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Renewable ENERGY

the new paradigm

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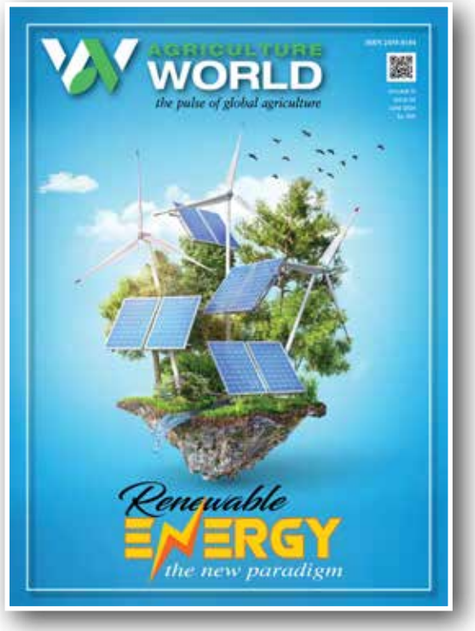

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CONTENT

THE VISION

M C Dominic
Founder & Editor-in-Chief

Renewable Energy - A Game-Changer For Indian Agriculture

India's agricultural sector, a cornerstone of its economy, is on the cusp of a transformative revolution through the adoption of renewable energy. Renewable energy sources, such as solar, wind, and biomass, promise to address some of the most persistent challenges faced by Indian farmers, from erratic power supply to escalating fuel costs, while fostering sustainable agricultural practices.

The integration of solar energy, in particular, is poised to be a game changer. Solar-powered irrigation systems are reducing dependence on diesel and grid electricity, offering a reliable and cost-effective solution for farmers. These systems not only lower operational costs but also enhance productivity by ensuring timely and adequate water supply. The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme aims to install solar pumps and grid-connected solar power plants, reflecting a strong governmental push towards this transition.

Wind energy, though less prevalent in the agricultural context, holds significant potential, especially in regions with favorable wind conditions. Small-scale wind turbines can complement solar power, providing a consistent energy supply that is crucial for operations like milling, drying, and cold storage, which are essential for value addition and reducing post-harvest losses.

Biomass energy, derived from agricultural waste, presents another opportunity. Converting crop residues into biogas or biofuels can mitigate the pollution caused by stubble burning. This not only provides a cleaner energy source but also adds an income stream for farmers through the sale of biomass.

The shift to renewable energy in agriculture is more than just an economic necessity; it is a path to sustainability. It aligns with India's commitments to reducing carbon emissions and combating climate change.

By embracing renewable energy, Indian agriculture can achieve higher resilience, improved livelihoods for farmers, and a sustainable future. This energy transformation is not merely an option; it is an imperative for the prosperity of India's agricultural sector and the overall well-being of its rural communities.

Millionaire Farmers of India

Gateway to Rural India's Prosperity

India's agricultural landscape is witnessing a remarkable transformation with the emergence of millionaire farmers, heralding a new era of prosperity in rural areas. These successful farmers, who have leveraged modern techniques, innovative practices, and strategic market linkages, are not only elevating their own economic status but also serving as beacons of hope and inspiration for their communities.

The success stories of "Krishi Jagran Millionaire Farmers of India" are rooted in diversification and value addition. By moving beyond traditional crops and embracing high-value produce like exotic vegetables, fruits, organic products, and floriculture, these farmers have tapped into lucrative markets both domestically and internationally.

Technological adoption has been a critical factor in this transformation. Precision farming, use of advanced machinery, drip irrigation, and greenhouse farming have significantly enhanced productivity and efficiency. Access to real-time market information and direct-to-consumer platforms through digital technology has enabled these farmers to fetch better prices, bypassing intermediaries and reducing losses.

Government policies and schemes have played a supportive role. Initiatives like the Pradhan Mantri Fasal Bima Yojana (PMFBY) and the Kisan Credit Card (KCC) scheme provide financial security and credit access, empowering farmers to invest in modern agricultural practices. The establishment of Farmer Producer Organizations (FPOs) has also fostered collective bargaining and improved market access.

The ripple effects of millionaire farmers' success extend beyond individual prosperity. They create employment opportunities, stimulate local economies, and inspire neighboring farmers to adopt progressive methods. Moreover, their success underscores the potential of agriculture as a viable and lucrative career, especially for the younger generation.

As millionaire farmers continue to pave the way for rural prosperity, their journey highlights the importance of innovation, education, and supportive policies in transforming the agricultural sector. Their success is not just a personal achievement but a testament to the potential of rural India to thrive and contribute significantly to the nation's economic growth.

"Krishi Jagran Millionaire Farmers of India" showcases the transformative journeys of India's most successful farmers. These visionary agriculturists have harnessed advanced techniques, innovative practices, and strategic market connections to achieve unprecedented prosperity.

Their stories not only highlight the potential of modern agriculture but also inspire countless others in rural communities. By embracing technology, diversification, and sustainable practices, these millionaire farmers exemplify how agriculture can be a lucrative and empowering career.

Their achievements underscore the crucial role of progressive farming in driving rural economic growth and shaping a prosperous future for India's agrarian landscape.

Shiny Dominic

Managing Director

A New Paradigm for Growth

In today's rapidly evolving world, the demand for Energy is escalating every day. Agriculture is no different! Adopting renewable energy sources not only contributes to a greener environment but also has a positive impact on the economics of farming. By harnessing the potential of solar panels, wind turbines, or biofuel production, farmers can decrease their reliance on expensive conventional options and lower operational costs.

Renewable energy sources such as solar, wind, and biomass, farmers can reduce their dependence on fossil fuels and mitigate greenhouse gas emissions. Solar panels can be installed on farm buildings or integrated into crop canopies to generate electricity, while wind turbines can be strategically placed in open fields to capture wind energy. Additionally, biomass resources such as agricultural residues and organic waste can be utilized to produce biofuels or biogas for on-farm energy production.

Furthermore, renewable energy deployment in agriculture opens up new avenues for income generation and economic growth in rural communities. Farmers can participate in energy markets by selling surplus electricity generated from renewable sources, thereby diversifying their revenue streams and enhancing financial stability. Renewable energy sources, such as solar, wind, and biofuels, offer numerous benefits to private farm operations and large-scale commercial agriculture. Our Farmers are embracing renewable energy as a pathway to a sustainable and economically viable future.

Renewable Energy: A New Paradigm for Growth in Agriculture presents a transformative vision for agricultural sustainability by integrating renewable energy technologies into farming practices. This paradigm shift not only addresses the pressing need for clean energy but also offers multifaceted benefits for agricultural productivity, environmental conservation, and rural development.

The adoption of renewable energy technologies in agriculture fosters resilience against climate change impacts by diversifying energy sources and reducing vulnerability to energy price fluctuations. Moreover, it promotes energy independence and self-sufficiency, empowering farmers to become net energy producers and contribute to the decentralization of energy systems.

The synergy between renewable energy and agriculture extends beyond energy production to encompass sustainable land management practices and environmental stewardship. Agroecological principles can be integrated with renewable energy projects to promote soil health, biodiversity conservation, and water resource management. For instance, agroforestry systems combining tree planting with solar energy installations can enhance carbon sequestration, improve microclimate regulation, and provide additional sources of income for farmers.

In conclusion, "Renewable Energy: A New Paradigm for Growth in Agriculture" advocates for a holistic approach to agricultural development that leverages renewable energy as a catalyst for innovation, resilience, and prosperity. By embracing this new paradigm, stakeholders across the agricultural value chain can collectively contribute to building a sustainable future for agriculture, energy, and the environment.

Mamta Jain

Group Editor & CEO

Millets The Global Food

Strategies for Enhancing Production and Utilisation

To facilitate the movement of the millets, GOI has revised the guidelines for movement of the surplus production of millets to other states

Millets are the traditional food grains cultivated without much demand for the resources and consumed in various forms. In the recent past, the consumption has been reduced due to the cumbersome in the preparation of grain for the processes and shift to the other grains, viz., rice, wheat, etc. This has resulted in the reduction in the cultivation and the production. Farmers, cultivating the millets mainly as rain fed crops, also less preferred to cultivate millets due to less market value. Realizing the nutritional importance of the millets and the livelihood of the millet cultivating farmers, Government of India declared millets as Nutri-cereals and globally the year 2023 has been declared as International Year of Millets by the United Nations. It would be appropriate to develop strategies and propose policies to the government for effective implementation to bring increase in area and production of millets, better utilisation of millets at industries level, higher returns to the farmers and processors and ensuring the nutritional security.

India produced 173 lakh tonnes of millets from an area of 138 lakh ha. which is 80% of Aisia's and 20% of global share (from 718 lakh ha.). Indian average yield is 1239 kg/ha. against the global average yield of 1229 kg/ha (FAO Stat, 2021). Millets are a rich source of protein, fibre, minerals, iron, calcium and have a low glycemic index. In 2012, through a brain storming session, National Academy of Agricultural Sciences (NAAS), New Delhi has brought a policy paper (Policy paper No. 54) and suggested, enhancing productivity, increasing the minimum support price for millets, harnessing the nutritional and therapeutic virtues of millets, increasing the awareness of the nutritive quality of millets and millet based food products, ensuring proper markets for millets and millet based food products, increasing the consumption of millets, and integration of millets in fortified foods chain.

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AGRICULTURE WORLD

Many of these recommendations / policies have been implemented by the Government of India, including declaring the year 2018 as National Year for Millets, all the millets, as Nutri – cereals, formation of Sub Mission on Millets under National Food Security Mission, etc. Several State Missions on Millets were launched by the states in India. Millets were included under Poshan Mission (Abhiyan) by Ministry of Women & Child Development. Through the programme National Agricultural Development Programme, the Government of India has implemented a scheme "Initiative for Nutritional Security through Intensive Millets Promotion (INSIMP) in the millets growing states to establish the rural processing centres at block level.

GOI Initiatives To Promote Millets

The Government is popularizing nutri-cereals through Research & Development support and has established 3 Centres of Excellence (CoE) at Chaudhary Charan Singh Agricultural University, Haryana, ICAR- Indian Institute of Millets Research, Hyderabad and University of Agricultural Sciences, Bangalore. Support is also given to start-ups and entrepreneurs for developing recipes and value-added products that promote consumption of millets.

To facilitate the movement of the millets, GOI has revised the guidelines for movement of the surplus production of millets to other states. The provision of inter-state transportation of surplus millets through Food Corporation of India (FCI) is incorporated to cater for advance demand placed by consuming state before the start of procurement (https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1796559 – 18.10.2022). Through these initiatives and policies, popularization of the millets in terms of hybrids / varieties, nutrition, consumption, etc. has only been highlighted and achieved. Policy proposals in terms utilization of millets to increase the consumption pattern, both at household and industry level and thereby increasing production are left with much scope.

The Gaps

Though the union and state governments have taken many policy steps in the recent past and implemented several schemes and programmes on promotion of millets, they aimed at developing hybrids / varieties, cultivation packages, processing and value addition technologies, value added products, market network, providing minimum support price, etc. These approaches achieved the popularisation of the Nutri-cereals and strengthened the research activities than expected and however the achievement on the utilization part still lag, which will increase the cultivation and improve farm income status. The issues still exist in this scenario can be summarised in the following way.

- Still in many states policy driven approach with target to increase the area and production of millets does not exist.
- Farmers are not motivated through incentives / subsidies and support prices for the cultivation of millets.
- Though exclusive markets / boards exist for various produces / commodities, millets have not gained similar importance.
- Technologies of value addition and the products have reached only the household / cottage industry level and yet to reach the industries for large scale utilization of millets.
- Large scale utilisation of millets at industry level has not been initiated / motivated by both union and state governments.

Thus, there is scope to discuss the above issues and propose policies to the government for implementation to increase the utilisation of millets.

Stretegies To Increase Production And Utilisation

Considering the issues listed, there is vast scope on the following aspects to bring the millets back to its fame in terms of production, utilisation, increasing the availability of nutrients, increased farm income, etc.

- Development of strategies to bring larger area under cultivation of the less resources demanding millet crops and increase the production through appropriate motivation to the farmers with incentives and subsidies.
- Establishment of good market network and ensuring the supply chain through appropriate government agencies.
- Focus on the refinement / scaling up of value addition technologies and millet products for large scale venturing through industries.
- Identification of the areas of utilization of millets at industry level production through incorporation / substitution / replacement of the other cereal / pulses to the accepted level.
- Identifying the areas of extending benefits to the industries and motivate for utilising millet crops in their process and production activities and focusing their products for both domestic and export.
- Supporting the start-ups linked to research organisations, incubation centres, etc. involved in value addition of millets in terms of incentives.
- Sustaining the creation of awareness to the consumers on the nutritional importance through millets.
- Identification of the avenues for intervening with millet-based products in the regular feeding activities in mass scale, viz., school children through noon meal scheme, feeding the patients, feeding the inmates of government run homes / hostels.

Approaches And Policies Demanded

With the interventions made by the earlier schemes / programmes and policies, identification of the gaps to be filled with the strategies, the following policies are demanded to enhance production and utilization of millets towards sustainable nutritional security and farm income.

- To bring larger area under cultivation of the less resources demanding millet crops through subsidies / incentives for the inputs, support price, etc. to compensate the revenue loss due to this choice of millet crops than any other cash crops.
- To support the farmers through timely procurement of millets, storage and distribution for large scale utilization.
- Extending financial support through research grants to the selective institutes for the refinement / scaling up of millet processing technologies for immediate adoption by industries.
- To make amendments in the food laws for incorporation / substitution / replacement of the other cereal / pulses to the accepted level with millets in the food products.
- Formulation of packages extending benefits to the industries, start-ups and incubation centres utilising millet crops in their process and production activities through tax concession, incentives, etc.
- Start-ups technically supported by the research organisations and incubation centres, and small enterprises may also be supported on quality control to meet the standards to export millet-based products.
- Bringing it as mandate to the Public Health Departments of the state governments to create awareness to the consumers on the nutritional importance of millets.
- Formulation of suitable laws / amendments to include millet-based products in the government schemes involving regular feeding activities, viz., noon meal scheme for schools, feeding the patients at government hospitals, feeding the inmates of homes / hostels run by union and state governments.

New Emission Norms For Tractors

– A Bane or Boon?

> We do have environmental issues but what is to be seen is the percentage of pollution attributed to tractors running in fields in remote areas. Does the Indian farming community need this disruption at all?

India is the largest producer of farm tractors in the world with an annual volume of approximately 9 lakh tractors besides, being the largest exporter of tractors in the world. The industry is an ideal case for the clarion call on 'Make in India and Sell to the world'. The tractors conducive for Indian farming conditions are built for usage in small farms.

The Bharat Stage Emission Standards (BSES) are instituted by the Government of India to regulate the output of air pollutants from compression ignition engines and spark-ignition engines equipment, including motor vehicles and agriculture implements. In India, the Emission norms evolved from BS -1 to BS-3 level in 2010. The nomenclature of Bharat Stage (BS) was changed to TREM (Tractor Emission) in the year 2020.

In 2010-11, TREM-3A Emission norm, more stringent and with further reduction in Emission values for Higher HP was introduced for 50+ HP Tractors in October 2011.The Indian Tractor Industry was moving towards higher HP Tractors with steady growth for 50+ HP models. Tractors in the 50+ HP Segment, starting from 2006, grew from 5% to 11% over 5 years. However, after the introduction of the TREM- 3A Emission Norms the Industry volume suffered degrowth, in the Higher HP Segment. The 50+ HP Segment moved from 11% in 2011 to less than 5% in 2013.

In 2022. TREM IV was made applicable to 50+HP segment of tractors in India. The total sales dropped by 65% to a meagre 20000 this year, after the implementation of TREM IV on >50 HP tractors from April 2023. The new technology could not be adopted by farmers due to issues related to technical complications, lack of after sale service and operational expertise.

The current scenario in India is that TREM 3 is applicable in all the tractors below 50 HP and TREM IV is applicable in all tractors above 50 HP.

The Government of India has decided to adopt TREM V emission norms for all category of tractors wef April 2026.

This will not just have severe impact on tractor sales but will be detrimental for farmers due to the technical complications and Indian environmental conditions, since TREM V norms necessitate the use of sensitive equipment, sensors and systems.

Farmers with low and average land holding less than 2 acres do not need this change. The average power of tractor used in farms is 40 HP that costs around Rs 6 lakh. The cost after implementation of new emission norms will add a cost of around Rs1.5 lakh to Rs 2.0 lakh per tractor.

In European Countries (EU), the farm sizes are large, ranging from 75 acres to 500 acres and the average power of the tractors is 125-150 HP. These farms have well trained operators and fully equipped workshops to take care of the repairs and maintenance of these machines.

The new norms as applicable in Europe, and proposed to be implemented in India, are not even applicable in advanced countries like Australia, USA, Brazil, and Thailand. We do have environmental issues but what is to be seen is the percentage of pollution attributed to tractors running in fields in remote areas. Does the Indian farming community need this disruption at all? The Government of India would need to rethink, relook, and rework on this before taking this giant leap forward.

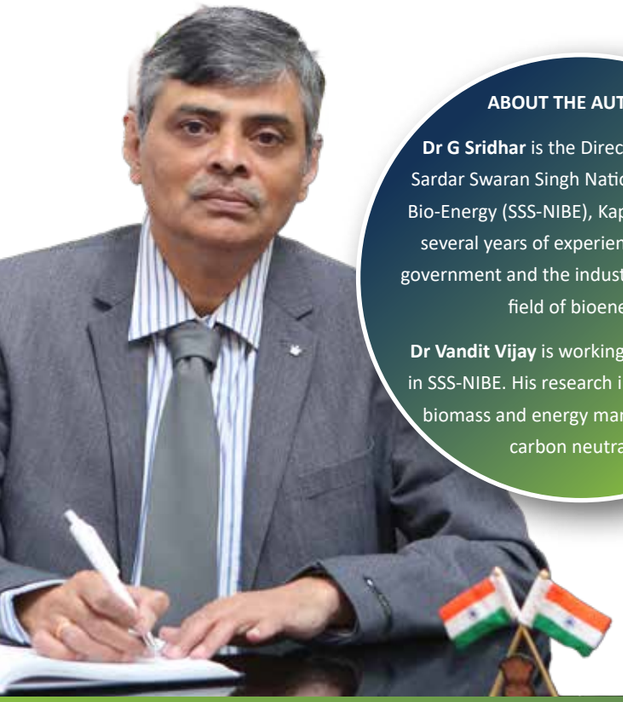
> By harnessing the potential of biomass, India can pave the way for a greener, more resilient, and energy-independent future while driving agricultural growth and rural prosperity

A New Paradigm for Growth *in Agriculture*

One of the primary challenges in India's agricultural landscape is the lack of adequate storage facilities, infrastructure, and supply chains. Additionally, addressing the environmental impact of food loss and waste, biomass burning, and rotting organic matter is significant. However, the same agricultural residues generated during crop cultivation, which pose problems, can also be solutions for a variety of other issues such as energy security, waste management, soil fertility improvement, and livelihood generation.

Harnessing Biomass for Energy Generation

Biomass, comprising agricultural residues, forestry residues, and livestock waste, presents a golden opportunity to bridge these divergent needs. A study conducted by the Administrative Staff College of India (ASCI) for the Ministry of New and Renewable Energy (MNRE) estimated that India has an annual agricultural residual biomass generation of ~750 Million Tonnes (MT) of which 230 MT remains surplus every year having a biomass power potential of about 28 GW.



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Prominent Bioenergy Technologies

Several existing bioenergy technologies hold promise in harnessing biomass for energy generation and value-added products. From energy perspective, these technologies can serve the whole spectrum of energy demands such as electricity generation, thermal applications (cooking/heating/cooling), and transportation fuels (petrol/diesel/CNG):

Agricultural Growth Pathways with Bioenergy

Enhanced bioenergy production offers various pathways for agricultural growth:

Production of organic fertilizer/biochar/compost

The use of chemical fertilizers (with import costs> Rs 40000 crore) in farming has significantly increased with time, leading to decreased soil fertility, health hazards, and environmental degradation as their production and transportation are energy and emission intensive. Fermented organic manure produced along with biogas during anaerobic digestion is a nutrient-rich organic substitute for chemical fertilizers. Biochar obtained from pyrolysis, is a versatile material whose application to farms can lead to positive effects on soil fertility, crop yield, and carbon sequestration. Composting is another well-proven method to convert organic waste into compost that can help improve soil quality and crop productivity. Govt. of India, giving due importance to biofertilizers from biogas plants, launched the Market Development Assistance scheme in 2023, with a Rs 1451.8 Crore budget to promote sustainable/organic agricultural practices.

Bioenergy generation for enhanced crop production

Crop productivity in India is low, particularly for rain-fed agriculture (accounts for about 51 % of the country's net sown area and nearly 40 % of total food production) and manual cropping practices. Productivity is affected by inadequate irrigation facilities and the inability to afford expensive fossil fuels (diesel, coal) driven power and transport applications. Decentralized bioenergy generation in the form of solid, liquid, or gaseous biofuels can power farm applications such as farm mechanization, irrigation, biomass supply chains, and fuel for farm machinery/tractors to enhance crop production.

Powering Food/Grain Storage/Cold Storage Facilities From Bioenergy

A significant amount of crops/food produced gets rotten due to inadequate post-harvest care (Indian post-harvest losses amounted to Rs 1.5 trillion). The cold storage facilities are insufficient leading to crop wastage and financial losses to the farmer. Decentralized biomass-based cold storage and biomass based drier options have been developed that could be owned and operated locally by farmers having the potential to preserve the produce and also increase the shelf-life reducing the wastage and loss which in turn can sustainably enhance farmer's income and overall rural economy.

Harmful Effects of Crop burning on Soil Nutrients

Burning of crop residues adversely affects the soil nutrients. For instance, burning one tonne of paddy straw releases 60 kilogram carbon monoxide (CO), 1460 kilogram carbon dioxide (CO2), 199 kilogram ash, 3 kilogram particulate matter, and 2 kilogram sulfur dioxide (SO2) into the atmosphere while also killing important microorganisms in the soil. It also leads to depletion of essential soil nutrients i.e., nitrogen (5.5 kilogram), phosphorous (2.3 kilogram), potassium (25 kilogram) and sulphur (1.2 kilogram), and other micro-nutrients besides organic carbon. Thus, by converting this agricultural residue into bioenergy can provide clean energy, preserve soil and the environment.

