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Inside the issue ...

Food, Water and Energy security in IHR

Hot springs of Uttarakhand and scheme for rejuvenation of Gaurikund at Kedarnath

Geothermal sites at the earth's surface are known to be present both on land and deep inside the sea. A considerable temperature gradient is the main reason behind the rise of temperature with depth of earth in certain geographical locations. As the ground water of these locations is heated by the hot rocks, geothermal reservoirs are formed beneath the earth. This hot water comes out through the openings at the earth's surface forms geothermal springs or hot springs (Joshi *et al.*, 2011). Hot water springs are evidences of geological activity and represent extreme environments in which the microbial and geochemical interactions are tightly interwoven. The Himalayas are rich in having numerous potential geothermal sites that emerges there spontaneously. About 60 hot springs have been reported in the Himalayan region which are rich in microbial diversity (Arya *et al.*, 2015).

Hot springs are a rich source of sulfur and used for balneotherapy due to its healing properties that include treating skin infections such as rashes and eczema. Because of medical benefits of these springs, they are well-liked tourist destinations and the sites of rehabilitation centers. The thermophilic microbial communities can be used to treat polluted soils and wastewater. The biomolecules, primarily proteins and enzymes, found in hot-adapted microorganisms have already found use in molecular biology, medicine, the beverage industry, soaps, and beauty products. The enzymes derived from heat-loving microorganisms serve as biocatalysts in a variety of industrial processes. Such enzymes can function well even in hot environments such as Taq DNA polymerase (Lopez *et al.*, 2013). Numerous thermophilic polymer-degrading enzymes, including amylases, chitinases, and cellulases, have excellent stability and activity at high temperatures. Streptococcus thermophilus, a bacterial species that was discovered in hot springs, has the ability to increase a person's immunity (Pathak and Rathod, 2014).

There are many hot springs located in different regions of Uttarakhand. Some of the well known hot springs located in Uttarakhand with their locations and respective temperatures are tabulated in Table 1.

Table 1. Some hot springs located in Uttarakhand

Springs	Location	Temperature
Soldhar (Tapovan) hot spring	Joshi math, Uttarakhand India	90 °C
Gaurikund hot spring	Kedarnath, Uttarakhand, India	50 °C
Suryakund hot spring	Yamunotri, Uttarakhand India	87 °C
Taptkund hot spring	Badrinath, Uttarakhand, India	56 °C
Gangnani hot spring	Nandgaon, Uttarakhand, India	57 °C

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The **"EIACP Centre on Himalayan Ecology"** collects, collates, compiles and builds quantitative and qualitative databases of information in the fields related to the Himalayan Ecology. The information is disseminated regularly via online as well as hardcopies to several valuable stakeholders and various users such as DICs, universities, institutions along with other EIACP Centres across India to support overall Environmental Information System in India.

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Photo credit (front): Dr. Ravindra K. Joshi

Editor's Note

The Indian Himalayan Region (IHR) is a unique and ecologically sensitive area that plays a pivotal role in sustaining life across South Asia. However, the region faces a complex interaction of challenges related to food, water, and energy security. Balancing these key elements is not only essential for the IHR but also holds lessons for sustainable development practices worldwide. The IHR stands at a critical juncture where the delicate balance between food, water, and energy security faces unprecedented threats. By seizing these opportunities through sustainable practices, inclusive policies, and community engagement, the Himalayan region can not only overcome challenges but also serve as a model for balanced and resilient development in the face of global changes. Water and energy are closely interlinked together and these two are intricately linked with food production. These interlinkages pose significant management challenges as well as opportunities. The key lies in recognizing and capitalizing on the interconnectedness of water, energy, and food systems to ensure a prosperous and sustainable future for the people of the Himalayas.

The present issue of EIACP Newsletter [20(3)] covers these vital issues which are very pertinent to IHR. The present issue of the newsletter includes 9 good quality articles on the subjects related to water, energy and food sustainability. The general views presented in the articles are the views of the concerned authors. Comments/suggestions for further improvement of the EIACP Newsletter are welcome.

