policy on Biofuels, revised in 2018,** highlights its strategic importance.
- The policy has the objective of reaching 20 per cent ethanol blending and 5 per cent biodiesel blending by 2030. Among other things, the policy expands the scope of feedstock for ethanol production and has provided for incentives to produce advanced biofuels.
- Some of the other innovative initiatives seen are the setting up of a plant to convert plastic waste into bio-diesel to be made operational at the Indian Institute of Petroleum (IIP) in Dehradun.

Different Schemes:

A. Gobardhan:

- As a part of Swachch Bharat Mission, the Government launched the GOBAR-DHAN – Galvanizing Organic Bio-Agro Resource Dhan' scheme in Feb 2018.
- This initiative of the Ministry of Drinking Water and Sanitation, aims to support biodegradable waste recovery and conversion of waste into resources.
- This aims to support, the creation of clean villages which is the objective of Swachch Bharat Mission (Gramin), and provide economic and resource benefits to farmers and households.

Need For GOBARDHAN Scheme:

- Presently, a very large fraction of bio-waste gets disposed in unsafe ways – burning, unscientific dumping, discharging into water bodies etc.
- On the other hand, bio resources such as animal dung cakes, crop residue and firewood are commonly used as cooking fuel leading to indoor air pollution. So, bio-waste has the potential to be harnessed as energy, fuel and fertilizer.
- Rural India generates enormous quantities of bio-waste. At least 5257 tonnes waste/day is estimated to be generated from livestock alone.

B. Plastic Waste:

- Everyday, about 15,000 tonnes of plastic waste are generated across India, of which, 60% is recycled and 40% is disposed unsafety.
- The open burning of plastics generates toxic emissions including carcinogenic compounds such as dioxins. There is an urgent need for attention on the management of plastic waste.

Extended Producer Responsibility (EPR) For Plastic Waste:

- Under this concept, the manufacture and importers of products are to bear a significant degree of responsibility for the environmental impacts of their products throughout the product life-cycle.
- The Indian 2016 Plastic Waste Management Rules also address the question of extended producer responsibility (EPR). They mandate plastic producers, importers and brand owners to contribute to the collection of plastic waste that is introduced by them.

Technology for managing Plastic Waste*:*

There are 4 main ways of managing plastic waste:

- **Re-extrusion**: It involves the introduction of clean scrap of single types of plastics that can be re-entered into manufacturing process to produces similar materials.

- **Mechanical Recycling**: Includes the variety of mechanical processes performed on plastic waste, before it is introduced in manufacturing processes.
- **Chemical and Thermal Recycling**: uses advanced technical processes that convert plastic materials into smaller constituent molecules which can then be used as feedstock to produce petrochemicals and plastics.
- **Energy Recovery**: It burns plastic to produce energy in the form of heat, steam and electricity.

There are efforts, now in the above direction. Some examples of use of plastic waste in India:

i. Plastics for road construction

ii. Waste to fuel plant **in Sriperumbudur in Tamil Nadu** run by Paterson Energy. The plant sources plastic waste from nearby automobile industries and paper manufactures to run a plant at a capacity of 7.5 tonnes/day.

Conclusion:

- Increasing energy needs of the country needs to be met from various sources.
- Management of waste is another national priority due to its impact, if not done scientifically, which can result in huge environmental and health consequences. The possibility of use of waste to generate energy thus becomes a win-like India with high waste, especially bio-waste, production.

DISEASE MANAGEMENT IN HORTICULTURAL CROPS

- Food and Agriculture Organization (FAO) of the United Nations estimates that pests i.e., insects, weeds, plant diseases, rodents and birds cause up to 35 percent of the losses in the crop production worldwide, annually.
- When losses due to pests are combined with postharvest losses, worldwide food losses would amount to 45 percent.
- **Chemical fungicides and fertilizers** have contributed in a major way to boost the crop productivity and production to make India self sufficient in food grain production. However, the use of chemicals in farming finds its way to the environment which creates lot of problems.