Government Initiatives and Schemes

The launch of programs, schemes, and incentives from the Government of India for sustainable agricultural practices and bioenergy adoption indicates the seriousness with which these issues are being tackled at a national level. Prominent schemes include the National Bioenergy Programme (NBP), Galvanizing Organic Bio-Agro Resources Dhan (GOBARdhan), Sustainable Agrarian Mission on use of Agri-Residue in Thermal Power Plants (SAMARTH), Sustainable Alternative Towards Affordable Transportation (SATAT), Ethanol Blended Petrol (EBP) Programme, Paramparagat Krishi Vikas Yojana (PKVY), Mission Organic Value Chain Development for North Eastern Region (MOVCDNER), and National Mission on Oilseeds and Oil Palm (NMOOP).

R&D play a crucial role in assisting the policies of the Government by providing technological solutions to address various challenges in the agricultural domain. SSS-NIBE is one such institution in the country that is working towards developing some of the technologies mentioned above such that the agricultural sector could contribute to sustainable energy growth of the country other than food production.

The innovative approaches under the schemes and technology development align harmoniously with the Sustainable Development Goals (SDGs), reinforcing goals related to clean energy, sustainable agriculture, livelihood generation, and climate action, offering a roadmap for a more sustainable and prosperous rural India.

GREEN HORIZONS

KPMG

> It is time to embrace renewable energy as the new paradigm for sustainable agriculture growth

ABOUT THE AUTHOR

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India's Green Revolution, catalysed in the late 1960s, marked a pivotal era of agricultural transformation, significantly enhancing productivity and food security. With the adoption of high-yielding crop varieties, modern agricultural practices, and increased fertiliser usage, India's agricultural landscape underwent a remarkable shift. According to the Food and Agriculture Organization (FAO), India's cereal production surged from 90 million metric tons in the mid-1960s to over 350 million metric tons by 2022.

However, this monumental shift has come with challenges. The exponential demand for energy, water, and chemical inputs to sustain intensive agricultural production has taken a toll on the environment and public health. Soil degradation, water scarcity, loss of biodiversity, and greenhouse gas emissions have emerged as pressing challenges, casting a shadow over the sustainability of India's agricultural model. Additionally, disparities in access to resources and benefits persist, exacerbating socioeconomic inequalities among farmers.

Quiet Revolution

Recognizing the urgent need for transformative change, a quiet revolution unfolding in the heart of the modern agricultural landscape – a shift towards a new paradigm driven by renewable energy. Central to this paradigm shift is the imperative to leverage solar, wind, and other clean energy sources to reduce the country's reliance on fossil fuels, mitigate greenhouse gas emissions, and enhance energy security for rural communities.

Solar power, harnessed through photovoltaic cells and solar thermal systems, offers a clean and renewable alternative to fossil fuels. One of the most innovative and promising approaches in this endeavour is the concept of agro-voltaic systems. These systems, which combine solar energy production with agricultural activities, utilise the same land for both solar panels and crop cultivation, thus maximising land efficiency while minimising environmental impact. This dual-use approach not only generates clean energy but also provides shade and shelter for crops, reducing water evaporation and enhancing yield in arid regions. Further, the shade-loving nature of certain crops makes them well-suited for cultivation beneath solar panels, creating additional revenue streams for farmers. Countries around the world such as Japan, Germany, France, etc. are increasingly embracing agro-voltaic systems as a key strategy for sustainable agriculture growth.

Transforming Agriculture

Beyond agro-voltaic systems, renewable energy holds immense promise for transforming agriculture into a more sustainable and resilient industry. Solar-powered irrigation systems, for example, offer an efficient and environmentally friendly alternative to diesel pumps, reducing greenhouse gas emissions and energy costs for farmers. In regions prone to water scarcity, such as arid landscapes or drought-prone areas, solar pumps provide a lifeline, enabling sustainable agriculture practices without exacerbating water stress.

From powering grain mills to electrifying rural communities, wind energy, too, offers a versatile and environmentally friendly alternative to conventional power sources. Wind turbines integrated into agricultural landscapes provide not only clean energy but also additional income through lease agreements with landowners. Furthermore, wind energy complements solar power, providing a reliable energy source even during periods of low sunlight or at night. By diversifying the energy mix, farmers can enhance energy security and resilience, ensuring uninterrupted operations in the face of changing weather patterns and climate extremes.

One must also not forget that in the cyclical rhythm of agriculture, waste begets wealth through the conversion of biomass into renewable energy. Agricultural residues, such as crop residues, animal manure, and food waste, hold immense potential as feedstocks for bioenergy production. Through anaerobic digestion, biomass gasification, and biofuel refinement processes, farmers can transform organic waste into biogas, biofuels, and bioelectricity.

Priority Areas

In the quest for sustainable agriculture, India must also prioritize carbon sequestration and adopting climate-smart food production strategies to mitigate the impacts of climate change. Agroforestry, wetland restoration, and soil carbon sequestration initiatives hold immense potential to enhance carbon sinks, improve soil health, and build climate resilience in agricultural landscapes. Additionally, investing in climate-smart technologies and early warning systems can empower farmers to adapt to changing climatic conditions and minimize production risks.

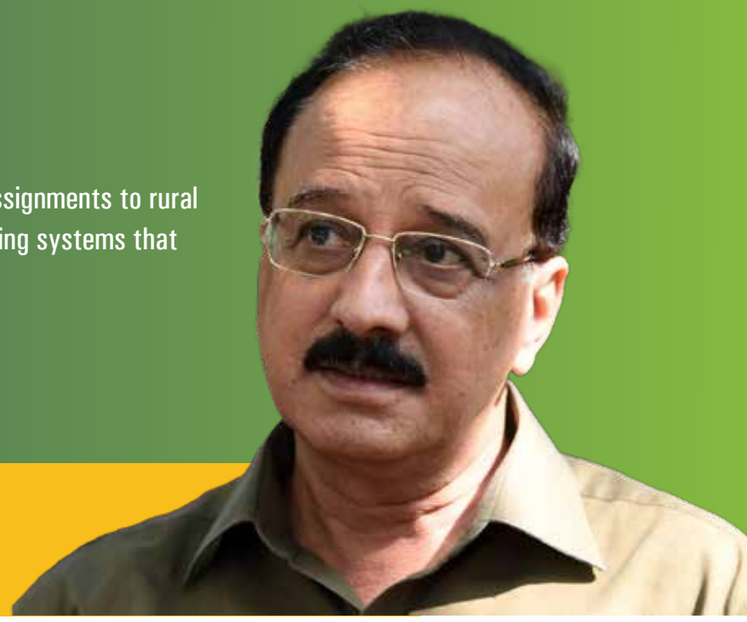
While the potential of renewable energy in agriculture is undeniable, realizing this vision requires concerted efforts from policymakers, institutions, and stakeholders. Governments play a pivotal role in creating an enabling policy environment through incentives, subsidies, and regulatory frameworks that promote renewable energy adoption and investment. Institutional support is essential for capacity building, technology transfer, and knowledge dissemination to empower farmers to become energy producers and stewards of the land within the agricultural sector. Innovative financing mechanisms, such as renewable energy cooperatives and community solar initiatives, enable smallholder farmers and rural communities to access and benefit from renewable energy technologies. By pooling resources and sharing infrastructure, these collaborative approaches democratize energy access and empower farmers to become active participants in the transition to a low-carbon economy.

In sum, as we stand at the crossroads of environmental sustainability and agricultural development, the choice is clear: embrace renewable energy as the new paradigm for sustainable agriculture growth. By harnessing the power of the sun, wind, and other renewable resources, we can cultivate a future where food security, energy independence, and environmental stewardship go hand-in-hand. Through collaborative efforts and bold innovations, we can cultivate a resilient and thriving agricultural landscape that nourishes both people and the planet.

Why a shift to natural farming is needed

Chemical farming is not only harmful to human health but also to the environment. The overuse of chemicals has destroyed soil fertility and contaminated the environment

> Policy planners should be sent for study assignments to rural areas to learn from the chemical-free farming systems that our progressive farmers have developed



About The Author

Mr Devinder Sharma is a noted food policy analyst and an expert on issues related to the agriculture sector. He writes on food, agriculture and hunger

Addressing a 'Regional Consultation on Science of Natural Farming' the other day, how Dr Yogita Rana, a Joint Secretary of the Ministry of Agriculture and Farmers Welfare, explained the importance of healthy foods, simply floored me.

I must say what the Joint Secretary said, and how well she articulated her argument against chemical inputs, was not only very courageous but exemplary. Although such saner voices in the bureaucracy are very limited, I only wish that the top administration – whether in science, agriculture and technology – were to introspect and see that the world has moved far away from the days of the Green Revolution when chemical fertiliser and pesticides were aggressively pushed to increase crop productivity.

We need healthy food, healthy environment, wealthy farmers

While the era of chemically-induced farming systems is now gradually receding into history, what is now urgently required is a food system transformation that results in healthy food, healthy environment and wealthy farmers.

As a student of agriculture, and then as a researcher, writer and policy analyst, I was always appalled at the folly of applying huge quantities of poison to increase crop production. The quantum of chemical pesticides that the standing crops were literally drenched with, and also the overuse of synthetic fertilisers that not only destroyed soil fertility by harming millions of bacteria and fungi that helps create organic material so essential for plants that a naturally-endowed healthy ecosystem was uprooted. Again, when it comes to genetically-modified crop varieties, the effort was to transfer a gene from a related (and also from unrelated species) to enable the plant to build its own toxins so as to take care of harmful pests.

As a student, I remember reading one of the research papers of late Prof David Pimental, a distinguished entomologist at the Cornell University and an influential champion of the environment, where he concluded saying that only 0.1 per cent of the pesticides applied hit the target pests. The remaining 99.9 per cent of the chemical pesticides being sprayed contaminate the environment. This study came out in the mid-1970s, and was simply ignored. That was the time when Green Revolution was at its peak, and when in the quest for increased productivity agricultural universities across the globe were pushing for fertilisers, pesticides, herbicides etc which eventually did more harm to human health and environment.

Stirring the pot

This is where I see Yogita Rana very ably stirring the pot. Providing a peep into the future, and more importantly brushing aside the corporate pressures that bureaucrats always appear to be working under, her clarity of thought was very clear and of course impressive.

Observing the global trends, especially at the time when temperatures are soaring, she said that the society is at a cusp in history when after a few years' synthetic fertilisers and other chemical inputs will not be a part of the dominant discourse. This is essentially because of a new awakening that has taken over the world in the post-Green Revolution period. People want safe and healthy food, and are willing to pay for it.

Shock therapy

Curious, I followed her talk on YouTube (web link here: https://www.youtube.com/watch?v=cy4A2DUJaUY). To make her point, she had carried a few packets of chemical fertilisers like Urea, Di-Ammonium Phosphate (DAP), and also a few micro-nutrients like Boron, Zinc Sulphate and Magnesium Sulphate that farmers normally apply in crop fields.

To her question how much should we normally eat -- a spoonful or a pinch of the chemical -- that should be sufficient for a human body, there was no response. The huge audience, which mainly comprised of agricultural scientists and farm officials, had obviously gone quiet.

What she was trying to convey is that while scientist and agricultural officials invariably ask farmers to apply heavy doses of synthetic inputs, these chemicals gets absorbed by the plant system, and eventually ends up in the food we consume. It was a kind of shock therapy that she effectively delivered.

On an average, she said the average consumption of chemical fertilisers is 138 kg per hectare although in some areas the application is much higher. The higher the fertiliser dose, the higher is the intake by plants. And yet, no scientist wants to consume even a spoon of chemical fertiliser.

At the same time, availability of carbon in Indian soils has come down to 0.3 per cent. But in lot many organic farms, the carbon availability is much higher. We have to learn from these farmers.

Calculating the damage

This reminded of a News Today programme which was telecast ten years ago by BBC News titled: How much sugar in Coca Cola? James Quincey, the then company's president for Europe, was taken by surprise when the journalist fished out a small cup that people normally buy in a cinema and poured out 23 sachets of sugar from the cup. The bigger cup that is also available in cinema halls contains as many as 44 sachets of sugar. This came as a shock for the company's president who obviously didn't know how to respond.

Similarly, the invitation to consume a small quantity of chemical fertilisers that scientists and agricultural officials otherwise force the farmers to apply, did come as a rude shock to those present. But I only hope they take home the underlying message, and start looking afresh at the polluting farm systems and how to transition towards healthier systems that do no more damage to the environment. As I have often said, agricultural universities have to take on the new role. They have to be the not only the pivot but a driver of the agro-ecological farming systems that the world is looking towards. There is ample evidence available now that productivity of these farming systems is no less than conventional agriculture. So let's not be brow-beaten by the agribusiness industry that continues to create a fear psychosis saying the shift towards agro-ecology will create food insecurity.

I am only hoping that more and more bureaucrats, because they call the shots when appropriate policies are framed, are sent for study assignments to the rural areas, and are expected to learn the numerous chemical-free farming systems an amazing lot of progressive farmers have developed over the years. These time-tested technologies are not only regenerative but location-specific, and utilise the locally available resources. These organic systems, based primarily on Low External Input Sustainable Agriculture (LEISA) approaches, should certainly be vetted by the formal agricultural research system and adopted. It is therefore high-time the Indian Council of Agricultural Research (ICAR) – the umbrella agricultural research body of the country – draws collaborative efforts with these farmers who hold the key to the future of Indian agriculture.

(The article first appeared on Bizz Buzz)

The Vital Shift

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> India achieved a significant milestone in September 2023, crossing 70,000 MW of solar installed capacity

With the goal of sourcing half of its electricity from renewable sources by 2030 and achieving net-zero emissions by 2070, India has made great strides in the adoption and development of sustainable energy sources. India, which has the fifth-highest installed capacity of renewable energy in the world, has undertaken programmes like the Green Energy Corridor project to incorporate renewable energy plants into the national grid. Major states like Karnataka, Tamil Nadu, Maharashtra, Gujarat, and Rajasthan contribute almost 67% of the country's total installed renewable energy capacity.

India's Renewable Energy Potential

India has a vast renewable energy potential, being the first country to establish a Ministry of Non-Conventional Energy Sources in the early 1980s. This was renamed as the Ministry of New and Renewable Energy in October, 2006 which reported India's installed renewable energy capacity to be 179 GW as of May 31, 2023. Of this capacity, solar and wind energy made up 67 GW and 43 GW, respectively.

Table 1: Total renewable energy mix in India (in GW)

Sources	As of March, 2022	As of May, 2023	Target for 2030
Wind power	40.35	42.86	140
Solar power	53.99	67.07	280
Biomass power	10.20	10.24	10
Small hydro	4.84	4.94	70
Waste to energy	0.477	0.55	(No target)
Total	109.88	125.69	500

(Source: Indian Central Electricity Authority, 2023)

Types Of Renewable Energy Sources Used In Agriculture

Solar Energy: India achieved a significant milestone in September 2023, crossing 70,000 MW of solar installed capacity, placing it among the top 5 countries globally. Indian agriculture faces challenges like climate change-induced extreme weather and inadequate electricity supply, with agriculture demanding 20% of India's total electricity but receiving only 8% due to heavy subsidies and free power.

Agri-voltaics (integrating solar panels at elevated levels of 2-3 meters allowing for crop production below or in between the rows of solar panels emerges as a sustainable solution. The techno-economic analysis of the agri-voltaic project installed at ICAR-CAZRI, reported by Poonia et al. (2020), highlighted favourable economic viability, with a Benefit-Cost Ratio (BCR) of 1.46, indicating returns that exceed costs, and an Internal Rate of Return (IRR) of 21.67%, reflecting a solid annualized rate of return on investment. Bihar exemplifies this with its innovative floating solar panel project at the Durgawati Dam in Kaimur district, showcasing how renewable energy initiatives can also address land scarcity and water conservation issues. Such projects align with India's goal of sustainable development and climate resilience.

Wind Energy: Wind energy, the second most preferred renewable after hydropower, is converted into electricity by wind turbine-based plants, both onshore and offshore.

Hydro Energy: Hydro systems, including micro-hydro plants, can power farms, machines, communities, and cities.

Bio-energy: Bio-energy aids waste management by converting organic waste into biogas through anaerobic digestion, which can be used for heating, electricity, or fuel. This process manages waste and produces renewable energy, lessening farming's environmental impact.

Geo-thermal Energy: In cold regions, geo-thermal heat pumps warm greenhouses, extending growing seasons and boosting crop yields. It also aids in drying crops, processing agricultural products, and heating irrigation water, cutting fossil fuel use and carbon emissions.

Hydrogen Energy: Hydrogen fuel cells power agricultural machinery, cutting fossil fuel use. It's also key in producing ammonia-based fertilizers and storing excess renewable energy for high-demand periods.

Major Ongoing Schemes in India

The Ministry of New and Renewable Energy is driving several impactful schemes:

PM- Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM)

- Promotes decentralized solar energy
- 88.45 MW capacity solar power plants installed under Component-A
- 1.81 lakh stand-alone solar pumps under Component-B
- 1174 solarised pumps under Component-C

Roof Top Solar (RTS) Programme Phase-II

- Targets 4 GW RTS in the Residential sector
- Around 1.66 GW capacity installed by December 31, 2022
- 7.6 GW of grid-connected RTS plants overall

Development of Solar Parks and Ultra Mega Solar Power Projects

- Scheme has approved 57 Solar Parks with a cumulative capacity of 39.28 GW in 13 states

These efforts are bolstered by the Production Linked Incentive (PLI) Scheme for National Programme on High Efficiency Solar PV Modules, Green Energy Corridor, Human Resource Development Programme wherein Suryamitras are given training, and the Renewable Energy Research and Technology Development (RE-RTD) Programme focusing on cost reduction, reliability and efficiency improvement, all contributing to India's renewable energy growth.

Challenges and Solutions

Challenges include the focus on fossil fuel reserves, inadequate government funding, price gaps between fossil fuels and renewables, and insufficient experience in managing environmental impacts in developing nations.

To overcome these challenges, subsidies and support for renewable energy are increasing, with efforts to expand policies and production globally. Governments must enforce effective policies and consider the interconnected elements affecting renewable energy sustainability.

Collaboration among decision-makers, researchers, and manufacturers is crucial for building and sustaining renewable energy infrastructure. Balancing economic growth with environmental protection is also vital. Innovation and research are key to improving renewable energy's economic, technical and energy conversion efficiency. Technological learning, government incentives, along with social awareness and acceptance play crucial roles in increasing renewable energy implementation rates. Continued research is essential to ensure the appropriate selection and implementation of renewable energy resources based on location.

Revolutionizing Growth & *Sustainability in Agriculture*

Pump Academy, a pioneering company in the field of smart pumping solutions, has introduced, iPUMPNET, the innovative Smart Pumping System

With the world population continuing to grow and food demand on the rise, the agriculture industry faces immense pressure to enhance yields while minimizing water and energy usage and environmental impacts. Conventional farming practices, heavily dependent on fossil fuels and recognised for high greenhouse gas emissions, are no longer sustainable.

In India, agriculture has a rich history that employs more than 50% of the Indian workforce and contributes over 20% to the country's GDP. It is the world's largest producer of milk, pulses, and spices and ranks second in farm outputs globally. India also leads in wheat, rice, and cotton produce and exports agricultural and horticultural products to over 120 countries.

Agriculture Sector Challenges

The agriculture sector is facing difficult challenges in terms of water and labour shortages, escalating energy demands, and the disrupting effects of climate change, including floods and droughts, along with stringent environmental regulations requiring proactive measures. Rapid population growth, urbanization, and changing dietary patterns are putting immense pressure on agricultural systems, exacerbating existing problems and creating new ones. Soil degradation, water scarcity, and biodiversity loss threaten the long-term viability of farming practices, while pests, diseases, and extreme weather events disrupt crop production and livelihoods. A pivotal approach to mitigate these challenges could be the integration of advanced agricultural technology, policy reforms, energy efficiency and sustainable practices into their farming operations.

Renewable Energy in Agriculture

The adoption of renewable energy in agriculture offers a promising solution. By integrating renewable sources into operations, a new era of sustainable and environmentally friendly farming practices is emerging.

The adoption of renewable energy in agriculture offers numerous benefits that extend far beyond just reducing the sector's carbon footprint. By harnessing the power of clean and renewable sources like solar, wind, and bioenergy, farmers can significantly reduce their reliance on costly electricity and polluting fossil fuels. This not only lowers operational expenses but also insulates agricultural sector from the volatility of energy markets, ensuring greater economic stability and profitability.

One of the most promising applications of renewable energy in agriculture is the use of solar power for irrigation systems. In many regions, access to consistent and reliable water sources is a critical factor in achieving optimal crop yields. Solar-powered irrigation systems can pump water from wells or surface sources, providing a sustainable solution for water management. These systems are particularly beneficial in remote areas where grid connectivity is limited or non-existent, enabling farmers to irrigate their fields without relying on expensive and polluting diesel generators.

Renewable energy can also play a vital role in powering various agricultural operations, from greenhouses and livestock facilities to processing plants and storage facilities.

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Mr Anil Sethi is Chairman, Pump Academy Private Limited. He established the company with the vision of offering innovative solutions aiming to transform pumping stations into technologically advanced, automated, and responsive machineries. He has received numerous awards and accolades for his nation-building initiatives

For instance, solar panels can be installed on the rooftops of barns and sheds, generating clean electricity to power lighting, ventilation, and heating or cooling systems. This not only reduces energy costs but also ensures a consistent and reliable power supply, essential for maintaining optimal conditions for livestock and crop growth.

As the costs of renewable energy technologies continue to decline and their efficiency improves, the economic case for their widespread adoption in agriculture becomes increasingly easier. Farmers who embrace these sustainable practices not only contribute to mitigating climate change and preserving the environment but also position themselves to capitalize on emerging market opportunities for eco-friendly and ethically sourced agricultural products.

Pump Academy's Contribution

Pump Academy, a pioneering company in the field of smart pumping solutions, has introduced, iPUMPNET, the innovative Smart Pumping System. This cutting-edge technology working on AI and IIoT is revolutionizing the way water is pumped and utilized in agricultural operations, promoting sustainability and resource efficiency.