Menace of Chemical Pesticides:

- Worldwide, 4.6 million tones of chemical pesticides are sprayed into the environment every year. Developing countries account for 25 percent of world pesticide use in farming, but account for 99 percent of the world's deaths due to pesticides.
- Recent estimates indicate that the economic impact of pesticides on non-target species (including humans) is approximately $8 billion annually in developing countries.
- In India, according to a report of the Ministry of Agriculture, residues of chemical pesticides were detected in 9.2 percent of the samples of different food articles collected between 2006 and 2012, out of which 1.5 percent of the samples contained residues above maximum permissible level.

- Thus, there is a need to promote the use of eco-friendly methods of disease management in our crops to make farming eco-friendly so that the agriculture produce is safe for the use of the consumers.

Alternatives:

- There are number of alternative approaches like botanical pesticides, bio-pesticides, plant resistance, manipulation of cultural practices, use of organic amendments, use of physical approaches like soil solarisation and modern molecular techniques of developing transgenic. In addition, tapping the potential of resistance sources through bio-technological tools have also been effectively used for the management of plant diseases. Nano-formulations of pesticides also have great promise in future to develop safer and green fungicides.

A. Bio-pesticides:

- Microbial pesticides are products derived from various microorganisms (e.g., bacterium, fungus, virus or protozoan) that are used as an active ingredient to control pests.
- E.g. *Bacillus thuringiensis* **,** B. thuringiensis-based biopesticides are an effective tool against lepidopterans insects.

B. Botanical Pesticides:

- Botanicals with antifungal compounds have been identified and these can be exploited for the management of diseases. Botanicals have low mammalian toxicity, target specificity, biodegradability and contain many active ingredients in low concentrations, thus posses biocidal activity against several insect pests and pathogens.
- Among such plants, **neem** is one of the most important trees which have a great potential for disease and insect-pest management in India and Neem pesticides have been reported to control more than 200 species of insect-pests, nematodes and also effective against more than 50 diseases.

C. Soil Solarization:

- It is an effective method to control soil-borne pathogens. Soil solarization is done by covering the moistened soil in summer months with thin transparent polyethylene mulch for capturing solar energy for heating the soil, which becomes lethal to the soil-borne pathogen.
- Bo-fuigation is another effective method of using the local bio-resources available it he field to the disadvantage of the plant pathogens. It is the process of growing, macerating/incorporating certain Brassica or related species into the soil, leading to the release of isothiocyanate compounds through the hydrolysis of glucosinolate compounds contained in the plant tissues.
- Bio-fumigation can be integrated with soil solarisation and it result in synergistic effect in the management of the soil-borne diseases.

D. Biotechnological Approaches:

- Biotechnology is proving to be important tool in plant pathology in understanding the host, pathogen and the process of pathogensis, thus opening new avenues for management of the diseases.
- Recently, two new technologies have emerged which seems to revolutionize the management of plant diseases e.g. miRNA based disease management and development of genome edited crops

using CRISPR/cas system. The biotechnological tools such as genetically modified crops are finding increased acceptance in the world.

E. Changes in Crop Growing Practices:

- Different cultural practices are done during the cropping period and slight modifications/alterations can be effectively used to the disadvantage of many plant pathogens. Cultural practices are modified in a way to that the yield and productivity of the crops is not affected. In these practices, either contact of the pathogen with the crop is avoided/minimized or disease cycle of the pathogen is interrupted.
- Cultural practices that promote soil health include crop rotation, use of crop residues and green manures or organic amendments. Use of soil amendments and green manures promote soil health which helps in greater biological suppression of pathogens. Cultural practices such as exclusion, eradication and sanitation are effective against different crop diseases.
- Incorporation of organic matter in the soil is generally considered to have a beneficially effect on the texture of all type of soils. Crop rotation is one of the important methods in soil and then making it one of the most important methods of management of soil-borne plant pathogens.
- Deep ploughing is another method in cultural practices which affect the survival of plant pathogens as many plant pathogens are oxygen loving and deep ploughing results in the inactivation or death of the pathogen propagules.

F. Use of Resistant Varieties of the Crops:

- Plant is endowed with capacity to defend itself against pathogen and the task before the breeders is to bring that potential to the frontline of commercial cultivars.
- For example, in stem rust of wheat, the threat of new race **Ug 99** is looming large but resistance sources have already been screened to counter the menace. Use of host plant resistance is most effective, economical and eco-friendly tool of disease management.
- Today, Bt cotton is the most important tool which has resulted in considerable reduction in the use of chemical pesticides in agriculture. There are various tools and approaches to use the host plant resistance like gene pyramiding, gene deployment, multiline, sequential release, varietal mixtures, composite like strains.

G. Nano-formulations of Pesticides:

- Different type of materials can be used for the synthesis of nano-particles. Among all, plant extract based silver nanoparticles (SNPs) have good potential for the management of various disease in plants.
- Plants also provide a better platform for nano-particle sysnthsis as they are free from toxic chemicals as well as provide natural capping agents. SNPs have been synthesized from many plants like neem, tulsi etc. Nanoparticles are effective in protecting neem oil from rapid degradation, allowing a prolonged effect on target pests.
- Antimicrobial effect of nano-particle has been attributed due to their small size and high surface to volume ratio which allow them to closely interact with microbial membrane, causing its rupturing and killing of pathogens.

Scope of Bio-pesticides;

- The use of biopesticides in agriculture is fully aligned with market trends that promote healthy eating without neglecting environmental conservation.
- Organic agriculture is practiced in 172 countries around the world and 43.7 million hectares of agricultural land are managed organically by approximately 2.3 million farmers.
- Australia is the country with the largest organic agricultural area, followed by Argentina and the United States of America.
- In India, are under certified cultivable organic farming has increased to 1.49 million ha with production of around 1.35 million tones which will have tremendous requirement of different organic inputs.

Conclusion:

- India needs to take lead by mix of initiatives may be in the form of gradual reduction of toxic chemicals and by incentivizing the production and use of bio-pesticides to promote chemical free farming.

TECHNOLOGY INNOVATIONS FOR SOIL HEALTH PRESERVATION

- Soil is a dynamic system, consisting of organic and mineral matters, air, water and living organisms along with their interactive processes. Soil is formed through a complex process which takes thousands of years to make an inch of soil.
- If managed unscientifically, it can easily be contaminated, eroded and destroyed in a very short span of time.
- Thus, there is a need to understand the soil health and the systems that affect it, so as to devise stregeis for its sustainable use for providing the human needs in the future.

Soil Health:

- Soil health is like animal health where the soil sustains production depending upon the status of soil health attributes.
- Soil health concept involves integration of physical, chemical and biological properties of a soil and role of its harmonious blend in sustaining growth, productivity and environmental security.
- Healthy soils maintain a diverse community of soil organisms that help to control plant disease insect and weed pests etc.
- A healthy soil also contributes to mitigating climate change by maintaining or increasing its carbon content.

Sustainable Soil Health Management:

- A soil that is able to optimally sustain its native/acquired productivity potential and render ecological services is said to be in good health. It is associated with the following characteristics:
    - Minimum soil erosion
    - Good soil physical properties
    - Sufficient soil cover

- Stable soil organic matter
- Improved soil fertility and productivity
- Absence of Soil salinization, sodificatio and alkalinization.

Good practices for Soil health preservation:

1) **Prevent soil erosion:**
   - Soil erosion causes the loss of top layer soil containing organic and mineral nutrient pools.
   - It should be minimized by growing cover plants. Maintaining organic or inorganic residues also protects soil surface. Several other measures are mulching, minimum tillage, no-till by direct seeding, strip cropping, agroforestry, shelter belts, and reduced stocking and grazing intensitities

Common Indicators of Soil Helath		
Chemical Indicators	***Physical Indicators***	***Biologicla Indicators***
Soil pH	Soil texture	Microbial biomass
Soil electrical conductivity	Soil particle and bulk density	Population of soil micro and macro organism
Organic matter content	Penetration resistance of soil	Soil enzyme activities
Total carbon and nitrogen	Aggregate stability	Pollutant detoxification
Cation exchange capacity	Soil water holdingcapacity	Soil respiration
Soil essential nutrient	Soil aeration and porosity	Soil pathogens
Heavy and toxic metals	Soil infiltration rate	