At the core of Pump Academy's smart pumping is an advanced pump control and monitoring system that optimizes water usage and energy consumption. This intelligent system uses real-time data and predictive algorithms to adjust pump performance based on factors such as crop water demand and weather conditions. The key advantage of iPUMPNET is its ability to reduce water wastage and energy consumption associated with traditional irrigation methods. By precisely managing water flow and pressure, the system minimizes overwatering and ensures that crops receive the optimal amount of water needed for healthy growth, leading to improved crop yields and water conservation.

Smart Pumping System

In addition to water savings, the Smart Pumping System also contributes to energy efficiency in agricultural operations. By optimizing pump performance and reducing unnecessary energy consumption, the system helps farmers lower their energy costs and carbon footprint, aligning with sustainable practices and environmental stewardship. Pump Academy's smart pumping also incorporates remote monitoring and control capabilities, allowing farmers to track and manage their irrigation systems from anywhere, using mobile devices or web-based interfaces. This feature enables proactive maintenance, minimizes downtime, and facilitates data-driven decision-making for more efficient resource management.

The iPUMPNET integrates seamlessly with renewable energy sources, such as solar panels or wind turbines, enabling farmers to utilize clean energy sources to power their irrigation systems. This not only reduces their reliance on fossil fuels but also contributes to the overall sustainability of agricultural practices.

Way Forward

The integration of renewable energy into agriculture represents a paradigm shift towards a more sustainable and resilient food production system. By harnessing the power of clean and unlimited energy sources, farmers can reduce their carbon footprint, lower operational costs, and enhance their long-term profitability. This transition not only benefits the environment but also contributes to the economic well-being of rural communities and supports the development of a more sustainable and equitable global food system.

Propelling Growth

> Biomass can be converted into biofuels such as biodiesel and bioethanol through processes like fermentation

Renewable energy has the potential to significantly enhance agricultural sector growth by addressing key challenges of increased energy requirements, improving productivity, and fostering sustainability.

If we take a quick look at the Energy Stats of the net imports of India in Fossil fuels, we will get a bird's eye view of where we are headed in terms of fossil fuel consumption in the coming years.

The agricultural sector is one of the largest energy consumers globally, with energy-intensive activities such as irrigation, machinery operation, and processing contributing significantly to its energy footprint.

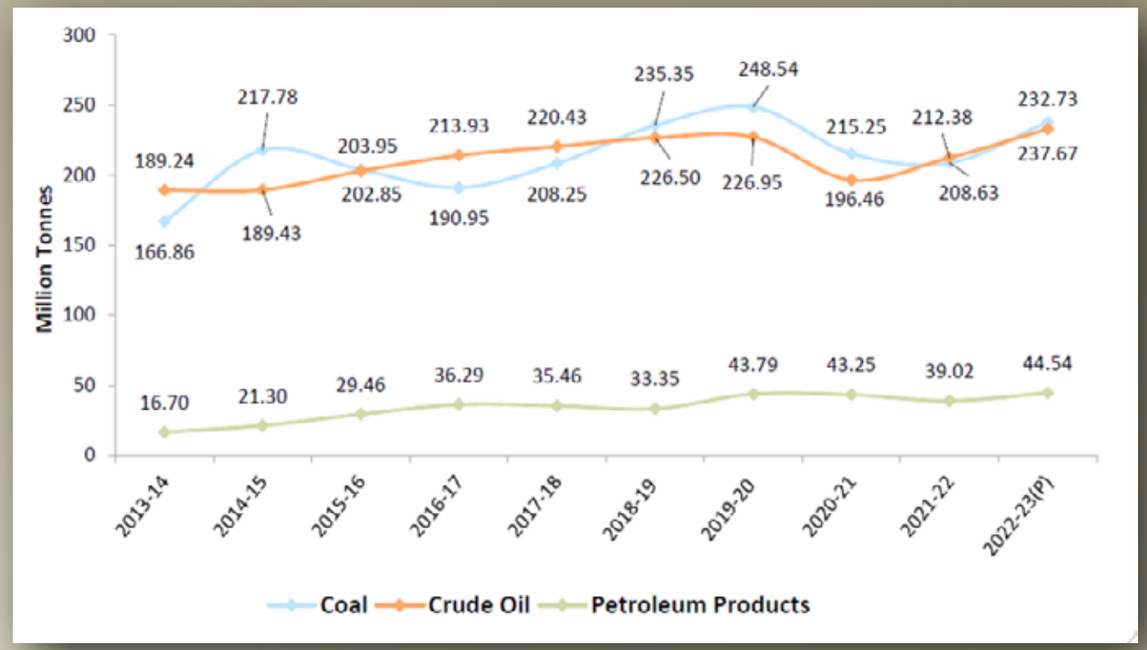
Energy in multiple forms like electricity, gases fuels for cooking & transportation, liquid fuels for transportation, generators, agriculture pumps, mobility-like tractor and farming equipment movements, etc are all needed to be decarbonised and agriculture residues to all forms of energy is the simple and effective way forward.

Benefits of Renewable Energy

Environmental Sustainability: By reducing greenhouse gas emissions and mitigating environmental impact, renewable energy adoption in agriculture can enhance the sector's reputation for environmental stewardship. This can lead to increased market opportunities, premium prices for sustainably produced goods, and improved brand reputation, ultimately driving sector growth.

Economic Viability: By investing in renewable energy infrastructure such as solar panels, wind turbines, or biomass digesters, farmers can reduce their energy costs over the long term. This allows farmers to allocate resources more efficiently, reinvesting saved funds into other aspects of their operations, thereby promoting growth and innovation within the sector.

Decentralised Renewable Energy: Energy sourcing and energy generation in a decentralised manner improves energy efficiency, reduces energy transmission or transportation costs and overall empowers the agriculture sector to have more control on the energy access and energy utilisation. Combination of solar, wind, biomass energy for various energy generation sources to include electricity, RNG/CBG for transportation, heating & cooling solutions for drying and cold storages, 2G ethanol for transportation, production of high value fuels like SAF, etc are all happening which will make the agriculture sector to be net generator of energy generation and energy distribution, and all this to be specifically RE.



Diversification of Income Streams: Through mechanisms such as feed-in tariffs, net metering, or renewable energy certificate programs, farmers can generate revenue by selling excess electricity back to the grid or participating in renewable energy incentive schemes. This diversification of income streams not only strengthens individual farm economies but also contributes to overall sector growth and resilience. Carbon credit markets are fast evolving, and farmer stakeholder participation is finding prominence. Thus, new revenue streams are coming up for farmers.

Energy Security and Resilience: On-site renewable energy generation, such as solar panels or wind turbines, ensures a reliable and consistent energy supply, even in remote or off-grid locations. This resilience to energy disruptions strengthens the overall resilience of agricultural operations, enabling farmers to better withstand unforeseen challenges and fluctuations in energy prices. Ann Data Se Urja Data is the a dream which is soon to be reality and the farmer is actually transforming the energy landscape by becoming the food and energy provider.

Technological Innovation: The integration of renewable energy technologies with emerging agricultural innovations, such as precision farming, smart irrigation systems, and automated machinery, can unlock new synergies and efficiencies. For

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example, solar-powered irrigation systems can optimize water use and increase crop yields, while data-driven analytics powered by renewable energy can enhance decision-making and resource management on the farm. This integration fosters technological innovation within the agricultural sector, driving productivity gains and fostering growth.

Applications of Renewable Energy in Agriculture

Solar Power: Solar energy is perhaps the most accessible and widely adopted renewable energy source in agriculture. Solar panels can be installed on farm buildings, irrigation systems, and open land to generate electricity for various on-farm operations.

Wind Power: Wind turbines can be strategically deployed in agricultural landscapes to harness wind energy for electricity generation. Wind power is particularly suitable for farms located in windy regions or open plains.

Biomass Energy: Agricultural residues such as crop residues, animal manure, and organic waste can be converted into biogas or biofuels through processes like anaerobic digestion or biofuel production, providing renewable sources of heat and power.

Hydropower: In regions with access to flowing water bodies, small-scale hydropower systems can be installed to generate electricity for agricultural purposes, such as powering irrigation pumps or farm machinery.

Biomass Energy – A Force Enabler

Biomass energy holds significant promise as a renewable energy source in agriculture, offering a sustainable solution to both energy production and waste management. Agricultural residues, including crop residues, animal manure, and organic waste, represent abundant and readily available feedstocks that can be converted into valuable biogas or biofuels through various processes such as anaerobic digestion and biofuel production.

Anaerobic digestion, a biological process in which organic materials such as crop residues and animal manure are placed in a sealed digester where bacteria break down the organic matter, producing biogas composed primarily of methane and carbon dioxide. Biogas can then be used directly as a renewable fuel for heating, electricity generation, or as a vehicle fuel, offering a versatile energy source for agricultural operations. Additionally, the byproduct of anaerobic digestion, known as digestate, is rich in nutrients and can serve as a valuable fertilizer for crops, completing the nutrient cycle and enhancing soil fertility. This closed-loop approach not only reduces the environmental impact of waste disposal but also promotes sustainable agricultural practices.

Biofuels

Biomass can be converted into biofuels such as biodiesel and bioethanol through processes like fermentation and transesterification. Crop residues, dedicated energy crops, and organic waste can be utilized as feedstocks for biofuel production, offering an alternative to fossil fuels in transportation and machinery operation. Biofuels derived from biomass are renewable, carbon-neutral, and can be seamlessly integrated into existing fuel infrastructure, making them a promising solution for reducing greenhouse gas emissions and mitigating climate change.

The utilization of biomass energy in agriculture not only provides a renewable source of heat and power but also offers economic benefits to farmers. By converting waste materials into valuable energy products, farmers can reduce their reliance on fossil fuels, lower energy costs, and potentially generate additional revenue through the sale of excess energy or biofuel feedstocks.

The deployment of biomass energy technologies can contribute to rural development and job creation, as it often involves localized production and processing facilities, thereby stimulating economic activity in agricultural communities.

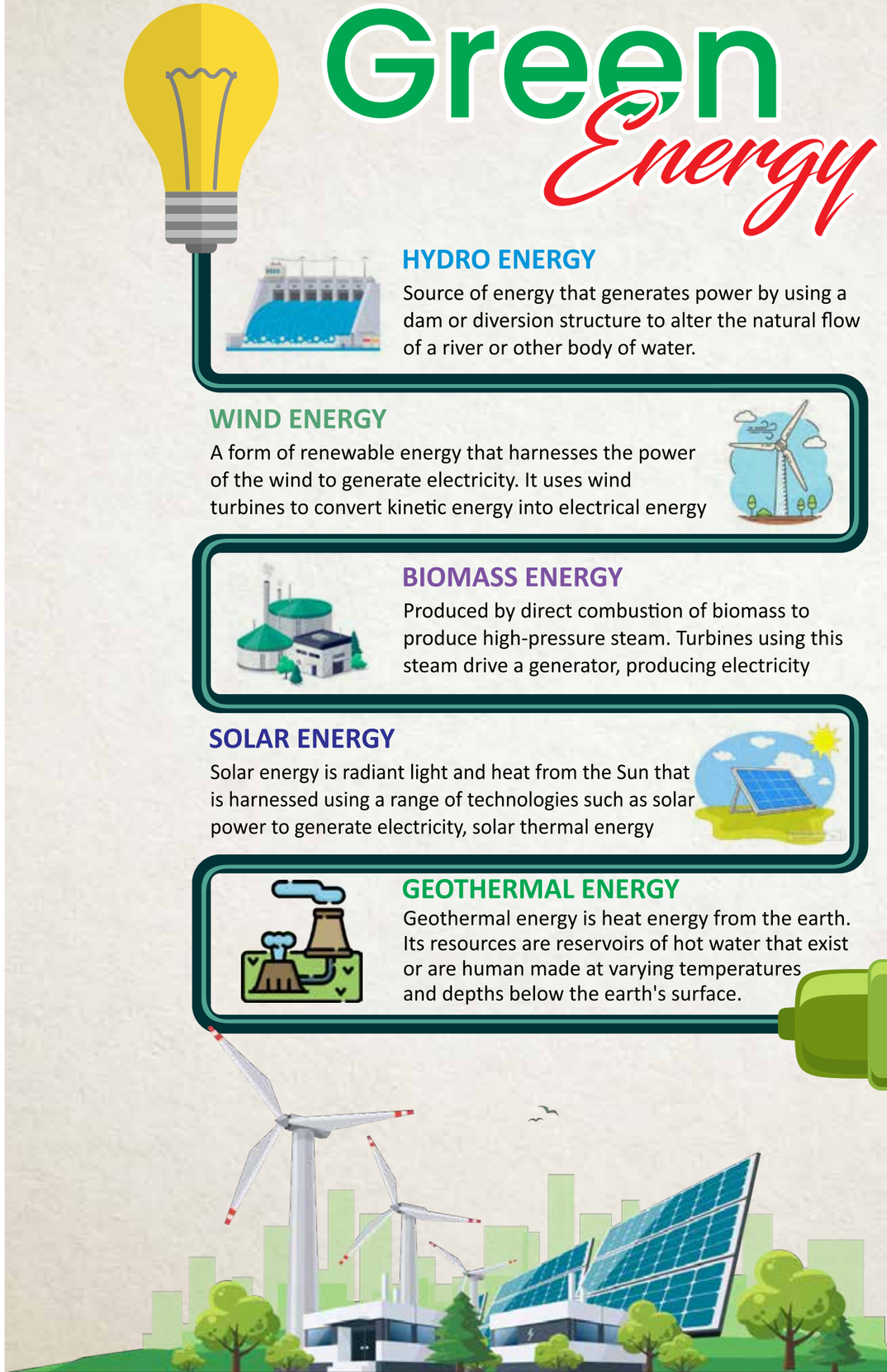
Challenges and Opportunities

Due to the absence of a centralised agency, the efforts of different stakeholders involved in biomass energy production remain fragmented. Moreover, there is limited communication and cooperation among biomass suppliers, policymakers and regulators, and investors, leading to reduced efficiency and loss of potential benefits. To address these issues, the government can establish a centralised agency to overlook the coordination of all stakeholders in the biomass sector. This will enable better collaboration and synchronisation of efforts and lead to greater efficiency and effectiveness.

Policy Initiatives in Agricultural Growth

At present, the biomass sector in India caters to demand from stakeholders across various areas such as electricity generation, heating and cooling solutions, CBG, and green hydrogen – all falling under the MNRE; co-firing of biomass in coal-independent power producers (IPPs)/captive power plants (SAMARTH scheme) under the Ministry of Power; the biofuels programme with CBG (SATAT scheme); the ethanol blending programme, sustainable aviation fuels and biodiesel under the Ministry of Petroleum and Natural Gas; and farm agriculture residues under the Ministry of Agricultural and Farmer Welfare, with involvement from the Ministry of Rural Development, and the Ministry of Environment, Forest and Climate Change.

The implementation narrative often gets lost amidst the tussle among stakeholders in achieving. coordinated efforts for sustainable biomass-bioenergy development, evidenced by the speed of development of projects. While policy advocacy has gained traction, however the constructs ahead of the policies made including the feedback loop for making incremental corrections in the constructs needs more traction if we wish to achieve cogent results with the force multipliers of now maturing startups india and Digital India initiatives coupled with Lifestyle for Environment initiatives of the Govt.



Agrivoltaics
A Boon For Farmers

> States in India need to develop policy and regulations for agrivoltaics

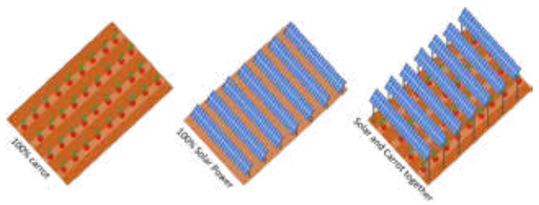
ABOUT THE AUTHOR

Mr Pranab Kumar Nath is Managing Consultant, Global Sustainable Energy Solutions India Pvt. Ltd.

India has an ambitious goal of achieving 500 GW of renewable energy (RE) capacity by 2030. Most of the total RE is projected from solar energy. However, large parcel of land is required to set up ground-mounted utility scale solar power plants and scarcity of land is a significant impediment to India's quest for clean energy. Further, the food-energy nexus, or the delicate balance between land use for food production and energy generation, is a critical issue.

In the early 2000s, countries with similar land scarcity challenges, such as Japan, initiated agrivoltaics. Agrivoltaics or Agri-protovoltaics (APV) is the use of same land for agriculture and producing solar energy. For India, APV will be a critical solution for sustainable clean renewable energy, food security, and reducing water security.

Shading by the solar panel allow for increased crop productivity while reducing water evaporation and thus conserving valuable water resources. APV helps to achieve four essential UN Sustainable Development Goals (SDGs): (1) Low-cost, clean energy; (2) climate action; (3) sustainable communities; and (4) eradication of hunger. Food and energy security are improved in an environmentally sustainable way by making better use of scarce water resources.



Another potential benefit of APV is additional income to farmers through - 1) higher agricultural yield, 2) income from power generation or from renting land for power generation. The environmental benefits include reduction in greenhouse gas emissions from conventional diesel-powered generating sets or use of coal/gas fired thermal power.

Why Agrivoltaics Is Urgently Needed

As per the Ministry of New and Renewable Energy, installed capacity of solar power in India by 31st Mar 2024 is 81813.60 MW. It's a significant progress in last one decade. At the same time, demand for solar energy is increasing as solar energy is now cheapest energy source. On top of that, electric vehicles, particularly the two-wheelers and three-wheelers are increasing, particularly the rural areas. The rural population is perennially facing severe energy access issues. They will need a large amount of reliable clean energy in their places to charge their vehicles in near future.

However, finding suitable land to develop commercially viable solar projects becomes increasingly difficult. The conflict between using land to decarbonize the energy sector and agriculture is imminent. We have limited land. Lands that were barren, and unsuitable for agriculture were already used or not feasible for bankable solar projects. As we need more and more solar energy, there is a distinct pressure on agriculture land that we need to grow food.

To address these concerns, the agriculture and solar sectors are working together to develop an emerging domain that can generate electricity while protecting agricultural production.

Why Agrivoltaics Is Becoming Popular

Agrivoltaics is a growing trend as it holds loads of promises.

Providing shades: Rising global average temperatures, unpredictable precipitation, and more frequent extreme weather events such as droughts and hailstorms had an adverse impact on agriculture in recent years. Solar panels at the top can provide shade to crops and reduce evaporation of irrigated water to a large extent.

Improved yield and consistent return: There are certain crops that need shades for better yield. Agrivoltaics help farmers achieve higher and more consistent agricultural yields by providing improved growth conditions.

Reduce water evaporation: One immediate effect of shading provided by the solar panels reduces the evaporation loss of irrigated water. That saves groundwater and pumping costs.

Long-term revenue stream: In agrivoltaics, farmers typically provide their land to solar power developers in long-term leases, typically for 25 years. If a farmer sets up their own solar PV systems, then they can reduce their energy cost as well as earn revenue by selling electricity to the grid. In both ways, it becomes a stable, long-term additional income for the farmers.

Distributed power for emerging demand: Electric vehicle adoption is increasing. More and more distributed clean electricity will be needed in rural areas to charge these electric vehicles. At least two-wheelers and three-wheelers initially, in rural areas.

Employment generation: Skilled manpower is required to design, install, and maintain this special kind of photovoltaic system for its 25 years of lifetime. That promises employment generation in rural areas.

Therefore, agrivoltaics is a win-win for both the farmers, solar power developers, governments, and society.

How Agrivoltaics Is Done

In India, agrivoltaics is already piloted in various states. Agrivoltaics is commonly done in the following ways:

- Crop cultivation between two rows of ground-mounted photovoltaic panels.
- Farming between and below ground-mounted panels allowing for manual cultivation or smaller farming equipment only.
- Farming below solar panels mounted on an elevated structure so that farm machinery can operate below.

Challenges In Adopting Agrivoltaics

Currently, agrivoltaics support only those crops that need shade, especially in the case of stilt-mounted agrivoltaics. Though research is on to accommodate more and more crops. At the same time, a high steel structure means a heavier structure to withstand the impact of wind. That increases the capital cost of the solar PV system considerably.

Policy and regulations:

States in India need to develop policy and regulations for agrivoltaics, which can affect project permits as well as potential financing and investments. Changes in land-use patterns, technical quality standards and benchmarking, and piloting agrivoltaics projects to establish the proof of concept are critical to sensitize the different stakeholders. National and state-wise targets with long-term policy visibility along with financial incentives will create the eco-system to attract investments.

The *Future* is Here

> Sustainable agriculture strives to ensure future food and energy supply while safeguarding natural resources

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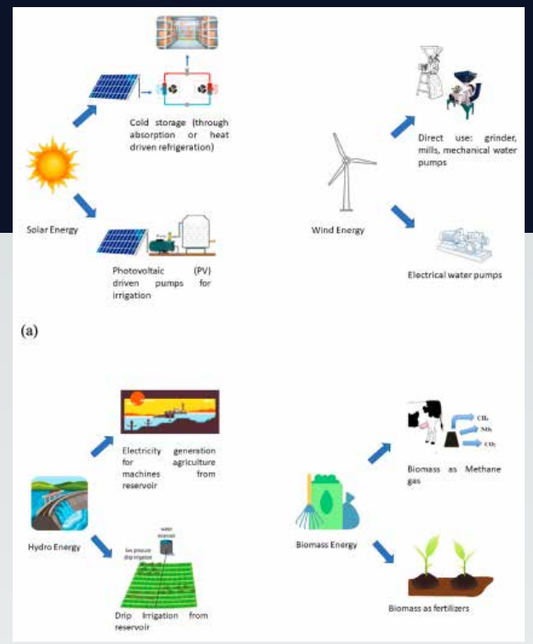

Globally, 30% demand for energy is from the agriculture and food sectors. The agriculture production cycle is heavily dependent on fossil fuels from manufacturing fertilizers to running machinery for field operations. Photovoltaic systems being used in residential buildings could be a potential solution to mitigate energy crises for promoting sustainable agriculture. These sources are profusely available in the agriculture sector.

Solar Energy

For example, crops grow in areas where there is sufficient sunlight around the year to support the growth of plants. It means, abundantly available sunlight energy can easily be harnessed using solar panels that can be used to run various agricultural equipment (i.e. water pumps for irrigation). Generated electricity from solar panels can also be used to run various refrigeration and drying units that are commonly used in agriculture to store and increase the shelf life of agricultural produce.