2) **Increase soil organic matter content:**
   - It plays a central role in maintain soil functions and preventing soil degradation. A loss of soil organic matter can cause a decline in soil quality and soil structure, and increase soil erosion, potentially leading to emissions of carbon into the atmosphere.
   - Innovative practices for increasing organic matter content are: managing crop residues, minimum grazing, practicing organic farming, applying integrated method of soil fertility management and pest management, applying animal manure or other carbon-rich wastes, using compost, and applying mulches or providing the soil with a permanent cover, reduced-orno-tillage practices, Implementing crop rotations etc.
3) **Soil Nutrient Balance and Cycles:**
   - It is crucial to select an appropriate plant nutrient management system for sustainable agriculture management.
4) **Mitigating Soil Salinization and Alkalinization:**
   - Salinization reduces crop yields and, above certain thresholds, completely eliminates crop production. Optimum irrigation management should ensure sufficient water for plant growth and

efficient drainage to avoid problems of salinizaiton. Surface and sub-surface drainage system should be installed and maintained to control groundwater tables and control soil salinity.

5) **Minimizing soil contamination:**
   - Contamination occurs if the rate of addition of a given contaminant exceeds its rate of removal from the soil system.
   - Contaminated soils should not be used for foods and feed production.

6) **Conserving soil Biodiversity:**
   - Soil organisms play key roles in the delivery of many ecosystems services. It can be maintained or enhanced through the provision of sufficient vegetative cover optimal nutrient additions, addition of diverse organic amendments, minimizing soil disturbance, avoiding salinization, and maintaining or restoring vegetation such as hedgerows and shelterbelts.
   - Use of nitrogen fixing leguminous species, microbial inoculants, mycorrhizas, earthworms and other beneficial soil organisms should be encouraged where appropriate.

Conclusion

- Hayne (1940) stated that, "**if we feed the soil, it will feed us,"** and that "only productive soil can support a prosperous people." Thus, preserving soil health is vital to human health, ecosystem functions and nature conservation.

BIO FERTILIZERS FOR SUSTAINABLE FOOD PRODUCTION

- It has been observed that up to 90% of applied p-fertilizer (Phosphorus fertilizer) is rendered unavailable for crop uptake due to fixation.
- For P-fixation, **mycorrhizal** inoculation of plants is one of the alternatives. Fungi, which form symbiotic association with roots of plants are refereed **as mycorrhizal fungi** and the association itself is referred to as **"mycorrhizae**".
- Mycorrhiza form a network of filaments that associated with plants roots, increases that associated with plant roots, increases the absorption of nutrients, particularly phosphorus and thus enhance the growth of crop plants and trees.
- Currently, VAM (Vesicular Arbuscular Mycorrhiza) as biofertilizer are utilized in fumigated soils, greenhouse crops, and in the reclamation of disturbed sites. Ectomycorrhizae are employed in the establishment of trees in nurseries and in the production of containerized seedling.
- Various functions of the mycorrhiza (VAM) are as follows:

a) The main function of the mycorrhiza is to dissolve the fixed phosphate available as insoluble phosphate in the rhizosphere zone.

b) Mycorrhiza also helps in the dissolution of trace elements which are in the form of insoluble compounds due to high alkalinity and make them available to the plants.

c) These fungi synthesis certain chemicals like HCN (Hydrogen Cyanide) etc. and release them in the rhizosphere zone, which protect the feeder roots of plants from the attack of various pathogens in the rhizopshere zone.

d) The mycorrhiza also helps during the nitrogen fixation because the phosphate requirement in the nitrogen fixation and water transport is fulfilled through mycorrhizal activity hence mycorrhiza can be used with Rhizobium.

Conclusion

- Mycorrhia, a potential biofertilzer is considered as a boon for agriculture because it provides phosphtae, trace elements to plants by forming a symbiotic association with plats. By the use of nitrogen fixing biofertilizers with mycorrhiza, PSB and organic manure, it will increase the C:N (Carbon to Nitrogen ratio) and ultimately, leading to increased production.

RENEWABLE ENERGY ADOPTION FOR RURAL AREAS

- A village is deemed "electrified", if **at least 10% of the households and public places** such as schools and health centres are connected and receive electricity from the grid, through the transformer established in the village.
- This would still leave 90% of people living in these villages "un-electrified".
- The government did embark on an ambitious program named "**Saubhagya"**, in order to provide power connections to every household by the end of March 2019.
- While the process of electrification **involves 3 steps**, the first being the extension of infrastructure to the village, followed by connecting the household, the last and most critical and challenging part would be the ensure the supply of reliable and affordable energy that is sustainable.