Direct sunlight can also be used for cooking, drying, and water heating using solar cookers, solar dryers, and solar water heaters, respectively. Additionally, fuel cells can enable efficient and effective utilization of hydrogen energy in the agriculture sector because of their flexibility and interoperability

Various applications of renewable energy resources in different agriculture sectors are discussed in Table 1.

Wind Energy

This is another renewable energy resource that can be harnessed by farmers to power their farms. In areas where wind energy is abundantly available farmers can generate electricity using wind turbines. This generated electricity could be used to power heavy machinery involved in agricultural operations and processing of the agricultural produce.

Bio Energy

Another huge source of renewable energy in agriculture is bioenergy source which agriculture has in abundance. According to studies, alone bioenergy can meet around 30%–40% of the entire world's energy needs by 2050. The raw material needed for bioenergy is available in surplus and cheap in the agriculture sector in the form of agriculture, food livestock, and municipal solid waste. Utilization of bio waste in agriculture can help to produce biogas which then can be used for generating electricity. Also, bio waste can be utilized as a fertilizer to reduce the heavy dependence on commercial fertilizers.

Sustainable agriculture strives to ensure future food and energy supply while safeguarding natural resources. The interpretation of sustainability varies by context and country, yielding distinct indicators. Researchers have studied sustainable agriculture for the past 25 years and have developed several indicators. Renewable energy holds a vital role in sustainable agriculture, aiding energy needs and mitigating environmental harm tied to agriculture. It curbs fossil fuel dependency and harnesses agricultural waste for energy. However, a consistent update of renewable energy indicators for agricultural sustainability is needed. Listed below are the few activities where renewable energy source can be used.

Table : 1 Applications of renewable energy resources in different agriculture sectors

Sr. No.	Sector	Renewable energy source	Technology
1	Irrigation	Solar panels assembly	Fuzzy logic and cloud tech
		Solar photovoltaic cells	Pump used for irrigation
		Wind onshore	RO (Reverse Osmosis) of water for irrigation
		PV panels	RO (Reverse Osmosis) of water
		Wind energy	Islanded micro grid for pumps Desalination system
		Geothermal energy	Field irrigation, heat pumps
2	Greenhouse management	Photovoltaic (PV) generator	Ventilation and heating wind turbine
		Photovoltaic and wind	Ventilation and heating Wind-PV hybrid generation system, modelling, simulation and analysis
		PV panels	Photovoltaic greenhouse tunnel
3	Monitoring/ Regulating systems	Solar-powered prototype nodes	Precision agriculture (pa), wireless sensor networks, internet of things (IoT)
		Photovoltaic (PV) centrifugal and positive displacement pump	Humidity sensors and global system for mobile (GSM) module
		Solar panels	Wireless sensor networks
4	Water pumping System	Solar PV water pumping systems	Brushless DC (direct current) motors, centrifugal and positive displacement pump, Solar thermal water-pumping-systems, Vapour power cycles, Wind energy, Wind powered synchronous generators, Biomass water pumping systems, Biomass gasifier dual fuel powered diesel engine coupled with a centrifugal pump
		Hybrid renewal energy water pumping system	The solar wind hybrid system
5	Drying	Solar dryers	Thermal energy storage (TES) Pebble-bed TES
		Solar drying system	Phase change material (PCM) based thermal storage
		Geothermal heating	Heat extraction from geothermal wells Biomass
		Biomass	Hot air is produced from biomass combustion and circulated through the dryer.
		Solar	PCM (pulse-code modulation) integrated heat pump dryers
		Solar thermal energy	Heat pump based solar microwave drying
		Wave and tidal	Reverse osmosis
6	Tractor	Solar radiation	Tractor propelling by energy from solar cells
		Photovoltaic panel	Vapour compression cycle
7	Refrigeration	Solar thermal collector	Steam jet cycle
		Solar energy	Adsorption refrigeration technology
8	Seed sowing	Solar controller	Radio frequency based sowing machine
9	Roasting	Solar	Batch-type direct roasting, Continuous-type thermal-oil based roasting

This Indian Billionaire Left The Business for
THE UPLIFT FARMERS IN GUJARAT

Bharat Parsana, who lives in the western Indian city of Rajkot, belongs to a well-known industrialist family with a business presence in Europe, America, and Japan. His family has been established in the engineering business for 57 years, exporting to 12 countries worldwide, with a group turnover exceeding INR 5 billion.

Belonging to the Patel community, his family owns a farm inherited from their ancestors near Rajkot, Gujarat. At the age of 38, Bharat embarked on a mission to teach cow-based organic farming techniques to farmers that can increase profits by 50%. These techniques, which involve using cow milk, jaggery, cow urine, and cow dung, were researched by Veljibhai Bhudia from Kutch Bhuj, and Bharat Parsana has spread this method worldwide.

Bharat has traveled globally to observe various farming practices. He visited Israel and China to see farming. In Israel, where farming is done in Kibbutz communities. He noted that in Israel, despite the challenging conditions, farming is 100% chemical and pesticide-based.

The organic vegetables grown using these techniques are superior in quality and can be sold at 25% higher prices than regular vegetables. For the last 20 years, Bharat has traveled 200 kilometers daily to conduct farmer meetings and visit different farms to teach them.

His farm is open for training anyone interested in these methods. He also uses ingredients like cow urine, sour buttermilk, and asafoetida in custom processes to make plant medicine. Bharat takes a deep interest in training farmers for free and follows up to ensure they achieve results.

According to Bharat Parsana, milk contains carbohydrates, proteins, minerals, vitamins, and lactobacilli; jaggery contains carbohydrates, vitamins, phosphorus, and calcium; cow urine contains nitrogen, amino acids, magnesium, and potassium; and cow dung contains nitrogen, carbon, calcium, and magnesium. When this mixture is sprayed on plants, it acts as a booster, helping the plants fight against germs. The sweet smell attracts bees from up to 3 kilometers away, aiding in pollination.

The pure organic vegetables grown at Bharat's farm near Rajkot are of such high quality that most urban dwellers have never tasted anything like them. Visitors to the farm often find themselves eating raw vegetables directly plucked from the plants due to their exceptional sweetness.

Bharat draws inspiration from reading numerous books, dedicating two hours daily to reading. He has read the four Vedas, Shivpuran, Bhagavad Gita, Valmiki Ramayan, and biographies of many famous people from India and around the world.

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Driving Sustainability

> **Integrating renewable energy into the agricultural sector in India can improve productivity, reduce costs, and contribute to sustainable development goals**

ABOUT THE AUTHOR

Mr Partha Das, a Chartered and Cost Accountant by Profession, is currently working as Chief Financial Officer of Indian Oil NTPC Green Energy Private Limited, a Renewable Energy JV between IOCL and NTPC Green Energy

Agriculture serves as the backbone of India's economy, contributing significantly to its GDP, employment, and food security. Here are some key data points highlighting the importance of agriculture in India:

GDP Contribution: Agriculture contributes around 15-20% to India's Gross Domestic Product (GDP), making it a crucial sector for economic growth and stability.

Employment: With over 50% of the workforce engaged in agriculture, it remains the largest employer in the country, providing livelihoods to millions of rural households.

Food Security: Agriculture ensures food security for India's vast population, meeting the dietary needs of over 1.3 billion people. It plays a pivotal role in addressing hunger and malnutrition challenges.

Export Revenue: India is among the world's largest producers and exporters of agricultural commodities such as rice, wheat, spices, and fruits. Agriculture exports contribute significantly to foreign exchange earnings and trade balance.

The significance of agriculture in India cannot be overstated. It not only drives economic growth but also sustains livelihoods, ensures food security, and promotes rural development. Thus, investing in agriculture remains crucial for the overall prosperity and well-being of the nation.

How Renewable Energy Can Help Agricultural Sector

Agricultural energy demand can be divided into direct and indirect energy needs. The direct energy needs include energy required for land preparation, cultivation, irrigation, harvesting, post-harvest processing, food production, storage and the transport of agricultural inputs and outputs.

Renewable energy can significantly benefit the agricultural sector in India in several ways:

Off-grid power supply: Many rural agricultural areas in India suffer from unreliable or non-existent grid electricity. Renewable energy sources such as solar panels and wind turbines can provide reliable off-grid power, allowing farmers to operate irrigation systems, machinery, and other equipment crucial for farming activities.

Cost savings: By investing in renewable energy solutions like solar power, farmers can reduce their reliance on costly diesel generators or grid electricity, thus lowering their operational expenses over time.

Water pumping: Solar-powered water pumps can be used for irrigation purposes, especially in areas with limited access to grid electricity or where diesel pumps are expensive to operate. This can help improve crop yields and reduce manual labour for water extraction.

Diversification of income: Farmers can generate additional income by installing renewable energy systems on their land and selling surplus electricity back to the grid through net metering arrangements.

Environmental benefits: Adopting renewable energy reduces greenhouse gas emissions and helps mitigate climate change, which can have long-term positive effects on agricultural productivity and sustainability.

Energy security: By harnessing renewable energy sources locally, farmers become less dependent on external energy sources, enhancing energy security for agricultural operations.

Renewable energy sources like solar, wind, and biomass are increasingly being used for agricultural applications. Solar panels and wind turbines can provide electricity to power irrigation systems, while biomass can be used to generate electricity or heat for greenhouses. These sources are sustainable, clean, and can help reduce greenhouse gas emissions associated with traditional fossil fuel-based agriculture practices. Additionally, some farms are using geothermal energy to heat greenhouses and water systems. Overall, renewable energy can help make agriculture more sustainable and efficient.

Rooftop Solar vs. Diesel

Rooftop solar power is much cheaper than power from diesel generators. Solar PV generates power at a cost of about Rs. 7-8.50/kWh while diesel generates power at about Rs. 17/kWh or more (a litre of diesel generates around 3-4 kWh per litre). Diesel power can be even more expensive once losses such as pilferage, evaporation, etc. are considered. In some applications, such as rural telecom towers, diesel power can cost as much as Rs. 40/kWh. The cost of diesel power has seen a steep increase over the last 10 years.

A price increase of more than 200% since 2002 and around 72% increase since 2010 is serious cause for concern for many industrial units that depend on diesel power. Solar PV can help offset part of this cost by supplementing diesel power.

Rooftop Solar vs. Grid

Whether rooftop solar is more expensive than grid power depends on your current tariff.

Commercial/industrial tariff – Rooftop solar may be cheaper than grid power, depending on the state and the specific consumer category.

A Commercial Consumer in Mumbai consuming greater than 500 kWh in a billing cycle will pay Rs. 11.91/kWh which is much more expensive than rooftop solar power.

Other consumers – Grid power is likely to be cheaper than rooftop solar power.

An LT I Residential Consumer in Mumbai consuming less than 100 kWh in a billing cycle will pay Rs. 3/kWh (drawing from BEST utility) which is cheaper than the cost of rooftop solar power.

Thus, overall, integrating renewable energy into the agricultural sector in India can improve productivity, reduce costs, and contribute to sustainable development goals.

The Way Ahead

> **Biofuels have emerged as a beacon of innovation and opportunity, bridging agriculture with renewable energy in a seamless synergy**

ABOUT THE AUTHOR

Mr. Kishan Karunakaran is the CEO of Buyofuel. Under his stellar leadership, the company is successfully empowering trading of biofuel-based commodities in a quick and secured manner by providing a platform with verified buyers and sellers

Agriculture in India is a powerhouse of productivity, yet it comes with a significant byproduct - agricultural waste. Annually, around 650 million tons of agricultural waste is generated in the country. However, this waste isn't just a problem; it holds immense potential for renewable energy, particularly biofuels. According to the Ministry of New and Renewable Energy Resources, this agricultural waste has the capacity to generate a staggering 24 GW of energy, a number that could significantly contribute to India's energy needs. Currently, India boasts 10 GW of biomass-based power generation capacity, showcasing the existing groundwork for a renewable energy revolution.

Every harvest season, farmers face the challenge of managing crop residues and agricultural waste. Traditionally, much of this waste ends up burned, contributing to environmental issues. However, there's a brighter path forward. Biomass, the agricultural waste in question, can be converted into valuable biofuels through processes like briquetting and pelleting. This conversion process transforms materials like sugarcane bagasse and groundnut shells into energy-dense briquettes and pellets, suitable for industrial use in boilers. This not only addresses waste management but also presents an economic opportunity for farmers and rural businesses to participate in the renewable energy sector.

As India's economy grows, so does its fuel consumption, making it the third-largest fuel consumer globally, using over 1300 million metric tons. This heavy consumption also makes India one of the largest CO2 emitters worldwide. Unfortunately, India relies on imports for more than 80% of its fuel needs, leading to significant foreign exchange outflows. However, by leveraging the wastes and agro-residues currently underutilized in the biofuel industry, India can reduce its reliance on fuel imports and instead produce biofuels domestically, mitigating forex outflows.

Commitment To Increased Biofuel Adoption

The Indian government has set mandates like the 10% co-firing of coal replacement products, promoting the integration of biofuels into energy generation. Moreover, targets for E20 (20% ethanol) and B10 (10% biodiesel) in the transport sector signal a commitment to increased biofuel adoption. As technology advances, more waste materials can efficiently be converted into biofuels, expanding the feedstock options and enhancing the overall efficiency of the biofuel industry.

India has a strong interest in finding effective solutions to global climate issues. Reports from the UN highlight that India is particularly vulnerable to droughts, heat waves, and rising sea levels due to climate change, which can lead to food insecurity, higher prices, migration, and reduced income. However, it's clear that addressing the climate crisis shouldn't hinder the improvement of living standards for the poor. The key is to promote economic growth and prosperity through affordable renewable energy that's accessible to all.

Fight Against Climate Change

The emergence of biofuels is crucial in the fight against climate change. Biofuels offer a significant reduction in carbon emissions, aligning with global efforts to reduce greenhouse gases. With climate change impacting economies and industries worldwide, there's a growing demand for sustainable solutions like biofuels. Projections indicate a 28% increase in global biofuel demand between 2021 and 2026, showcasing the trajectory towards low-carbon alternatives across sectors.

Solid biofuels from agricultural and wood residues are already playing a vital role. Additionally, liquid fuels from sources like used cooking oil (UCO), waste tires, and plastics contribute to a diversified biofuel portfolio. The sustainability of biofuels lies in their sourcing - strictly from waste materials, ensuring minimal impact on ecosystems.

On the global front, Brazil stands out as a leader in biofuel production, especially ethanol from sugarcane. India, inspired by Brazil's success, aims to introduce Flex Fuel Vehicles (FFVs) capable of running on various fuel blends, reducing emissions and crude oil imports. With targets like achieving a 20% ethanol blend by 2025, India is on track to become a major player in biofuel adoption and production.

While coal power growth has slowed down, new energy production is mainly from affordable renewable sources like wind, biofuels and solar. The focus on renewable energy isn't just about making India greener; it's because it makes economic sense.

Promising Future

The future of renewable energy and biofuels in India looks promising. With commitments to reach net-zero emissions by 2070 and increasing renewable energy targets, India is set for a green transformation. The National Biofuels Policy introduced in 2018 provides a robust framework for biofuel growth, including blending targets, production incentives, and tax exemptions, paving the way for a sustainable and vibrant biofuel industry.

Considering supportive policies and growing backing for biofuels, let's take a practical look at their future globally. Key factors like oil prices, raw material costs, government policies, biofuel technology advancements, and competition from fossil fuels will shape this future. India's agricultural presence adds a much-needed dimension as it remains a cornerstone of our economy.

The integration of renewable energy not only addresses environmental concerns but also drives economic growth and sustainability. As we navigate towards a greener future, biofuels have emerged as a beacon of innovation and opportunity, bridging agriculture with renewable energy in a seamless synergy.

Empowering Change

Biogas Poised To Replace Diesel

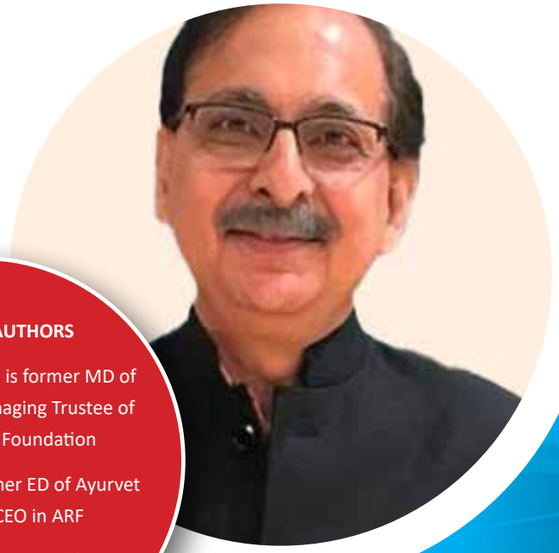
> ARF actively promotes the adoption of small and medium-scale biogas plants in gaushalas and among individual farmers

On the alarm bell of "Quick Climate Crisis" call of UNDP Emission gap report, 2022, Government shared their commitment to reduce and produce responsibly. In response to the commitment, various green options that were crawling, got a momentum. Renewable energy options like nuclear, solar, wind, hydro, and bioenergy, are getting attention of the policy makers.

"ARF envisions harnessing biogas not only as a fuel source but also as a fertilizer, presenting a dual opportunity to address agricultural and energy needs simultaneously." It has the potential to replace diesel and chemical fertilizer. This belief is firmly grounded in firsthand understanding and insights from the grassroots.

Relevance of Bio-gas in Rural Panorama

Agriculture Sector uses 13% of total Diesel as per Ministry of Petroleum & Natural Gas. The alternative such as diesel per unit cost is as high as Rs 33-38 Per unit. Clean cooking fuel access and affordability is another aspect of energy that needs to be addressed, what the Ujjala LPG refilling data suggest. On one hand, this reliance worsens the problems such as frequent biomass burning, depleting fossil fuel reserves, and a significant carbon footprint. On the other side, mismanagement of fertilizers leads to soil degradation on agricultural lands, casting doubt on global food security ambitions. The magic wand that alone can address the above-mentioned issues is Bio-gas.



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AGRICULTURE WORLD

Does India have the required resources for Biogas mass production?

With a livestock population of 535.78 million, making India the world's largest owner of livestock, coupled with the generation of approximately 500 million tonnes (Mt) of crop residue annually, as reported by the Ministry of New and Renewable Energy (MNRE), and a staggering 74 million tonnes of food wastage, are the resources to unlock the potential of biogas plants.

India can mitigate 43 million tons of CO2 emissions annually from biogas projects as per the estimates of The Global Methane Initiative. According to the Ministry of New and Renewable Energy (MNRE), the estimated biogas potential in India is **approximately 17,000 MW** from various sources.

The question arises, can agricultural pump-sets be transformed into biogas-based machines? The answer lies in the innovative technology developed by IIT Delhi, offering a biogas conversion kit tailored for small, stationary diesel engines typically found in rural settings. Converting diesel pumps to operate on biogas presents a viable option; nevertheless, the cost of modification remains a crucial consideration.

Rapid Strides In Recent Years

Indore has Asia's largest bio-CNG plant, located in Devguradiya village. This plant produces 17 tonnes per day (TPD) of bio-CNG, fueling 146 buses in Indore, with plans to increase to 400 buses by March 2023.

Centre for Rural Development and Technology of IIT Delhi has been engaged in various research on biogas enrichment and bottling such as developing low-cost water scrubbing system, CO2 Separation for industrial use and developing H2S removal system, which is under investigation. There is various development we can expect in near future.

Government Initiatives

The Ministry of New and Renewable Energy allocated a budget of INR 100 crore for the Biogas program under the National Bioenergy program in the fiscal year 2022-23. It is projected to increase to INR 10,000 crore in the year 2023-24. The ministry's portal outlines the Central Financial Assistance (CFA) and implementation mechanisms (PIA) clearly.

Biogas has brought together several ministries due to overlapping objectives. It aligns with the sanitation goals of the Jal Sakti Ministry's GOBARdhan project, as well as the Department of Fertilizer and the Department of Animal Husbandry and Dairying. SATAT' scheme on Compressed Bio Gas (CBG) encourages entrepreneurs to set up CBG plants. Government is all set to make 5% mandate for all entities marketing Natural gas in India.

With collective action from NGOs and government financial assistance to support Biogas under MNRE has resulted in installation of 12,693 small Biogas Plants & 1.107 Mweq (medium size biogas plants) were installed. For the FY 2023-24 Annual target of 30795 number of small biogas plant installation was allocated to the designated Program Implementing Agencies of states.

ARF presence in Biogas promotion

For the past 15 years, ARF has been operating an indoor biogas plant at Chidana. This facility serves as more than just a technological showcase; it acts as a training and demonstration center. Here, individuals can learn firsthand about the functioning and benefits of biogas technology. Moreover, the plant contributes to various community needs such as street lighting, cooking, and electrification, showcasing the multifaceted advantages of biogas utilization.

Furthermore, ARF's initiatives extend to specific applications tailored to unique settings. For instance, we have implemented a biogas plant at the Jindal farmhouse in Noida, addressing the specific needs of horses on the premises. By utilizing biogas technology, they efficiently manage waste while providing a sustainable energy source for the farm.

Additionally, ARF actively promotes the adoption of small and medium-scale biogas plants in gaushalas and among individual farmers. These efforts aim to reduce reliance on diesel and effectively convert animal and farm waste into valuable nutrient-rich manure. By advocating for the widespread implementation of biogas technology, ARF contributes to environmental sustainability, agricultural productivity, and energy independence in communities across various contexts.

A New Paradigm for Sustainability & Growth in Agriculture

> Innovations in biogas technology are driving significant advancements in efficiency and cost-effectiveness

About The Author

Mr Piyush Sohani is India Managing Director, Sistema.bio, an Ashden Award winning social enterprise working in clean energy with innovative biogas technology. Based at the headquarters in Pune, Mr Sohani started Sistema.bio India with a humble team of 22 people in the area of sales and technical operations with a pilot project in Gujarat.

Within a span of 5 years, the company has over 700 people and is delivering thousands of digesters every month across 21 states in India

The agriculture sector faces many challenges, including the need to mitigate environmental impact, enhance productivity, and ensure long-term sustainability. A particularly pressing issue is the agriculture sector's reliance on fossil fuels for energy-intensive operations such as machinery, irrigation, and transportation. This dependance not only contributes to greenhouse gas emissions but also exposes farmers to volatile fuel prices and farm operations disruptions. As a result, the need for energy transition in agriculture has become increasingly crucial to address these challenges effectively.