Need For Decentralized Renewable Energy:

- Decentralized renewable energy in the form of mini-grid and rooftop solar are a crucial part of the solution where the grid cannot reach or serve in a reliable manner. It is here that distributed renewable have crucial role to play, for energy to be universally accessible.
- It is a known fact that India relies on coal, to meet 60% of its electricity demands. With stagnation in the production of coal, it would be an uphill task for the government to provide uninterrupted power to its citizens.
- With India's energy distribution companies suffering huge losses and on the brink of collapse, increasing the share of renewable energy in the energy mix should be high on the policy agenda.
- Renewable energy, with its renewability and non-polluting property, promises to grow to be an effective and practical choice guaranteeing the future development of the world.

Types of Renewable Energy:

- International experts have categorized renewable energy as traditional and new. The former referring to giant hydropower and biomass burnt directly, while the latter refers to small hydropower, geothermal energy, wind energy, biomass energy, solar energy, ocean energy, etc.
- While **hydroelectricity** refers to potential and kinetic energy of water being converted into electricity in hydroelectric plants, **Geothermal energy** is available as heat emitted from within the earth's crust, usually in the form of hot water or steam.
- In **solar plants** the solar radiation is exploited for electricity generation and hot water production.
- In **Tide/Wave/Ocean**, the mechanical energy derived from tidal movement, wave motion or ocean current are exploited for electricity generation. In **wind**, kinetic energy of wind is exploited for electricity generation by the use of wind turbines.
- In **biogas plants**, the gases composed principally of methane and carbon dioxide that are produced by anaerobic fermentation of biomas, or by thermal processes which includes landfill gas, sewage sludge gas, other biogases from anaerobic digestion and biogases from thermal process are utilized.

Challenges and Opportunities:

- A number of possible constraints to RE adoption include: (i) unfamiliarity with the technology, (ii) lack of awareness of the environmental benefits, (iii) opinion that the technology is unreliable, (iv) belief that the technology can have harmful side effects, (v) unsuitable location for the installation, (vi) inability to access sufficient credit, (vii) invested capital needs elsewhere, the (viii) fear of the administrative work involved in RE systems
- A recent study from Bihar suggests that a critical determinant of electricity access in rural India is proximity to the Central power grid. This essentially suggested that remote villages in rural India would be deprived of access to power. Hence, it is imperative that rural India develops and adopts self-sustaining community-managed local generation, storage and grid-connected electricity models (popularly termed microgrids).
- The Government of India should consider setting up of the solar plants through *a large number of Renewable Energy Cooperatives rather than through setting up Mega Solar parks.* It is better to set up 5000 numbers of 1 MW plant in each village rather than setting up a single 500 MW in one location.
- Off-grid rural electrification with RE is the best alternative to provide electricity for the rural population.
- **Grossbardorf, a village in Germany** runs a successful **micro grid rural cooperative model** that generates four times the electricity need to power individual businesses and homes of the community. Excess power is fed back to the main electricity and through a feed-in tariff system, and the revenue generated is shared equally among the various stakeholders.
- A **biomass-based rural cooperative** in Tumkur district of Karnataka owes its success to institutional aspect like will-defined property rights in ownership, institutionalized markets and decentralised environmental governance.
- One of the reasons why the cooperative model of enterprise has been effective is that it responds to the increasing demand for democratization of energy.

- The growth of energy cooperatives, particularly in the renewable energy sector, suggests that cooperatives are increasingly being chosen by people around the world to respond to their needs.
- However, this growth is also attributable to increasing public interest in community-owned and locally based energy solutions, new energy regulations and support measures for renewable energy, and raised awareness on green issues and climate change.

Conclusion:

- Renewable energy-based rural cooperative models across India would require high levels of initial seed capital. Banks, governments and international agencies such as the United Nations may not help in achieving the scale of financing required.
- So, it is imperative that private players such as big industrial houses and high net-worth philanthropic individuals take the lead in establishing rural energy cooperatives. The needs of the hour is a private-cooperative partnership.