Bio Energy

Bioenergy has emerged as a key solution in driving this shift. Unlike fossil fuels, bioenergy sources are renewable and can be produced from organic materials such as crop residues and animal waste. By harnessing these resources, farmers can reduce their dependence on fossil fuels, reduce costs, curb carbon emissions, and promote circular economy practices. Moreover, bioenergy offers a decentralized energy solution, enabling farmers to generate power locally and potentially achieve energy self-sufficiency.

The dairy industry has been experiencing exponential growth, fueled by technological advancements and the widespread adoption of agricultural machinery. According to a report from 2023, the dairy sector has witnessed a substantial increase in productivity, with a significant rise in milk production worldwide. This surge in efficiency has resulted in a heightened demand for energy, particularly to power equipment like milking machines, chaff cutters, milk chillers and water pumps. As a result, dairy farmers are grappling with escalating energy costs and the need for reliable power sources to sustain their operations.

Biogas Technology

For instance, consider the case of Mr. Singh, a dairy farmer from Punjab managing approximately 100 cows and relies on equipment like milking machines and water pumps. Data indicate that farms of similar size typically require around 10kW of power and approximately 3000 units of electricity per month, Mr. Singh's farm represents the energy challenges faced by the dairy industry.

One of the primary hurdles for dairy farmers like him is the need for uninterrupted power supply, particularly during critical tasks like milking. To address this issue, many farmers, including him, rely on diesel generators, despite the associated high running costs and maintenance requirements. Biogas technology offers a cost-effective and seamless alternative for farmers like Mr. Singh. By utilizing biogas plants to convert cattle waste into clean energy, he not only ensures a reliable energy supply for his farm but also contributes to the advancement of a sustainable dairy industry.

Utilizing biogas for energy requirements is emerging as a viable option for medium-scale dairy farmers. With a growing emphasis on sustainability and cost-efficiency, farmers in this category, facing similar challenges as Mr. Singh, are increasingly turning to biogas to meet their energy needs. Additionally, the utilization of biogas technology offers benefits beyond energy production. Biofertilizer, a by-product of biogas plants can be utilized as an alternative to chemical fertilizer, enhancing soil fertility. As such, biogas technology not only addresses the energy challenges faced by medium-scale dairy farmers but also contributes to environmental sustainability and operational efficiency, positioning them for long-term success in a rapidly evolving agricultural landscape.

Innovations In Biogas Technology

Innovations in biogas technology are driving significant advancements in efficiency and cost-effectiveness. Traditional systems, such as Floating Drum and Fixed Dome types, were often characterized by high construction costs and maintenance expenses. However, recent breakthroughs in materials and design have transformed the landscape.

The utilization of LLDPE Geomembrane offers extended lifespans of over 20 years, coupled with simplified installation processes and cost savings. Similarly, the introduction of PVC Coated Fabric provides a flexible and easy-to-install alternative. Hybrid Reactors, combining civil construction bases with PVC-coated fabric gas storage, further enhance versatility in design. Modular structures and plug flow system designs enable customization tailored to specific farm layouts. Advancements in scrubbing systems are also effectively reducing H2S (hydrogen sulfide) levels in biogas. Finally, innovations in optimizing biogas production via measuring instruments assume an important role. These devices are crucial for monitoring critical parameters like gas composition and production rates.

On the other hand, innovations on the application front are streamlining the transition to going off-grid. Biogas generators, in particular, stand out as a focal point. Positioned as viable alternatives for medium-scale productive farmers, biogas generators offer an economically sound approach to meeting energy requirements. In contrast to diesel generators, they reduce the running cost of electricity substantially. rendering them financially attractive options. With impressive running times and capacities, biogas generators ensure consistent and reliable energy supply for various applications, from electricity generation to fueling thermal equipment like water heaters and stoves.

This versatility, coupled with their cost efficiency, highlights their significance in modern energy systems. For example, the cost of electricity produced by biogas generators is substantially lower at approximately ₹14 per unit compared to the ₹29 per unit of diesel-generated electricity. If we consider the additional revenues and savings on biofertilizer along with Govt of India's Central financial assistance (CFA), the cost/electricity from biogas reduces even more. The relatively shorter payback period of around 3 years for biogas generators as compared to their diesel counterparts also highlights their economic viability and the potential for long-term savings.

Government Subsidies And Support

Government subsidies and support from the Ministry of New and Renewable Energy (MNRE) also plays a crucial role in facilitating the adoption of biogas technology. Under the Biogas Programme, MNRE offers subsidies for the installation of biogas plants and generators, significantly reducing the financial burden on farmers. For small-scale biogas plants, MNRE subsidies vary based on size, ranging from ₹9,800 to ₹52,800 per plant for capacities between 1 to 25 cubic meters per day.

In the case of biogas generators, subsidies are provided for both power generation and thermal applications, with amounts ranging from ₹35,000 to ₹45,000 per kilowatt for power generation, and ₹17,500 to ₹22,500 per kilowatt equivalent for thermal applications, for plant capacities between 25 to 2500 cubic meters per day. This Central financial assistance provided by MNRE effectively shortens the payback period for farmers investing in biogas plants and generators, making them more economically viable.

Biogas technology has emerged as a game-changer in agriculture, addressing energy challenges while fostering sustainability and growth. Innovations in biogas technology, alongside government subsidies and MNRE support, empower farmers to embrace renewable energy solutions effectively. By streamlining processes and reducing financial barriers, the transition to biogas not only becomes feasible but also economically beneficial.

Indian Seed Sector Bats For A Resilient Agriculture Sector

Technology in agriculture, particularly seeds, has great potential to provide sustainable, profitable yet affordable solutions for a wide array of challenges including climate change. But to maximize the benefits, it is important to establish an open, unbiased and enabling policy environment

The seed industry is keenly aware and reiterates the importance of biotechnological solutions as vital aids in addressing the challenges confronting the agriculture sector. For example, with heatwaves causing a 4.5% decrease in wheat yield across India, with some areas experiencing up to a 15% drop. This decline highlights the immediate impact of climate change on agricultural productivity and food security.

Rising global temperatures, coupled with increasingly severe and unpredictable weather patterns, have been exacerbated by the greenhouse warming effect, contributing to the occurrence of the El Niño weather phenomenon. Heatwaves, insufficient rainfall, and changes in monsoon patterns have collectively resulted in significant water stress in agricultural fields, leading to reduced crop yields. Rising temperatures can lead to heat stress in crops, affecting their growth and development. Heatwaves during critical stages of crop growth can reduce yields and quality.

India is close to reaching a tipping point where groundwater levels will plummet, according to a 2023 UN Water report. The northern parts of the country have lost 95 per cent of their groundwater between 2002 and 2022, and some areas in the Indo-Gangetic basin have already passed the groundwater depletion tipping point. India is the world's largest consumer of groundwater, using about a quarter of the world's total.

Need For Developing Drought-Resistant Crop Varieties

The combination of water scarcity, heatwaves, frequent droughts, and unpredictable monsoons presents a significant challenge to India's agricultural productivity. These challenges underscore the urgent need to prioritize the development of drought-resistant crop varieties. With climate change exacerbating these issues, the cultivation of crops with enhanced drought tolerance is increasingly essential to safeguarding food security of the nation. Redirecting focus towards the breeding and promotion of drought-resistant varieties is imperative to ensure the resilience and sustainability of India's agricultural sector in the face of mounting environmental pressures.

Plant breeders in both private and public sectors have dedicated their efforts to develop varieties and hybrids capable of withstanding drought stress across various crops. Although the process is gradual, there have been notable successes in breeding drought-tolerant crops. Examples include conventional breeding programs such as the creation of rice, wheat, and Indian mustard varieties resilient to salt and alkali soils by the Central Soil Salinity Research Institute in Karnal.

Additionally, maize hybrids with heightened drought tolerance have been developed, along with endeavours to integrate salt tolerance into wheat from wild relatives. Notably, drought tolerance has been prioritized as a selection trait in the generation of new maize and wheat germplasm by the International Maize and Wheat Improvement Centre (CIMMYT). The advent of genetic modification (GM) and gene editing technologies offers a swifter route to producing drought-tolerant crops. Presently, GM varieties of Glycine max (soybean) and Zea mays (maize), as well as gene-edited wheat for drought tolerance, have been developed and sanctioned in many countries.

> **Climate change poses a formidable threat to both agricultural sustainability and food security**

Role Of Private Seed Industry In India

The private seed industry in India has been a key driver of technological advancements in agriculture, with significant contributions to the sector's growth and development.

This sector has witnessed a steady increase in investments in research and development in advanced technologies, reflecting a strong commitment to exploring innovations and several members of Federation of Seed Industry of India invest, on an average, over 10 percent of the annual turnover for R&D.

Furthermore, the private seed sector has introduced a wide range of high-yielding hybrid seeds, genetically modified crops, and biofortified varieties, catering to the diverse needs of Indian farmers and consumers. These technological interventions have led to notable improvements in crop yields, quality, and resilience, contributing to food security and sustainable agriculture practices.

All these efforts collectively empowered the farmers particularly, smallholders, to enhance their productivity and profitability, driving overall agricultural growth in India. Overall, the private seed industry's relentless focus on technology-driven solutions, coupled with strategic investments and market expansion efforts, has positioned it as a key player in India's agricultural transformation, fostering innovation, sustainability, and economic development in the sector.

The Challenges Of Climate Change

In the current scenario, climate change poses a formidable threat to both agricultural sustainability and food security. Increasing frequency of extreme weather events underscores the urgency of addressing these challenges. As we navigate these uncertain conditions, it's evident that our agricultural systems face mounting pressures. However, amidst these challenges lies an opportunity for technologies in seed including biotechnology to play a pivotal role in adaptation and resilience.

As we mark National Technology Day, it's imperative for policymakers, researchers, and the seed industry to collaborate in promoting the adoption of biotechnology-driven solutions among farmers. By enhancing the genetic makeup of crops, we can bolster their ability to withstand prolonged periods of drought and other climatic stresses. This is the time for the policymakers, researchers, and seed industry to come together to promote this sustainable solution to the farmers and make the agri-food system climate-resilient.

ABOUT THE AUTHOR

Dr. Ratna Kumria is Senior Director Biotechnology, Federation of Seed Industry of India (FSII)

Green Tech

How Biofuels Can Increase Farmer Incomes In India

Agriculture in India generates about 750 million tonnes of agricultural residue annually. Almost 200 million tonnes of this has historically been burnt or disposed of without productive use. This not only contributes to severe environmental pollution but also represents a lost economic opportunity estimated at around Rs 50,000 crore.

With the use of modern technology and partnering with the right players, farmers can easily convert biomass into greener energy forms. An important component of these sustainable solutions is biofuels, a renewable energy source with the potential to reduce carbon emissions and mitigate climate change.

Biofuels can be used in solid, liquid as well as gaseous forms. Solid biofuels in the form of briquettes and pellets are used by industries in their boiler furnace to produce energy while liquid biofuels like biodiesel are used as transportation fuel. Biogases, obtained from anaerobic fermentation, can be used to run microturbines and automobile engines besides being used as a piped gas for cooking.

Government Initiatives and Policies

The Indian government has taken significant steps towards sustainable energy practices through initiatives like the SAMARTH and SATAT missions, both aiming to integrate agricultural inputs for fuel and feedstock. The SAMARTH Mission (Sustainable Agrarian Mission on use of Agro Residue in Thermal Power Plants) focuses on mitigating the environmental impact of stubble burning by utilizing agricultural residue as a supplementary fuel in coal-based thermal power plants. In order to reduce the carbon foot-print and to reduce the burning of agro-residue by the farmers, the Ministry of Power has mandated the use of 5% biomass pellets made primarily of agro-residue along with coal.

The mission involves enhancing the technology in power plants to accommodate the burning of biomass, improving the supply chain for biomass pellets, and adjusting regulatory frameworks to support biomass co-firing. Farmers would no longer need to burn the agro-residue as it can now be used for pellet manufacturing affording them additional income and several other benefits. This co-firing enables the use of surplus biomass, which was burnt earlier in the fields, for generation of electricity for millions of homes. This not only helps in reducing the carbon emissions of thermal plants but also tackles the issue of air pollution from stubble burning.

> Apart from generating an additional income source for farmers, biofuels also offer opportunities to create entrepreneurs in the hinterland

ABOUT THE AUTHOR

Mr Ashvin Patil is Founder and Director of Biofuels Junction Private Limited. He has more than 20 years of corporate experience in financial and manufacturing sectors

SATAT Mission

The SATAT Mission (Sustainable Alternative Towards Affordable Transportation) complements these efforts by promoting Compressed Biogas (CBG) as an alternative fuel for transportation. By leveraging agricultural waste, cattle dung, and municipal solid waste, the mission aims to establish biogas production plants that produce CBG, thus providing a cleaner, affordable, and sustainable alternative to conventional fossil fuels. This not only helps in reducing the dependence on imported fossil fuels but also supports the agricultural sector by providing farmers an additional source of income from agro-waste, thereby promoting a circular economy. Together, these missions embody the government's approach to harnessing agricultural resources for energy needs, emphasizing sustainability and economic benefits.

The government has also recently mandated the phased blending of CBG in compressed natural gas (CNG) for transport and piped natural gas (PNG) for domestic purposes. It is also providing financial assistance to CBG producers for procurement of biomass aggregation machinery to support the collection of biomass.

The adoption of CBG technology using the latest advancements has expanded the variety of residues and waste that can be utilized as feedstock for energy production. This innovation is particularly significant in addressing environmental concerns, such as pollution and waste management, especially in India's northern regions where agricultural residue burning is a prevalent issue.

Paddy Straw

Paddy straw, often burned in fields contributing to severe air pollution, has proven to be an effective feedstock for CBG production. Unlike its limited use as a solid biofuel due to suitability issues, paddy straw is efficiently processed into CBG, offering a sustainable energy alternative. This shift has the potential to revolutionize the agricultural residue management system in the north by accelerating the collection and processing of paddy straw.

Such development could significantly reduce the instances of crop burning, a major environmental challenge during the post-harvest season. This creates a lucrative opportunity for farmers. Farmers currently get rid of paddy straw mostly by burning it, which pollutes the environment and also causes health problems. Instead of burning, farmers can sell it to biofuel manufacturers, who can collect the residue and use it to make compressed biogas or solid biofuel pellets for coal firing in industries.

Ethanol Blended Petrol (EBP) Program

Additionally, The Ethanol Blended Petrol (EBP) Program which aims to reach a blending of 20% of ethanol in petrol by 2025 requires an increase in ethanol production. In India, sugarcane and its by-products serve as the primary raw materials for ethanol production, constituting over 90 percent of fuel ethanol supplies under the EBP initiative. This program not only infuses liquidity into the sugar sector but also offers farmers an alternative income source. Moreover, it helps stabilize sugar prices during years of surplus or excess production.

Importantly, it saves foreign exchange and reduces India's dependence on imports. The blending of ethanol into petrol resulted in savings of over Rs 24,300 crore of foreign exchange in the supply year 2022-23, as per the government data. Public sector oil marketing companies also saved 509 crore litres of petrol from ethanol blending besides paying Rs 19,300 crore to farmers.

Another avenue for farmers to benefit from biofuels is the cultivation of non-edible oilseeds. Biodiesel production in India is mostly being done using non-edible oilseeds like jatropha and Karanja besides, used cooking oil (UCO), algal feedstock, etc. Farmers can use barren or uncultivable land for farming jatropha and Karanja, which require extremely low levels of water and give good returns at low costs.

Creating Rural Entrepreneurs

Apart from generating an additional income source for farmers, biofuels also offer opportunities to create entrepreneurs in the hinterland. As agri residue is low in bulk density, the manufacturing of any type of biofuel has to be close to the source and hence in rural areas. This ensures the benefit goes to the rural economy in terms of employment, vendor development etc. Additionally, since the basic premise of biofuels is to cut carbon footprint, most manufacturers focus on reducing the distance between the source of biomass and its conversion into biofuels. Players like Biofuels Junction help entrepreneurs set up and scale their plants with the latest technology at minimum costs and near the source of biomass. The ready biofuel, which is compressed and non-bulky, can be transported at a much lower carbon footprint to the required location. One rural entrepreneur can generate employment for others who can work for biomass collection, in the biofuel plant, for transportation etc. Thus biofuels have the potential to create both direct and indirect employment in rural areas, reducing the need for migration to urban centers and alleviating urban pressure.

Green Energy

Towards Prosperity of Farmers, Society, and Government and Safer Environment

> The world is moving away from reliance on fossil fuels and embracing renewable energy sources

Agriculture is a fundamental component of the global economy, essential not only for food production but also for sustaining the livelihoods of billions worldwide. Energy in its various manifestations is the prime mover of life and all activities in the world. However, the world is currently grappling with significant challenges due to adverse impacts on environment as well as high energy costs and price volatility of the energy market. According to a 2010 report by the International Energy Agency (IEA), global energy demand is projected to increase 50% by 2035. Agriculture is sometimes accused for some of the energy crisis and climate impacts but the same agriculture also offers passible solutions and green/renewable resources. In the true sense, green energy refers to solar, wind, geothermal, hydropower, ocean and bio-energy. The biogas and bioethanol are also relatively green renewable forms of energy.

Energy Efficiency: A Path to Savings

Achieving sustainable development goals of the United Nations hinges upon maintaining a delicate balance between energy demand and economic viability. Technology enhanced, energy efficiency, coupled with the utilization of green energy sources within factories, farms and transport offer promising solutions to energy shortages as well as environmental pollution. The renewable energy resources within the agriculture sector present significant opportunities for fostering sustainability while driving rural economy and development. Green energy stands as a winning solution for all stakeholders involved in agriculture. For distressed farmers, it serves as a lifeline, offering alternative income sources and reliable power supply. Simultaneously, for governments, it presents an avenue to mitigate escalating debts, ensuring the sustainability of agricultural practices.

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Impact of Green Energy in Sustainable Agriculture

Green energy has emerged as a transformative force in the realm of sustainable agriculture, offering a myriad of benefits that contribute to the resilience, productivity, and environmental stewardship of farming practices. Here is a fact sheet of key renewable energy technologies that are making inroads in agricultural practices.

Hydropower

India is bestowed with large water resources, network of rivers and elevations enabling 5th position globally for installed hydroelectric power capacity. As of 31 March 2020, India's installed utility scale hydroelectric capacity was 46,000 MW, or 12.3% of its totally utility power generation capacity. Hydropower is the only renewable source of energy that can replace fossil fuels. This technology that could provide 12% of energy used in pressurized irrigation. Government has given highest priority for its development, since hydroelectric generation can meet the growing need of power for industry, agriculture, rural electrification and sustainability as well.

Solar-Powered Agriculture

Solar energy emerges as a pivotal solution in tackling critical agricultural challenges, leveraging the immense energy potential of the sun. All the energy stored in Earth's reserves of coal, oil, and natural gas is equal to the energy from only 20 days of sunshine. Recognizing this potential, the Ministry of New and Renewable Energy (MNRE) has introduced the PM KUSUM (Kisan Urja Suraksha Evam Utthaan Mahaabhiyan) scheme, offering substantial financial assistance totalling ₹ 34,422 crores to support farmers in harnessing solar power. This reform solidifies the ongoing solar revolution in our nation, propelling us towards the ambitious target of 450 GW of renewable energy by 2030.

Ground-mounted renewable power plants stand as pillars of this revolution, providing a stable income source for 25 years, even on uncultivable or under-utilized land. Beyond financial benefits, the installation of these plants generates a ripple effect, catalysing socio-economic development. Locally generated electricity fulfils regional power needs, reducing transmission losses and fostering energy independence.

With the declining cost of solar modules, solar pumps emerge as a financially viable option for farmers, with the potential to save 4 billion litres of diesel annually and curtail 5% of total greenhouse gas emissions. Moreover, the solarization of agriculture pumps offers farmers an additional advantage through grid-connected systems, enabling them to sell surplus power back to the grid. This not only creates a secondary income source for farmers but also assists the government in meeting Renewable Purchase Obligation (RPO) targets, further propelling the nation towards sustainable energy goals.

Wind Power's Agricultural Revolution

As of March 2021, India boasted a cumulative installed wind power capacity of approximately 39 GW. However, the commercial viability of wind resources remains concentrated in seven states: Andhra Pradesh, Gujarat, Tamil Nadu, Madhya Pradesh, Maharashtra, Rajasthan, and Karnataka. Private developers drive the establishment of wind power projects, assessing the techno-economic feasibility of each endeavour. India's ascendancy as the world's third-largest country in renewable power capacity expansion in 2021, following China and the United States, underscores its commitment to sustainable energy growth. Wind energy production produces no CO_2 emissions, making it a potent tool in combating the greenhouse effect and curbing pollution. In off-grid regions with adequate wind (>5 m/s) and groundwater supply, wind pumps present a cost-effective solution for domestic and community water supply, small-scale irrigation, and livestock watering needs.

Biomass: Agricultural Impact

Another boon for farmers is the biomass energy. Solid biomass, Biogas, Biofuels, Biochar etc are various form of biomass energy. National Policy on Biofuels, 2018 and Biomass based cogeneration plants utilise sugarcane and its by-products, surplus rice, maize, damaged food grains and non-edible seeds to produce biodiesel and ethanol. This further creates an opportunity for farmers to boost their income from un-utilised organic waste. Subsequently, this will also stanch the emissions to an extent, as burning of agricultural residue will reduce use petrol and diesel. Blending of petrol with bioethanol yields is much economical and environmentally friendly. Burning of bioethanol does produce CO_2, but the crop grown to produce these more than compensate through photosynthesis and carbon sequestration.

Geothermal Energy's Agricultural Influence

Geothermal energy, sourced from the Earth's magma beneath the crust, has emerged as a prominent renewable power option with diverse applications including in agriculture. Geothermal water, utilized to regulate soil temperature, shields crops from cold weather, ensuring optimal conditions for growth. Through underground piping systems, farmers can efficiently transport this water for irrigation, enhancing water management practices. Additionally, the heat generated can facilitate moisture removal from plants, extending their shelf life and minimizing degradation concerns. Geothermal energy thus presents farmers with a versatile and environmentally friendly tool for enhancing agricultural productivity and sustainability.

Harnessing the Sun

Solar Energy's Role in Agricultural Sustainability

> By harnessing solar energy, Indian agriculture can become more resilient, environmentally friendly, and economically viable

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India's agricultural sector is a significant consumer of fossil fuels, accounting for nearly one-fifth of the country's electricity and one-seventh of its diesel. This reliance on conventional energy sources is a hurdle in achieving the nation's net zero target by 2070 and intensity emission reduction goals by the year 2030. However, India's abundant sunshine presents a promising solution: solar energy. By harnessing this renewable resource, we can revolutionize Indian agriculture. Solar power can be utilized for various farm activities not only to reduce dependence on fossil fuels but also empower farmers with cleaner, more sustainable, and potentially cost-effective solutions for a brighter agricultural future.

Agro-Photovoltaic (Agro-PV) Projects

Agro-photovoltaic (agro-PV) projects are innovative initiatives that combine agricultural activities with solar photovoltaic power generation. These projects involve installing solar panels above cropland or livestock grazing areas, allowing for dual land use and maximizing the productivity of the land.

Solar-Powered Fences

Solar-powered fences offer a sustainable and cost-effective solution for protecting crops and livestock. They use solar panels to charge a battery, which then powers an electric pulse sent through wires along the fence perimeter. This deters animals from touching the fence due to the mild shock. Unlike traditional fences, solar fences require no grid connection, making them ideal for remote areas. They're also eco-friendly, eliminating the need for harmful chemicals or constant battery replacements. While the initial investment might be higher, solar fences offer long-term savings and a humane way to protect farms.

Solar Water Pumping System

A solar water pumping system is a sustainable solution for providing water in areas where access to grid electricity is limited or unreliable. This system uses solar panels to power a pump that draws water from a well, river, or other water source. Solar water pumping systems are environmentally friendly, as they do not produce greenhouse gas emissions or require fossil fuels. They are also cost-effective in the long run, as they reduce the need for diesel or electric pumps and the associated fuel or electricity costs. Solar water pumping systems are widely used in agriculture for irrigation, livestock watering, and other water-related applications, providing a reliable and renewable source of water for farming activities. Schemes like Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) offer significant subsidies on the initial cost of installing solar water pumps. In some states, net metering policies allow farmers to sell surplus electricity generated by their solar pumps back to the grid. This incentivizes investment in larger solar pump systems and provides additional income.

Solar Lighting Systems

Solar lighting systems are revolutionizing agriculture in India by providing a reliable and sustainable source of lighting for various farming activities. These systems use solar panels to harness sunlight and convert it into electricity, which is then stored in batteries for use during the night or when natural light is insufficient. In agriculture, solar lighting systems are used to illuminate farm fields, livestock sheds, and storage areas, extending the working hours and improving productivity.

Solar Dryers

Solar dryers are an essential tool in agricultural settings, particularly in regions like India where sun-drying crops is a common practice. These dryers harness solar energy to remove moisture from crops, fruits, and vegetables, preserving them for longer periods and reducing post-harvest losses. In India, solar dryers are widely used for drying spices, grains, fruits like mangoes and bananas, and vegetables like chillies and onions. For example, in Tamil Nadu, solar dryers are used to dry turmeric, ensuring better quality and higher market value.

In Maharashtra, solar dryers are used for drying grapes, improving their shelf life and marketability.

Solar Water Heating Systems

These systems utilize solar collectors to heat water, offering a sustainable and cost-effective solution for tasks requiring warm water. In poultry farming, for instance, maintaining proper brooding temperatures for chicks is crucial. Solar water heaters can provide warm water for chick brooding houses, reducing reliance on conventional energy sources and lowering operational costs. Additionally, greenhouses can benefit from solar water heating systems to regulate temperature, particularly in cooler regions, creating a more favorable environment for plant growth.

Solar Distillation Systems

Solar distillation systems are increasingly being used in agriculture in India to address water scarcity and improve water quality. These systems use solar energy to evaporate water from contaminated sources such as brackish or saline water, leaving behind impurities and producing clean, distilled water. This water can then be used for irrigation, especially in areas where water quality is poor or access to clean water is limited.

Major Benefits

From innovative agro-photovoltaic projects maximizing land use to efficient solar water pumping systems and dryers reducing post-harvest losses, solar energy offers a multitude of solutions. Empowering farmers with solar lighting extends working hours and enhances security, while targeted applications like solar water heating and distillation systems address specific needs.

By harnessing solar energy, Indian agriculture can become more resilient, environmentally friendly, and economically viable. However, to realize the full benefits of solar energy in agriculture, concerted efforts are needed to promote awareness, provide incentives, and facilitate widespread adoption of solar technologies across the agricultural sector. Government initiatives promoting solar technology adoption, coupled with its inherent environmental and economic benefits, position solar energy as a key driver for a brighter future of Indian agriculture.

Profitable Paddy

Case Study of A Tenant Farmer

Eluru District, Andhra Pradesh

> ***This story is inspiring for all unemployed youth shying away from agriculture and paddy farming***

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Paddy is being cultivated in the state of Andhra Pradesh in an area of 15.52 lakh ha. during Kharif and 7.91 lakh ha. during Rabi season. Godavari Districts of the state are known for their fertile soils and high paddy yields and hence, are popular as rice bowl of the state. Paddy is being grown in Eluru, an important Godavari district in an area of 1.05 lakh ha. during Kharif and 40,000 ha. during Rabi. However, increasing cultivation, input and labour costs in addition to decreasing resources are forcing the paddy farmers to look at other remunerative alternatives, such as oil palm cultivation, etc.

In this context, the story of a tenant farmer of Eluru district belonging to Unguturu Mandal, Bommidi Village with no own land is inspiring to all unemployed youth shying away from agriculture and paddy farming, in particular. The farmer, Bandi Trimurthulu with Mobile number 9701133783 has been cultivating paddy during both Kharif and Rabi seasons on lease in 27.0 acres for the past 25 years and the land owners are job holders and business persons with no interest or patience for agriculture.

The current lease amount is the cash equivalent of 16 bags of Paddy per season and hence, 32 bags of paddy per year. The cost of cultivation of paddy during Kharif is about 30,000/- per acre, while it is 35,000/- per acre during Rabi season and also varies based on the variety under cultivation.

The farmer prefers to grow Swarna (MTU 7029) variety with assured yield potential and duration of 140-145 days during Kharif season in the entire 27 acres and the economics are as follows:

Swarna – 27.0 acres – Yields 40 bags of 75 kg/acre (Dry weight basis) and is sold @ 1637/- per bag of 75kg (MSP of 2183/- per quintal) in November 2023

- Therefore, Gross Returns = 65,480/- per acre
- Cost of cultivation = 30,000/- per acre
- Hence, Net returns = 35,480/- per acre
- Therefore, Total returns = 9,57,960/- for 27 acres in 140 days with Swarna variety
- However, Lease amount = 16 x 1637/- x 27 = 7,07,184/- for Kharif season
- Therefore, Net profit to the tenant farmer = 2,50,776/- for 6 months or 41,796/- per month, much higher or equivalent to the earnings of a educated person with freedom from stress and job related pressures, in addition to healthy lifestyle in an unpolluted environment.

Reasons for Preferance for Swarna Variety

- Cosmopolitan variety with assured yield, in spite of adverse climate
- Miller preferred variety due to high Head rice recovery (HRR)
- Tolerant to BLB, BPH and low input responsive variety
- Dormancy of two weeks and low shattering
- Also used for consumption in certain districts of the state

Disadvantages of Swarna Variety

- Lodges completely at maturity during cyclones/heavy rains due to weak culm
- Highly susceptible to Blast

The farmer has diversified from growing of Shridruthi (MTU 1121) in the entire 27.0 acres in the past to grow Swarna (MTU 7029) variety for seed production in 17.0 acres; PR 126, a short duration variety of 120 days from Punjab with high yield potential of 60-70 bags per acre on fresh weight basis and preferred by exporters for export to Africa due to its rice kernel length > 6mm for instant cash in 7.0 acres; and MTU 1121 with high returns in an area of 3.0 acres during Rabi season and the economics are as follows :

PR 126 is grown in 7.0 acres and yields 68 bags of 75kg/acre (on Fresh weight basis) and is sold @ 1270/- per bag of 75kg in April 2024

- Therefore, Gross Returns = 86,360/- per acre
- Cost of cultivation = 30,000/- per acre
- Hence, Net returns = 56,360/- per acre
- Therefore, Total returns = 3,94,520/- for 7 acres in 120 days with PR 126 variety

Reasons for preference for PR 126 variety

- Ready market for fresh produce without drying at the farmers field itself and instant cash to the farmer
- Short duration variety of 120 days and therefore Low GHG emission
- Drought tolerant and less water requirement per kg of grain
- Low biomass variety, suitable for parboiled rice and export to African countries, in view of rice kernel length >6mm

Disadvantages of PR 126 variety

- Lack of availability of Pure and good seed
- Not notified for cultivation in the state of Andhra Pradesh
- Being discouraged by the Dept. of Agriculture and hence, procurement problem through RBK's, in case of large scale cultivation
- Discouraged by local millers, in view of the local mills being used for raw rice milling only

MTU 1121 is grown in 3.0 acres and yield 55 bags of 75kg/acre (on Dry weight basis) and is sold @ 1637/- per bag of 75kg in April 2024

- Therefore, Gross Returns = 90,035/- per acre
- Cost of cultivation = 30,000/- per acre
- Hence, Net returns = 60,035/- per acre
- Therefore, Total returns = 1,80,105/- for 3 acres in 130 days with MTU 1121 variety

Reasons for preference for MTU 1121 variety

- Variety with high yield potential
- Good head rice recovery
- Suitable for raw rice
- Preferred by local rice Millers
- Dries on the standing crop itself and hence, no need for further drying on floor

Disadvantages of MTU 1121 variety

- Highly susceptible to BLB and Stem rot diseases
- 130 days duration in Rabi
- Market mostly through procurement by Govt. with no scope for instant cash and other issues related to procurement

The farmer is also growing MTU 7029 for seed in 17.0 acres with an average yield of 55 bags of 75 kg/acre (Dry weight basis) which is sold @ 1900/- per bag of 75kg to Seed Companies in April 2024

- Therefore, Gross Returns = 1,04,500/- per acre
- Cost of cultivation = 35,000/- per acre
- Hence, Net returns = 69,500/- per acre
- Therefore, Total returns = 11,81,500/- for 17 acres in 135 days with MTU 7029 variety seed

Hence, Gross total for 27 acres in Rabi (PR 126 + MTU 1121 + Swarna Seed) = 17,56,125/- in 150-180 days, while the Lease amount for 27 acres = 5,48,640/- (16 bags x 1270/- =20,320/- per acre). Hence, the Net profit during Rabi Season for 27 acres = 12,07,485/- in 150 – 180 days or 2,01,247/- per month.

The average income per month during 2023-24 is therefore, 1,21,521/- per month from 27.0 acres of leased land to the tenant farmer, who remains to be satisfied with his profession, income, and contribution to the society, while maintaining his natural health without the intervention of costly medicines due to his lifestyle and involvement in Agriculture. His wealth has grown over the years, and he is now the proud owner of a tractor and several cows, which also contribute to his income additionally, over and above the income received from leased land. Benefits to the landowner are Rs. 12,55,824/- (7,07,184/- + 5,48,640/-) for 27 acres per year or 46,512/- per acre per year.

The above story of the tenant farmer is expected to motivate and help the unemployed youth to return to the villages and Agriculture and make it a profitable enterprise.

Critical Interventions, Expectations Of Farmers From Agricultural Scientists

- 140 days duration, non-lodging variety with strong culm and high yield potential of 50 bags/acre and high HRR > 65% tolerant to BPH, BLB, Blast, dormancy of more than 2 weeks with germination < 10% in the first week, low shattering, brown glume colour, medium slender grain with transluscent grain and no abdominal chalkiness in addition to intermediate amylose content for Kharif season.
- 110-120 days duration, non-lodging variety with strong culm and high yield potential of 60 bags/acre and high HRR > 65% tolerant to BPH, BLB, Blast, dormancy of more than 2 weeks with germination < 10% in the first week, low shattering, medium slender or long slender (kernel length > 6.40mm) grain with transluscent grain and no abdominal chalkiness in addition to intermediate amylose content for Rabi season.
- Promotion of Wet direct seeding during Kharif and Rabi seasons with tractor drawn drum seeder to reduce the cost of cultivation by 5000-6000/- per acre
- Effective Weed control technology for transplanted and direct seeded rice to reduce labour costs for weeding
- Suitable varieties for wet direct seeding with non-lodging, anaerobic germination, increased root length and root volume, in addition to drought tolerance and above traits described for Kharif and Rabi seasons
- Seed to seed mechanization and promotion of farm machinery for weeding, fertilizer application and spraying
- Reduction of inorganic fertilizers by the incorporation of straw and bio-fertilizers to reduce the cost of cultivation
- Promotion of Green manure crop during the months of May-June for soil health and reduction of inorganic fertilizers for sustainable agriculture
- Establishment of Ethanol production industries for increased returns from Paddy straw and better price for drenched paddy during cyclones
- Creation of Farmer-Miller-Trader-Consumer linkages and clusters for the benefit of different stakeholders
- Promotion of Solar driers and Mini-rice mills on subsidy

The above interventions are expected to increase the farmer net income by about 15-20 per cent, resulting in stable and sustainable agricultural systems and society in addition to attracting the unemployed rural youth back to villages, agriculture and healthy lifestyle.

These interventions are expected to increase the farmer net income by about 15-20 per cent, resulting in stable and sustainable agricultural systems and society

Forward March

Leading Our Farmers On The Path Of Growth

"Investment in rural electrification and the provision of efficient storage and transportation facilities would help reduce post-harvest losses and bridge the gap between farmers and markets

ABOUT THE AUTHOR

Mr Ritesh Taunk is Founder, Kash Hith Innovations, Durg C.G.

The development of robust agricultural infrastructure is crucial to support the sector's growth.

1 **Enhancing Infrastructure:**

The new government should prioritize the improvement of irrigation facilities, particularly in rain-dependent regions, to mitigate risks associated with inadequate water availability. Investment in rural electrification and the provision of efficient storage and transportation facilities would help reduce post-harvest losses and bridge the gap between farmers and markets. Upgrading rural roads and connecting remote areas to agricultural hubs would enhance accessibility, enabling farmers to benefit from markets and agricultural inputs.

2 **Ensuring Access to Credit:**

Access to affordable credit is essential for farmers to invest in modern agricultural practices, buy quality inputs, and manage risks effectively. The new government should work towards simplifying loan procedures and expanding credit availability to cater to small and marginal farmers who often suffer from financial exclusion. This can be achieved by strengthening cooperative banks, promoting digital lending platforms, and incentivizing commercial banks to increase lending to the agricultural sector. Additionally, efforts should focus on educating farmers about financial literacy and encouraging them to adopt prudent financial practices.

3 **Promoting Technology Adoption:**

Technological advancements have the potential to revolutionize Indian agriculture, significantly improving productivity, reducing wastage, and enhancing resource utilization. The new government should encourage and support the adoption of modern technology, such as precision farming, intelligent irrigation systems, crop monitoring through drones, and use of data analytics. Furthermore, investing in agricultural research and development will foster innovation and help develop climate-resilient and high-yielding crop varieties that suit diverse agroclimatic zones in the country.

4 **Strengthening Farm Extension Services:**

Access to accurate and timely information is crucial for farmers to make informed decisions and adopt best practices. The new government should strengthen the farm extension services, aiming to bridge the gap between agricultural research institutions and farmers. This can be achieved by recruiting and adequately training more extension workers, promoting the use of mobile-based information platforms, and organizing regular training and awareness programs. Empowering farmers with knowledge on sustainable farming practices, efficient water management, and climate-smart agriculture will ensure productivity enhancements and reduce dependence on chemical inputs.

5 **Ensuring Fair Market Access:**

One of the biggest challenges faced by farmers is the lack of fair market access, often leading to distress selling and inadequate returns for their efforts. To address this issue, the new government should focus on creating a robust and transparent agricultural market ecosystem. This includes establishing more agricultural produce markets (APMCs) and improving their functioning, promoting direct marketing initiatives, encouraging the development of farmer producer organizations (FPOs), and enhancing value chain linkages. Additionally, the government should consider reforming the Essential Commodities Act and Agricultural Produce Marketing Committee Act to remove unnecessary restrictions and promote a competitive marketplace.

6 **Climate Change Adaptation:**

Climate change poses a significant threat to Indian agriculture, with increasingly erratic weather patterns, extreme events, and water scarcity becoming more common. The new government must prioritize climate change adaptation and resilience-building measures. This includes promoting climate-smart agricultural practices, strengthening early warning systems, supporting the adoption of climate-resilient crop varieties, and incentivizing the use of renewable energy sources for irrigation. Collaborating with international organizations and investing in climate research will provide valuable insights and assistance in formulating effective policies.

Route To Revolution

> GOI is inviting farmers and farmers' cooperatives to develop CBG programs in districts for converting bio-waste into compressed bio-gas

Renewable energy, for me, is the management of waste-to-energy systems. What we once considered waste has now become a valuable source of energy. India has shown its commitment to the world by adopting good practices to save the environment and demonstrating leadership in this area.

Currently, the Indian agriculture sector is heavily dependent on electricity generated from fossil fuels. Fossil-based fuels contribute significantly to pollution, which is increasing at a dangerous pace in India, and there is tremendous pressure from the international community to reduce coal usage. The agriculture sector is one of the largest consumers of fossil fuels, contributing to high levels of carbon emissions and environmental pollution. Reducing carbon content in the environment is crucial to saving the Earth and its ecosystems.

The growing demand for food and the unstable prices of fossil fuels have led to the search for environmentally friendly energy sources. Energy is one of the largest overhead costs in the production of greenhouse crops, which require climate control.

Today, global power consumption is about 18 trillion watts. The energy consumption in agriculture has increased with the introduction of high-yielding plant varieties and mechanized crop production practices. After labor, energy is typically the largest overhead cost in the production of greenhouse crops, even in temperate climates. Of the total energy required, about 75% is consumed by heating, 15% by electricity, and 10% by vehicle transportation. To provide better conditions for crop growth, adequate lighting, temperature, humidity, and gas composition or concentration must be regulated in greenhouse cultivation using electricity.

Hybrid System Of Solar And Wind Energy

In modern agricultural practices, greenhouses and polyhouses are playing a dominant role. The use of wind-solar renewable energy systems for controlling greenhouse environments reduces fuel consumption and enhances the sustainability of greenhouse production.

To meet the growing power demand in agriculture, a hybrid system of solar and wind energy is currently recommended. The generated power is transmitted to the power grid, which can be utilized on an as-needed basis. This approach avoids the need for large battery backup systems, which would require significant capital investment.

Power generated through the hybrid system can be utilized by solar pumps to meet irrigation needs as well as polyhouse management.

Sources of Renewable Energy:

1. Wind Mill
2. Solar Power
3. Biogas
4. City Waste Management

The government is continuously increasing awareness about the use of renewable energy through various schemes. The list of introduced schemes is given below.

Major Renewable Energy Initiatives

1. Development of Solar Parks and Ultra-mega Solar Power Projects with a target of setting up 40,000 MW capacity. The Central Public Sector Undertaking (CPSU) Scheme is for setting up grid-connected Solar Photovoltaic (PV) Power Projects by government producers, using domestically manufactured solar PV cells and modules.

2. Production Linked Incentive scheme 'National Programme on High Efficiency Solar PV Modules.'

3. PM-KUSUM Scheme to promote small grid-connected solar energy power plants, stand-alone solar-powered agricultural pumps, and the solarization of existing grid-connected agricultural pumps. The scheme benefits not only farmers but also states and DISCOMs. States will save on subsidies provided for electricity to agricultural consumers, and DISCOMs will get cheaper solar power at the tail end, saving on transmission and distribution losses.

4. Rooftop Solar Programme for grid-connected solar rooftop power plants.

5. Green Energy Corridors (GEC).

6. Bio-Energy Programme:

- Waste to Energy Programme
- Biomass Programme
- Biogas Programme: for the promotion of family-type biogas plants.

7. National Green Hydrogen Mission launched with an outlay of Rs. 19,744 crore, aiming to make India a global hub for the production, utilization, and export of green hydrogen and its derivatives.

Cluster Development Programs

The government, through Cluster Development Programs (CDP), is inviting farmers and farmers' cooperatives to develop CBG programs in districts for converting bio-waste into compressed bio-gas. This will significantly reduce the cost of importing CNG. Through CDP programs, manufacturers are distributing the produce through Indian Oil in the market. The bio-waste used in making CBG is also utilized as organic fertilizer for farmers.

The Government of India has announced the mandatory blending of Compressed Bio-Gas in CNG (Transport) and PNG (Domestic) segments of the CGD sector. This initiative aims to stimulate demand for CBG in the CGD sector, substitute imports of Liquefied Natural Gas (LNG), save on foreign exchange, promote a circular economy, and assist in achieving the target of net-zero emissions.

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Expectations from Government for Growth in the Livestock Sector

Policy Frameworks and Support Mechanisms

A conducive policy required for effective utilization of stray animals

Livestock is pivotal in Indian agriculture, supporting mixed farming systems and enhancing resource efficiency. It sustains over 55% of rural livelihoods and contributes significantly to agricultural value-added, reaching 28.63% in 2021. Additionally, it empowers women, mitigates risks for small farmers, and aligns with the goal of doubling farmers' income.

Challenges

Livestock farming confronts multifaceted challenges, including the scarcity of superior breeding bulls and subpar sperm quality. Access to credit and insurance remains limited, exacerbating the plight of farmers. Emergence of zoonotic diseases necessitates improved veterinary diagnostics and treatment facilities, while antimicrobial resistance underscores the urgency for trained personnel and effective therapy.

Inadequate feed resources and a lack of conservation plans for indigenous breeds further impede progress. The sector's growth is hampered by insufficient infrastructure and a shortage of expertise and support services. A comprehensive strategy is imperative to overcome these hurdles and foster sustainable development in the livestock industry.

Government schemes

Indian Govt. has already taken steps by launching several missions to boost the livestock sector e.g. Animal Husbandry Infrastructure Development Fund (AHIDF) supports various stakeholders like Farmer Producer Organizations (FPOs), private dairy companies and entrepreneurs.

National Livestock Mission aims for qualitative and quantitative improvements in animal production and capacity building. National Artificial Insemination Program innovates impregnation techniques for better breed efficiency and disease control. National Animal Disease Control Programme targets Foot and Mouth Disease (FMD) and Brucellosis with 100% immunization

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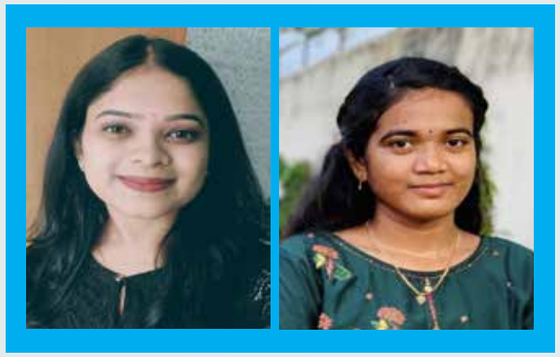

of cattle, buffalo, sheep, goats, and pigs. Rashtriya Gokul Mission promotes indigenous bovine breeds for increased milk output and profitability.

Agriculture and livestock sectors serving as the backbone of our economy, the expectations from this new administration are profound and far-reaching. As this sector continues to grow, stakeholders have certain expectations from the government to ensure its sustainable development. These expectations encompass policy frameworks and support mechanisms aimed at promoting growth and addressing sector-specific challenges.

Policy Frameworks

Investment in Infrastructure: Adequate infrastructure is critical for the livestock sector's development. The government should invest in refrigerated transportation networks, cold storage facilities, and modernized processing plants to ensure efficient movement and storage of livestock products.

Research and Development: Government funding for research and development in breeding, nutrition, and disease management would lead to significant advancements in livestock productivity and health.

Genomic selection of superior bulls can increase performance and decrease risk in animal breeding. Crossbreeding using a bull of a different breed of cowherd can increase fertility, longevity, and health which all lead to increased profitability.

Sex screening helps in optimizing reproductive efficiency by ensuring that breeding animals with desirable sex and genetic traits leading to increased fertility rates, shorter generation intervals, and higher productivity in the herd or flock.

Rich diversity of indigenous livestock breeds possess unique genetic traits adapted to local environments. Promoting the conservation and sustainable utilization of indigenous breeds can enhance resilience and biodiversity while offering niche market opportunities.

Regulations and Standards: To ensure high-quality livestock products and protect public health, governments must establish and enforce regulations and standards for animal welfare, food safety, and environmental protection standards.

Primary contributors of methane emissions are paddy cultivation and enteric fermentation. Government initiatives like climate resilient practices in paddy cultivation, crop diversification programs and feeding livestock with superior quality balanced ration by promoting green fodder production, silage making and total mixed ration reduces methane emissions.

Biogas generated through anaerobic digestion of dung, can reduce dependency on fossil fuels, enhance energy security and reduce greenhouse gas emissions. Biomethane produced produced from dung will act as a source of clean and green energy and recycling of nutrients back into the soil.

Access to Markets: Policies that open up domestic and international markets for livestock products can stimulate growth. This might involve negotiating trade agreements, reducing tariffs, and addressing non-tariff barriers.

Support Mechanisms

Beyond policy frameworks, the livestock sector requires specific support mechanisms from the government to achieve sustainable growth:

Financial Support and Incentives: Governments can offer grants, subsidies, and tax incentives to encourage investment in the livestock sector. This financial support can help farmers and businesses modernize their operations and increase production capacity.

Extension Services and Education: Extension services and educational programs help farmers to adopt best practices in livestock management.

Health and Biosecurity Programs: Governments should implement comprehensive veterinary health and biosecurity programs to prevent and manage such risks.

Insurance and Risk Management: Given the inherent risks in agriculture, governments should promote insurance schemes and risk management programs for livestock farmers.

Promotion of Livestock Export: Government should focus on promoting exports of high-quality livestock products, facilitating trade agreements, improving quality standards, and investing in value addition will unlock new opportunities for farmers and bolster India's position in global market.

Stray animals: A conducive policy required for effective utilization of stray animals.

An effective approach to supporting the livestock sector requires collaboration between government, industry stakeholders, and other relevant entities. This includes engaging in public-private partnerships, consulting with livestock associations, and involving local communities in decision-making processes. Growth of livestock sector depends on government's commitment to creating favorable policy frameworks and providing robust support mechanisms. Through strategic investments, effective regulation, and collaboration with stakeholders, government can meet the expectations of livestock sector and contribute to its sustainable development.

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Poolani Milk Cooperative Society

Fastest Growing In The Dairy Sector Of Rural Kerala

For the purpose of giving its members a guaranteed market for their milk, Poolani Milk Cooperative Society [PMCS] undertook a number of activities and has a highly promising future. Currently, conditions are excellent for both the welfare of animals and the success of dairy producers.

Dairy farming has become the primary source of revenue among farmers of Meloor panchayat. It had 30 members when it was officially registered in 1976 under the Co-operative Societies Act of 1912. It has 1368 members and can handle 2250 litres of milk per day as of 2012. The initiative has successfully integrated improved technology and management into the conventional small milk producer production system, making significant improvements to animal husbandry at Meloor Village.

In the hamlet, it directly and indirectly supports 2000 employments, and it gives its members about Rs 25 lakhs each month. Additionally, PMCS are certified to ISO 9001:2015 and ISO 2200:2005.

Emphasis On Milk Quality

All members of PMCS are required to maintain the quality of milk and milk products in accordance with the standards of the Kerala Co-operative Milk Marketing Federation (KCMMF), also known as Milma, and the National Dairy Development Board [NDDB]. PMCS has one main centre with a chilling plant at Poolani and two sub centres at Adichili and Pusphagari.

The board is always concerned with customer concerns about quality issues and offers milk farmers a competitive milk market and technological assistance to increase milk output.

To prevent adulteration of flour, urea, and detergent with water. sustaining their inherent nutritional content is crucial for sustaining the quality. Since milk and milk products are consumed by many social groups and are the primary source of calcium and protein may be found in milk. In addition to these, it is a fantastic source of vitamins, minerals, potassium, B12, and omega 3 fatty acids., it has been difficult to screen for and approve non-adulterated milk and milk products. Members delivered the milk to the appropriate centres, where it was subjected to normal quality inspection procedures.

Utilising the MILKO Tester and an automated milk collecting unit (AMCU), the quality measurement is carried out scientifically. The MILKO Tester aids in the quick determination of the milk's fat percentage, and the AMCU shortens farmers' waiting times and eliminates unfair practises. Installed Automatic Milk Chilling Plant, Capacity: 2000 litters at centre and applied for 5000 litters. By the conclusion of every 10 days, the cashier settles the account and transfers into shareholders account after inputting the milk measurement twice every day. Camp and monthly meetings were organised to enhance cattle, and participants included farmers, veterinarians, livestock specialists, and government officials.

> *PMCS is considered as a viable source for developing the rural economy and provide synergy between industry and agriculture against the backdrop of self-employment or group employment*

To increase livestock output and productivity in the village, veterinarians perform regular checkups and offer high-quality animal health services, including technological input services such animal health care, artificial insemination services, immunisation, and the provision of balanced cow feed.

Major Support System For Dairy Farmers

Meloor produces enough milk on its own. According to instructions from KCMMF and NDDB, PMCS assists farmers in price negotiations and the assembly or marketing of milk and dairy products to wholesalers and retailers. The sector plays a crucial role in achieving food security, reducing village poverty, generating employment opportunities for women, and providing a regular source of income. It also promotes sustainable agriculture practices and contributes to the overall economic development of rural areas.

Equal pay for men and women is guaranteed. By providing jobs for women, PMCS has significantly contributed to the economic empowerment of women and laid the foundation for increased independence and self-esteem.

Women's ability to manage an independent income and education is made possible by their ability to work. The idea that if one woman is educated, the entire family is educated and if the family is educated, the entire society is educated is valid in a bigger context. The establishment of PMCS also aids in raising milk prices, resulting in higher rural incomes, lowering waste, ensuring value addition, and creating job possibilities.

Every five year, elections are held to choose the director board members, and the president is chosen by the nine members that make up the membership. The president and the elected members are present during every ordinary meeting. The reports must be delivered to NDDB and Milma.

The administrative team arranges a number of social programs, including pensions and subsidies for livestock feed, among others. The President, Shri N G Sathish Kumar, and Secretary, Smt. P P Jalaga and other elected members, now set the standards for PMCS in terms of how to handle farmers, employees, suppliers, customers, and other stakeholders. The PMCS built an APCOS hall to hold meetings in addition the unit giving pensions to 86 members and providing pension to seven members who were in pathetic condition using their own cash.

For the benefit of dairy farmers, PMCS is promoting a variety of advantageous programs. For the benefit of dairy farmers in Kerala, Milma also provides free insurance plans, discounted veterinary services, pension plans, free housing to a select group of farmers each year, help finding milch cows, discounted feeds, and other services.

In accordance with several programs, the animal husbandry department offers dairy farmers a subsidy of '3 lakh as part of the Milkshed Development Programmes, as well as a 50-percentage subsidy for the purchase of cows, incentives throughout the summer, and incentives to grow fodder in and above 50 cents. government is offering free labour and seeds. Farmers get subsidies from the zilla panchayat, block, and gram panchayath totalling Rs. 2, Rs. 1, and 1 Rs. Milking machines, rubber mats, pressure washers, slurry pumps, chaff cutters, plastic cow drinkers, and generators all receive a 50% subsidy from the Milma and Dairy Development Board.

Cattle Feed

All farmers are worried about cattle feed, which is the milch cows' primary dietary need. PMCS is pushing people to plant more varieties of grasses and giving out free seeds to get their fields with different types of fodder are Bajra Napier (Co-4), Guinea grass (Anjan grass), Fodder sorghum (CoFS-27), Multi cut fodder sorghum (CoFS-29), African tall maize, Legumes, Cowpea, and tree fodder variants Sesbania and Glyricidia. started because the rising cost is cause for concern. Due to the recent increase in feed prices, dairy farming has become less profitable and more burdensome for the common dairy farmer. The average price of feeds is between Rs 1560 and Rs 1600 for a 50 kg bag. 10 to 12 kg of are consumed daily by single cow.

PMCS opened a little shop where they sold all value-added goods including cheese, paneer, ice-cream, biscuits and ghee rusks. PMCS is the largest milk supplier of milk in Ernakulam Regional Co-operative Milk Producers' Union Ltd.' Dairy product demand will rise as a result of the rapidly rising population, especially the expanding rural population and the developing urban population. Greater opportunities and potentials are provided for milk producers as well as for the growth of the milk production and processing sector by the increase in demand for milk and dairy products. PMCS is considered as a viable source for developing the rural economy and provide synergy between industry and agriculture against the backdrop of self-employment or group employment.

Tech Buzz

Expectations from the New Government to Boost IT Applications in Indian Agriculture

The Green Revolution's legacy in India is a complex one. While it undeniably propelled the nation towards self-sufficiency in food grains and boosted overall agricultural production, there's still significant room for growth. Compared to the global average, India's agricultural productivity per hectare remains considerably lower. This shortfall can be attributed to several factors, including limited access to advanced irrigation techniques, fragmented landholdings that hinder mechanization, and a persistent lack of investment in agricultural research and development. To bridge this gap and ensure long-term food security, India needs to prioritize sustainable agricultural practices, encourage farmer education and innovation, and invest in infrastructure that can streamline production and distribution.

Technological Advancements

Recent advancements in artificial intelligence (AI), machine learning (ML), block-chain, satellite imagery, and spectral image analysis offer exciting tools to revolutionize agriculture. While these technologies hold immense potential to inform government policies at the macro level, their implementation on the ground, particularly for small and marginal farmers, is a significant challenge. The current system often struggles to translate these advancements into low-investment, easy-to-adopt solutions that directly enhance the productivity and profitability of these smaller farms. By addressing this gap and empowering individual farmers with accessible tools, we can unlock India's agricultural potential and contribute to a significant improvement in average productivity compared to global productivity.

Government Infrastructure Establishments

India boasts a vast network of government bodies, agricultural universities, Krishi Vigyan Kendras (KVKs), and other institutions aimed at empowering farmers at the local level. However, the effectiveness of these institutions in addressing farmers' daily challenges remains a concern. Unfortunately, some have become more focused on data collection and disbursement of financial aid through government schemes rather than on providing practical guidance. This approach neglects the crucial need to equip farmers with the knowledge and skills to overcome real-world hurdles, minimize production costs, and maximize efficiency.

To unlock India's agricultural potential, a renewed focus is required on farmer engagement. These institutions need to transform into dynamic support systems that actively collaborate with farmers, providing practical solutions and fostering a knowledge-sharing environment for long-term agricultural success.

The Opportunity

The widespread adoption of mobile phones and internet access, particularly in rural areas, has emerged as a game-changer for tackling some of the intricate challenges plaguing India's agricultural ecosystem. This connectivity empowers farmers with vital information and resources, fostering a new era of opportunity for the agricultural sector.

Mobile technology offers a far more cost-effective and personalized approach to supporting small and marginal farmers at the village level. This approach can bridge the gap between established research institutions and local universities, empowering them to deliver targeted advice directly to individual farmers. Imagine farmers receiving customized advisories on their phones, tailored to their specific fields and needs. This real-time information can equip them with actionable solutions for everyday challenges like pest control, improved crop practices, adapting to weather fluctuations, optimizing harvests, and even finding nearby markets for better profits. This shift towards mobile-based support has the potential to revolutionize rural agriculture in India.

Way forward

India's agricultural sector presents a unique challenge due to its vast and diverse agro-climatic zones. Each state grapples with distinct agricultural issues requiring tailored solutions. Recognizing this complexity, state government involvement alongside the central government becomes inevitable. To effectively address these regional variations, a degree of policy customization at the state level is crucial. This flexibility will allow states to craft solutions that resonate with their specific agricultural needs and challenges.

Time for National Digital Agricultural Policy

The success of initiatives like the Digital India Act 2023 demonstrates the central government's ability to implement impactful policies. A similar approach – a National Digital Agricultural Policy – could significantly enhance agricultural productivity and empower small and marginal farmers. This policy framework should empower state governments to develop localized agricultural strategies. These strategies, informed by local agricultural experts, would identify ecologically-suited crops, optimal planting patterns, and best practices for each region. Additionally, the policy should establish a framework for disseminating real-time, personalized support to farmers in their native languages. This comprehensive approach, combining national vision with regional customization, has the potential to revolutionize Indian agriculture.

A National Digital Agricultural Policy should prioritize

National Policy Framework: Advocate for the establishment of a National Digital Agricultural Policy, mirroring the success of the Digital India Act 2023.

Decentralized Strategy Development: Empower state governments to develop localized agricultural strategies based on their unique agro-ecological zones.

Expert-Driven Approach: Ensure these strategies are informed by consultations with local agricultural experts, fostering knowledge-based decision-making.

Ecological Sustainability: Encourage the identification of crops that are ecologically suited to each region, promoting sustainable agricultural practices.

Region-Specific Optimization: Facilitate the development of optimal planting patterns and best agricultural practices tailored to the specific needs of each region.

Real-Time Personalized Support: Establish a framework for delivering real-time, personalized agricultural support directly to farmers in their native languages.

Technological Enablement: Leverage advancements in mobile technology and other digital tools to create an efficient and accessible support system.

Farmer Empowerment: Combine a national vision with regional customization to empower small and marginal farmers, ultimately revolutionizing Indian agriculture.

> *To unlock India's agricultural potential, a renewed focus is required on farmer engagement*

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NaPanta Recognized as Top 10 Most Innovative and High Potential Startup from Telangana by Microsoft in Jan 2020

Millets

The Future Crops For Sustainability And Nutrition

> *A breakthrough in rainfed agriculture is essential for poverty alleviation, food security, and nutritional security in India*

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Millets are a group of small-seeded grasses that have been cultivated for thousands of years, particularly in Asia and Africa. Millets are recognized as certain "Future crops" in the context of climate change because of their resistant to a majority of pests and diseases, and their ability to thrive in extreme harsh conditions of arid and semi-arid regions in Asia and Africa.

The most commonly cultivated millets in India are sorghum (Sorghum bicolor L.), pearl millet (Pennisetum glaucum), finger millet (Eleusine carocana), proso millet (Panicum miliaceum), kodo millet (Paspalum scrobiculatum), foxtail millet (Setaria italica), little millet (Panicum sumatrense). (Rao et.al., 2017).

GOI has designated millets as Nutri-Cereals, emphasizing their nutritional superiority over conventional staples like wheat and rice. In a world grappling with multifaceted global issues such as malnutrition and climate change, the role of millets, is gaining prominence. In 2023, Global Hunger Index, India ranks 111 th out of 125 countries. India has the world's highest child wasting rate at 18.7 per cent indicating severe undernutrition (GHI, 2023). Besides, India is often referred to as the 'Diabetes Capital of the World'. Against this backdrop of mounting nutritional challenges, millets emerge as a beacon of hope. This review article explores the potential of millets as the future crops for sustainability and nutrition.

Current Scenario Of Millets

The primary agricultural climatic zones (ACZs) responsible for significant rice production in the irrigated north western and semi-arid tropics are facing sustainability challenges (Chand et al., 2020). Millets is considered for sustainability in farming, but due to increased cultivation of fine cereal crops in India, the cultivation of major and minor millets has been declining over the past five decades. In India the growth rates of area, production, and productivity of minor millets were found negative (Rafi et al.,2023).

With a substantial portion of the Indian diet centred on fine cereals such rice and wheat, per capita availability and per capita millet consumption in India is drastically reduced from 26.22 kg in 1960s to 3.87 kg in 2022 (APEDA, 2022). Indeed, the expansion of rice-wheat systems in India has significantly alleviated hunger and malnutrition. However, this growth relies on escalating agricultural inputs and has adverse environmental consequences, particularly for freshwater resources (Davis et al., 2018).

Millets As An Alternative Cereal

In India, the demand for food will increase exponentially with a growing population. While maize, rice and wheat have been adopted as the major staple cereals, millets are lagging behind. Meanwhile, there is a lesser possibility of crop improvement of major staple cereals such as rice and wheat because the production of those cereals is facing so many constraints as the world is already facing the challenges of drylands expansion, soil degradation, and groundwater scarcity.

For example, in India, according to the National Rainfed Area Authority (NRAA, 2020) report states that even after utilizing maximum irrigation potential, about half of the total irrigated land will continue to remain unirrigated. These alarms are forcing us to promote alternatives to major water consuming cereal crops.

Approximately 56% of India's total cultivated land is dedicated to rainfed agriculture. The significance of rainfed agriculture is evident in its contribution, accounting for 40% of the nation's total food production (Venkateswarlu and Prasad 2012). Thus, rainfed agriculture continues to play a vital role in ending India's hunger crisis. Therefore, a breakthrough in rainfed agriculture is essential for poverty alleviation, food security, and nutritional security in India (Shankar, 2011). Offering increased market prospects for traditionally rainfed crops and promoting the diversification toward less water-demanding crops like millets are viable long-term strategies (Suresh et al., 2014).

Consumptive water demand in cereal production has notably increased from 482 to 632km 3 H 2O Year -1 from 1966 to 2009, primarily driven by a surge in blue water demand for wheat. This transition raises concerns about water resource depletion. By replacing rice with alternative cereals such as millet with the lowest irrigation (blue) water footprint (WFP), it is possible for India to reduce irrigation water demand by 33 per cent and improve the production of protein (+1 per cent), iron (+27 per cent), and zinc (+13 per cent) with only a modest reduction in calories. (Davis et al., 2018).

Due to projected population growth, India faces a challenge in balancing food security. Increasing the cultivation of coarse cereals like millets and sorghum has several positive outcomes: it enhances nutritional availability, with an average increase of 1 to 5 per cent in protein and 5 to 49 per cent in iron content, bolsters the resilience of crops to climate extremes, resulting in 1 to 13 per cent fewer calorie losses during severe dry years, reduces GHG emissions by 2 to 13 per cent, lowers the demand for irrigation water by 3 to 21 per cent, and decreases energy consumption by 2 to 12 per cent (Davis et al., 2019).

Apart from this, millets have enormous nutritional benefits. Millets offer a promising solution to tackle malnutrition and diabetes. The mean GI of millets is 52.7 ± 10.3, about 36 per cent lower than in typical staples of milled rice (71.7 ± 14.4) and refined wheat (74.2 ± 14.9) (Anitha et al., 2021). Millets are naturally gluten-free and have a low glycemic index, making them an ideal choice for individuals with dietary restrictions and those seeking to manage chronic health conditions.

Catalyst For
Transformative Change

> Renewable energy will play a central role in shaping the agriculture sector

In today's rapidly evolving world, the demand for energy is escalating every day, and agriculture is no exception. Adopting renewable energy sources not only contributes to a greener environment but also has a positive impact on the economics of farming. Renewable energy, epitomized by solar panels, wind turbines, and biofuel production, stands as a beacon of hope for a greener agricultural landscape. The integration of renewable energy sources not only reduces the carbon footprint but also offers tangible economic benefits to farmers. That's what we do at SatGuru Superfoods! We have embraced this paradigm shift by implementing sustainable practices such as solar dryers, not only for drying of sprouted millets and lentils, but also developed a solar-operated facility with the usage of solar panels.

The potential for renewable energy in agriculture is immense. As per available data, the cost of setting up a 100kW transmission line ranges between INR 1Cr to 3Cr PER KM, whereas the installation of solar plant ranges from INR 80 lakh to 1.5Cr. This significant cost differential underscores the immediate accessibility and affordability of renewable solar energy for the food and agriculture sector. Our adoption of solar panels and solar dryers underscores our commitment to sustainability, reducing the reliance on conventional energy sources and minimizing our environmental impact.

The techno-economic analysis underscores the compelling business case for renewable energy adoption in agriculture. While the initial investment may pose a challenge, the long-term benefits in terms of reduced operating costs and increased revenue streams far outweigh the upfront expenditure. In addition to the environmental benefits, renewable energy technologies provide resilience against volatile energy prices, offering stability and predictability to agricultural operations.

The Indian Context

In the Indian context, the trajectory of renewable energy in agriculture appears promising, buoyed by ambitious government targets and supportive policies, paving the way for a greener and more prosperous agricultural sector. There is a growing recognition of the importance of sustainability in farming and ample opportunities for farmers and food processors to embrace renewable energy technologies. SatGuru Superfoods aligns with this vision, leveraging renewable energy technologies to enhance the sustainability and resilience of our operations.

Expanding upon the significance of renewable energy in agriculture, it is essential to delve into the multifaceted benefits it offers. Firstly, renewable energy mitigates the environmental impact of conventional energy sources, which are often associated with greenhouse gas emissions and air pollution. By transitioning to renewable sources such as solar and wind power, agricultural operations can significantly reduce their carbon footprint, contributing to global efforts to combat climate change.

Secondly, renewable energy enhances energy security and resilience in the agricultural sector. Traditional energy sources are subject to price fluctuations and geopolitical tensions, which can disrupt supply chains and inflate operational costs for farmers. In contrast, renewable energy technologies like solar panels and wind turbines provide a reliable and decentralized energy source, reducing dependency on imported fossil fuels and mitigating the risk of energy supply disruptions.

Renewable Energy Infrastructure

The adoption of renewable energy fosters economic development and empowers rural communities. By investing in renewable energy infrastructure, such as solar farms or biogas digesters, agricultural regions can create new job opportunities, attract investment, and stimulate local economies. Additionally, decentralized renewable energy systems enable farmers to become energy producers, generating additional revenue through feed-in tariffs or selling excess electricity back to the grid.

Beyond its environmental and economic benefits, renewable energy also promotes innovation and technological advancement in food & agriculture. The integration of renewable energy technologies with precision agriculture techniques, such as IoT sensors and data analytics, enables farmers to optimize resource utilization, improve crop yields, and enhance overall productivity. Moreover, research and development in renewable energy solutions tailored to the specific needs of agriculture, such as solar-powered irrigation systems or biomass-based heating, drive technological innovation and knowledge exchange within the sector.

Addressing The Challenges

To maximize the potential of renewable energy in agriculture, it is crucial to address existing barriers and promote widespread adoption. Financial incentives, such as subsidies, tax credits, and low-interest loans, can help offset the initial capital costs of renewable energy investments and encourage farmers & food processors to transition towards sustainable practices. Moreover, capacity-building initiatives, technical assistance programs, and knowledge-sharing platforms play a vital role in educating farmers about the benefits and best practices of renewable energy adoption.

Renewable energy stands as a catalyst for transformative change in agriculture, offering a pathway towards a more sustainable and prosperous future. By harnessing the power of solar, wind, and bioenergy, renewable energy will play a central role in shaping the agriculture sector and ensuring a brighter, more sustainable future for generations to come. As we embark on this journey towards a greener tomorrow, SatGuru Superfoods remains steadfast in our mission to champion sustainability!

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AGRIVOLTAICS SYSTEMS

Sustainable Income Generation in Agriculture

> By capitalizing on synergies between solar energy production and agricultural cultivation, farmers can mitigate risks associated with climate variability

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Agrivoltaics, the harmonious integration of solar photovoltaic panels with agricultural practices, represents a dynamic solution for sustainable income generation in agriculture. This abstract delves into the transformative potential of agrivoltaics systems, emphasizing their capacity to optimize land use, enhance crop yields, and diversify revenue streams.

By capitalizing on synergies between solar energy production and agricultural cultivation, farmers can mitigate risks associated with climate variability while simultaneously bolstering their economic resilience. Drawing on empirical evidence and case studies, this article elucidates the multifaceted benefits of agrivoltaics, including improved water-use efficiency, reduced soil erosion, and increased farm profitability. Moreover, it discusses the role of agrivoltaics in fostering agricultural innovation, community engagement, and environmental stewardship. As policymakers and practitioners increasingly recognize the value of agrivoltaics, these abstract advocates for its widespread adoption as a pivotal strategy for advancing sustainable income generation and agricultural resilience in a rapidly changing world.

Introduction

In recent years, the agricultural sector has faced numerous challenges ranging from climate change-induced weather fluctuations to market volatility and land degradation. As the global population continues to grow and natural resources become increasingly strained, there is an urgent need for innovative approaches to ensure food security, mitigate environmental degradation, and foster economic resilience in rural communities.

Agrivoltaics, the integration of agricultural activities with solar energy production, has emerged as a promising solution to address these multifaceted challenges. Agrivoltaics systems represent a synergistic approach that leverages the complementary benefits of agriculture and renewable energy production.

At its core, agrivoltaics involves the co-location of photovoltaic solar panels above agricultural land, allowing for dual land use and maximizing the efficiency of land utilization.

Unlike traditional solar farms that occupy large swathes of land exclusively for energy production, agrivoltaics systems enable farmers to simultaneously cultivate crops or raise livestock beneath solar panels, thereby optimizing the productive capacity of the land.

Principles Of Agroecology

The concept of agrivoltaics builds upon the principles of agroecology, which emphasizes the interconnectedness of ecological processes within agricultural systems. By integrating solar energy production into agricultural landscapes, agrivoltaics systems promote ecological resilience, resource efficiency, and biodiversity conservation. The shade provided by solar panels creates microclimatic conditions that can benefit certain crops, reduce water evaporation, and mitigate soil moisture fluctuations, thereby enhancing overall land productivity and crop yields. One of the key advantages of agrivoltaics systems is their potential to generate multiple revenue streams for farmers. In addition to income from agricultural products, farmers can also derive revenue from the sale of solar energy generated by the photovoltaic panels.

This diversified income model helps farmers mitigate the risks associated with fluctuating market prices and climate variability, thereby enhancing economic resilience and livelihood security. Moreover, agrivoltaics systems contribute to the transition towards renewable energy and the reduction of greenhouse gas emissions. By harnessing solar energy, agrivoltaics systems help offset the carbon footprint associated with conventional energy sources and contribute to the decarbonization of the agricultural sector.

As governments and policymakers worldwide increasingly prioritize renewable energy targets and climate mitigation efforts, agrivoltaics represents a practical and scalable solution to align agricultural practices with sustainability goals.

Promising Pathway

Agrivoltaics systems offer a promising pathway towards sustainable income generation in agriculture. By integrating solar energy production with agricultural practices, agrivoltaics systems optimize land use, enhance resource efficiency, and create diversified revenue streams for farmers.

As the global community strives to address the interconnected challenges of food security, climate change, and energy transition, agrivoltaics represents a practical and scalable solution to build resilient and sustainable agricultural systems for future generations.

RENEWABLE ENERGY

SUSTAINABILITY AND STRENGTH

> *Through innovative technologies and supportive policies like the PM-KUSUM scheme, India can revolutionize its energy landscape while bolstering rural livelihoods and mitigating climate change*

India's agricultural sector, often referred to as the backbone of the nation, stands at a critical juncture as it grapples with the dual challenge of ensuring food security for a burgeoning population and confronting the escalating threats posed by climate change. In this dynamic landscape, the integration of renewable energy into agriculture emerges as a beacon of hope, offering not only a sustainable solution but also a pathway towards transformative growth. With ambitious targets set by the Ministry of New and Renewable Energy (MNRE), India aims to achieve 500 gigawatts (GW) of renewable energy capacity by 2030, with solar and wind power at the forefront of this renewable revolution (MNRE, 2023). Against this backdrop, this article explores the latest data and insights on how renewable energy can empower Indian agriculture, driving sustainability, resilience, and prosperity.

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Potential

Solar Potential

Recent assessments by the Ministry of New and Renewable Energy (MNRE) indicate that India's solar potential exceeds 900 gigawatts (GW). This substantial figure underscores the nation's capacity to harness solar energy as a key pillar of its renewable energy strategy (MNRE, 2023).

Wind Power Potential

According to the latest data from the National Institute of Wind Energy (NIWE), India's wind power potential stands at over 373 GW. With advancements in wind turbine technology and favourable wind regimes across several states, India continues to leverage its wind resources for clean energy generation (NIWE, 2023).

Hydropower Potential

The Central Electricity Authority (CEA) estimates India's hydropower potential at approximately 167 GW. Despite challenges related to land acquisition and environmental concerns, hydropower remains a significant component of India's renewable energy mix (CEA, 2023).

Bioenergy Potential

India's bioenergy potential, encompassing biomass, biogas, and biofuels, remains robust. The Ministry of Petroleum and Natural Gas (MoPNG) reports that India's biofuel potential stands at around 65 million metric tonnes per year, offering opportunities for sustainable energy production (MoPNG, 2023).

Geothermal and Ocean Energy

Preliminary assessments by the Geological Survey of India (GSI) suggest promising geothermal potential in select regions, while the Ministry of Earth Sciences (MoES) explores the viability of ocean energy. Although in nascent stages, these sources hold promise for India's renewable energy future (GSI, 2023; MoES, 2023).

Opportunities

Renewable energy (RE) integration in Indian agriculture presents lucrative opportunities for sustainable development. Solar-powered irrigation stands out as a promising avenue, with the potential to replace diesel pumps and save over 20 billion litres of diesel annually (IWMI, 2023). Additionally, biogas production from agricultural waste offers substantial benefits, generating around 67 million tons of bio-manure and 12.88 million tons of bio-CNG each year (CII, 2023).

Wind energy co-location with agricultural land is another promising strategy, enhancing land productivity and providing additional income streams for farmers (IIT Delhi, 2023). Solar-driven agro-processing units also hold immense potential, reducing energy costs, and stimulating economic growth in rural communities (MoAFW, 2023).

Available Technologies

Innovative renewable energy (RE) technologies integrated with the agriculture sector offer promising solutions for sustainable development. Solar photovoltaic (PV) systems, widely adopted for irrigation, are becoming more efficient and affordable, with advancements in panel technology and smart grid integration (MNRE, 2023). Additionally, solar-powered drip irrigation systems are gaining traction, optimizing water use and enhancing crop yields (IWMI, 2023).

Wind energy technologies, such as small vertical axis wind turbines (VAWTs), are emerging as dual-purpose solutions, serving both as wind barriers to control erosion and as electricity generators (IIT Delhi, 2023). Biogas plants utilizing agricultural waste are another vital technology, providing clean energy for cooking, heating, and electricity generation while managing organic waste sustainably (CII, 2023).

Furthermore, the development of solar-driven agro-processing units and solar thermal devices, such as solar cookers and solar dryers, is revolutionizing value addition in agriculture, reducing post-harvest losses, and improving farmer incomes (MoAFW, 2023).

Role in Mitigating Climate Change

Renewable energy (RE) plays a pivotal role in mitigating climate change by reducing greenhouse gas emissions and promoting sustainable development. As on Feb, 2024, India's renewable energy capacity reached 136 GW (excluding hydro) and 183 GW (including Hydro), and it avoided an estimated 350 million tons of CO2 emissions annually (MNRE, 2023). Solar photovoltaic (PV) systems alone contributed to averting over 200 million tons of CO2 emissions since their widespread adoption (IEEFA, 2023). Additionally, wind energy installations accounted for an annual reduction of 70 million tons of CO2 emissions (GWEC, 2023).

Furthermore, biofuel production from agricultural waste through anaerobic digestion prevents methane emissions from organic decomposition while providing clean energy alternatives. India's commitment to renewable energy transition aligns with its climate goals, contributing significantly to the global effort to limit temperature rise and combat climate change.

Techno-Economic Analysis

A techno-economic analysis of renewable energy (RE) solutions reveals their viability and impact on the agricultural sector. In India, solar photovoltaic (PV) pumping systems have emerged as a cost-effective alternative for irrigation. Through life cycle cost (LCC) analysis, these systems have shown promising results in terms of overall cost efficiency. Additionally, integrating bidirectional energy meters allows farmers to sell surplus electricity generated by solar PV systems to the grid, offering an additional source of income (MNRE, 2023).

Another aspect of techno-economic analysis involves calculating the payback period, which indicates the time required for the cumulative net present value of a project to become positive. Solar PV pumping systems typically have a payback period ranging from 3 to 5 years, depending on factors such as system size, installation costs, and solar irradiance levels (IREDA, 2023).

Moreover, the integration of renewable energy technologies with agriculture, such as agri-voltaic systems, offers additional economic benefits. These systems not only generate electricity but also increase farmers' income by utilizing the same land for agricultural production. The adoption of agri-voltaic systems has the potential to provide substantial returns on investment, contributing to the overall economic prosperity of rural communities (TERI, 2023).

Global Success Stories

Denmark: With over 6,000 onshore wind turbines, Denmark leads in wind energy integration, generating approximately 40% of its electricity from wind. Farmers leasing land for turbines earn up to €100 million annually.

Germany: Agri voltaic systems cover over 10,000 hectares, demonstrating a 186% increase in crop yield for cherry tomatoes and 74% for potatoes. Water savings of up to 20% have been observed.

United States: Solar-powered irrigation systems in California save farmers $1,000 per acre annually on diesel fuel costs. Over 78,000 farms utilize solar energy, reducing carbon emissions by 16.8 million metric tons annually.

China: China's biogas plants produce over 20 billion cubic meters of biogas annually, meeting the energy needs of 35 million households. This reduces CO2 emissions by approximately 50 million tons per year.

Netherlands: Greenhouses with integrated renewable energy systems produce 20-40% of their energy needs on-site. This reduces greenhouse gas emissions by 2.8 million tons annually.

Future of RE in India

The future of renewable energy (RE) in India holds immense promise, driven by ambitious government initiatives and technological advancements. With the goal of achieving 500 gigawatts (GW) of renewable energy capacity by 2030, India is making significant strides towards a sustainable energy future. The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme, launched to promote solar power adoption in the agriculture sector, exemplifies the government's commitment to RE integration. Under PM-KUSUM, 314675 standalone pumps, 2571 individual pump were solarized and 1.66 GW solar power capacity was installed. 9207 feeder were solarized.

In addition to PM-KUSUM, other government initiatives such as the National Solar Mission and National Wind Mission are driving the growth of RE in India. These initiatives incentivize investment in solar, wind, and other renewable technologies, fostering innovation and market competitiveness. Furthermore, policies like renewable purchase obligations (RPOs) and net metering regulations create favourable conditions for RE deployment and grid integration.

Conclusion

In conclusion, the symbiotic relationship between renewable energy (RE) and agriculture offers immense potential for India's sustainable development. Through innovative technologies and supportive policies like the PM-KUSUM scheme, India can revolutionize its energy landscape while bolstering rural livelihoods and mitigating climate change. However, realizing this potential requires collaborative efforts from governments, industry players, and agricultural communities. By embracing renewable energy solutions, India can enhance energy access, increase agricultural productivity, and promote environmental sustainability. As the world moves towards a greener future, India has a unique opportunity to lead the way, leveraging its abundant renewable resources and fostering a culture of innovation and sustainability. By seizing this opportunity, India can pave the path towards a more prosperous and resilient future for generations to come.

Disclaimer: This article is intended to inform decision-makers in the public, private and third sectors. The views of writers are personal and it does not represent the views of either the Government of India or NITI Aayog. They are intended to stimulate healthy debate and deliberation in power sector. The data are taken from published source, MNRE/ CEA/Ministry of Power website. For any query please contact us on E-mail: mk.upadhyay@nic.in and Telephone no.: 011-23042422/9971131218

Renewable Energy

New Paradigm for Sustainability & Growth

> Green Energy must be our collective goal. Much more needs to be done before we reach our net zero objective by 2070

We see clear signs of climate change everywhere on Earth. Globally, our cultures are shifting due to unpredictable weather patterns, rising sea levels, and melting glaciers caused by climate change.

In India, this crisis is already affecting our economy, agricultural production, wildlife, human health, and access to clean water. We face difficult policy trade-offs. We must improve living conditions for our 1.4 billion citizens while significantly reducing greenhouse gas emissions worldwide.

Our government has implemented several regulations to encourage renewable energy production and move away from coal. However, much more needs to be done before we reach our net zero objective by 2070. Lowering GHG emissions will likely have a detrimental effect on growth in the near term and significantly impact people and communities currently dependent on coal.

Renewable Energy in India

We are proud to highlight the strides India has made in Renewable Energy. Renewable energy in India refers to energy derived from natural processes that replenish faster than consumption, such as solar, biogas, geothermal, hydro, and certain biomasses. We rank fourth globally in installed renewable energy capacity, including major hydro, wind, and solar power. Our ambitious goal is to achieve 500 GW of non-fossil fuel-based energy by 2030.

As of July 2023, our non-fossil fuel capacity, including major hydro and nuclear power, has expanded by an impressive 396% over the past 8.5 years, exceeding 179.322 GW, which constitutes almost 43% of our total energy capacity. In 2022 alone, we saw a 9.83% annual growth in renewable energy additions. Our solar capacity has grown 24.4 times over the past nine years, reaching 67.07 GW. Since 2014, our total renewable energy capacity, including major hydro, has expanded by around 128%.

The Electricity Act 2003 allows renewable energy projects to attract up to 100% FDI through the automatic route. The combined installed capacity of all renewable energy sources now surpasses 150 GW, with large hydropower accounting for 179.322 GW as of July 2023. This substantial growth underscores India's commitment to increasing our renewable energy capacity and reducing reliance on fossil fuels, positioning us as a global leader in renewable energy deployment.

Renewable Energy in Agriculture

Integrating Renewable Energy with Agriculture can significantly advance the Global Climate Action Movement by reducing GHG/ CO_2 emissions and enhancing savings and income for farmers and rural households.

Approximately 60% of India's population lives in rural areas, facing challenges such as irregular and limited power supply and reliance on fossil fuels like diesel for their energy needs. About 66% of rural households still use firewood for cooking, which adversely affects family health and increases the effort and time required for collecting firewood, leading to deforestation.

Farmers face post-harvest losses and depend on diesel to power gensets for electric water pumps, milking machines, and cooking. Additionally, they often have animal, food, and agricultural waste that goes unused as energy, contributing to GHG/CO_2 emissions. India is the third-largest GHG emitter globally. However, if farmers wish to transition to renewable energy, there is no dedicated marketplace or village store where their energy needs can be understood and suitable products recommended within their budget.

There is also a lack of knowledge dissemination or education about various renewable energy products like solar, biogas, thermal, wind, and electric energy. These products are not readily available or accessible at the village level.

The absence of accessible renewable energy solutions and education in rural areas hinders the adoption of sustainable energy practices, perpetuating reliance on fossil fuels and contributing to environmental degradation. Addressing these gaps by providing marketplaces, education, and accessible renewable energy products can empower rural communities, reduce emissions, and support sustainable agricultural practices.

Tech Push

India is the 3rd largest Greenhouse Gas Emitter in the world where agriculture alone contributes to the GHG emissions in the range of 18-20%. With the advent of technology and with the honourable PM Narendra Modi ji's mission to make the nation Independent resulted into 1.7 lakhs+ registered startups today since 2016 out of which there are close to 7000+ Agritech startups solving the pressing issue with their product and business model innovations. However the space has been difficult coupled with multiple parameters like Climate Change, Demography & varied Weather Conditions across India as a country. While most of the startups are working around Agri-Input like Seeds, Pesticides, Fertilisers, Equipment's, AI, IoT, Weather Forecasting, Supply Chain & Forward Linkage there are very few startups working around Renewable & Green Energy or Climate Change. The penetration of Renewable & Green Energy like Solar, Biogas etc. across India despite the Government Initiatives & Schemes have not penetrated to the extent as it should due the adoption, availability & affordability challenge at the last mile aligned with UN SDGs.

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STIHL's Power Tiller Makes Farming a Breeze and Boosts Productivity

The power tiller by STIHL revolutionizes farming, providing ease of use and enhanced productivity with its modern design and powerful performance.

The saying, "Good beginnings lead to good results," emphasizes the importance of a positive start for successful outcomes. This applies to agriculture as well. Indeed, farmers who use modern agricultural machinery for soil preparation instead of traditional methods experience better productivity without the heavy physical and mental stress. One such modern agricultural machine used for tilling fields is the power tiller. With the help of this machine, farmers can plow the corners of the fields easily and properly.

If you're planning to purchase a strong and durable power tiller for farming, you can opt for STIHL India's MH 710 and MH 610 power tillers. These modern power tiller machines from STIHL India are designed according to the needs of farmers, being not only affordable but also convenient to use. Let's understand more details of these machines:

Features of STIHL MH 610 Power Tiller:

STIHL India's MH 610 power tiller machine is equipped with a petrol engine. It features a single-cylinder 4-stroke, air-cooled engine generating 6 horsepower. It comes with a fuel tank capacity of 3.6 liters, allowing farmers to work for extended periods with a single refill. The total weight of the STIHL MH 610 power tiller is 60 kilograms. With this machine, farmers can till the soil up to a width of 78 centimeters and a depth of 5 inches in one go. It has a gearbox with 2 forward gears and 1 reverse gear. The company has designed this power tiller with an ergonomic body, enabling the use of other gardening machinery and tools with more power.

Features of STIHL MH 710 Power Tiller:

STIHL India's MH 710 power tiller machine is also powered by a petrol engine. It features a single-cylinder 4-stroke, air-cooled engine generating 7 horsepower. Similar to the MH 610, it comes with a fuel tank capacity of 3.6 liters. The total weight of the STIHL MH 710 power tiller is 101 kilograms. With this machine, farmers can till the soil up to a width of 97 centimeters and a depth of 6 inches in one go. It also has a gearbox with 2 forward gears and 1 reverse gear and is designed with an ergonomic body for ease of use with other gardening machinery and tools.

Special Features of STIHL MH 610 and MH 710 Power Tillers:

Currently, the biggest challenge facing our country's farmers is the uncertain availability of labor. This results in heavy physical and mental stress for farmers, leading to delayed completion of agricultural tasks and ultimately reduced productivity. However, with the use of STIHL power tiller machines, all these issues faced by farmers can be resolved.

STIHL's power tiller efficiently handles even the most intricate and challenging agricultural tasks with ease. Moreover, both the MH 610 and MH 710 models feature a grip handlebar that can be adjusted according to the user's height. These power tillers generate minimal vibration during operation, making it comfortable for farmers to work for extended periods. With the help of these power tiller machines, farmers can easily perform tasks related to both farming and gardening.

STIHL's power tiller can handle tasks such as plowing, dry land cultivation, and leveling with ease, marking the beginning of a new era in farming.

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