Er. Mahendra Singh Lodhi
EIACP, Coordinator

Disaster at Gaurikund Hot Spring during Kedarnath Tragedy

The Gaurikund hot spring is situated, on the way to the Kedarnath temple. It is located on the Mandakini River's bank. This location gained notoriety following the Kedarnath flash flood disaster in 2013, which left this location completely destroyed. The majority of Gaurikund town including this geothermal site, and the temple complex were severely submerged under debris in the disaster of 2013 as shown in Fig. 1. The microbial and aquatic habitat was also disturbed due to this disaster (Khanna *et al.*, 2022).

Fig. 1. (a) Gaurikund pre disaster view **(b)** Gaurikund post disaster view

Nurturing nature: Uttarakhand's journey towards a green economy

Schemes for restoring and rehabilitation of the Gaurikund hot spring

There was widespread concern to revive the spring and restore the surroundings because it is an important geothermal spring for the area and has a lot of religious sentiments and importance. The river developed an avulsion toward the west during the Kedarnath disaster, so it is necessary to reclaim area for future floods to pass. Construction of a Flood Protection Wall (FPW) on banks of the river, spanning a 300-meter stretch of the Mandakini River from north of Gaurikund to south of the iron bridge on the Gaurikund-Sonprayag road, to reduce the risk of future flooding and to improve bank stability. The construction of retaining walls has prevented the geothermal spring water from being channelized (Khanna *et al*., 2022).

In order to accommodate religious activities, Khanna *et al*., 2022 suggested that the spring sources that are currently flowing beneath the retaining wall be directed into a new storage tank/ bathing complex. It is also suggested to drill and provide horizontal perforated pipes to collect water in a big pond in order to lessen the loss of discharge from hot springs. However, efforts should be made in the future to find additional primary source outlets in the immediate area and direct the flow to the proposed pond.

An unbroken flow in the upstream area of the Gaurikund temple complex, a series of gully plugs must be built along the seasonal streams to enter in the Mandakini River. These gully plugs will stop monsoon runoff, aid in water conservation, and make it easier for shallow recharge to lead to deep percolation, which will revitalize the hot spring source. To evaluate the changes in surface flow regime, regular monitoring of river flow should be conducted. A requirement for implementing sustainable spring rehabilitation, disaster management, and mitigation programs is the regular evaluation of discharge and water quality (Khanna *et al*., 2022).

Conclusion

This article focuses on importance of hot springs of Uttarakhand and reviving the Gaurikund hot spring, which was buried by a landslide and river-borne debris. To gauge the effect of spring rehabilitation at Gaurikund, it is necessary to implement these suggestions on the various damaged hot springs of Uttarakhand. By implementing the aforementioned strategies have been helps to bringing back spring and are essential for maintaining people's way of life.

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Introduction

In the heart of the Himalayas, where towering peaks touch the sky and pristine landscapes weave tales of natural beauty, Uttarakhand stands as a testament to the symbiotic relationship between mankind and the environment. Recognized as "Devbhoomi" or the "Land of the Gods," this northern Indian state has embarked on a transformative journey towards a green economy, echoing the global call for sustainable development. Uttarakhand, while adorned with unparalleled biodiversity and scenic wonders, grapples with the environmental challenges that accompany such delicate ecosystems. Deforestation, climate change-induced natural disasters, and the pressures of development pose significant threats to the state's ecological equilibrium. In response to these challenges, Uttarakhand has emerged as a vanguard in the adoption and implementation of green economy initiatives, weaving together the threads of economic prosperity and environmental stewardship. This narrative explores the unfolding chapters of Uttarakhand's odyssey towards a green economy. From harnessing renewable energy to nurturing biodiversity, promoting organic farming to sustainable tourism, the state's endeavours reflect a holistic vision where nature and economy coalesce in harmonious coexistence. As Uttarakhand treads the path of responsible development, this exploration delves into the strategies, challenges, and triumphs that mark the state's commitment to nurturing nature for the well-being of its people and the generations yet to come.

Environmental Challenges in Uttarakhand

Uttarakhand state is ecologically rich and sensitive and various environmental challenges has been identified in the state.One of the foremost challenges confronting Uttarakhand is the persistent issue of deforestation, leading to a profound loss of biodiversity. The expansive forests, home to a myriad of flora and fauna, face threats from logging, agricultural expansion, and human settlements. The depletion of these natural habitats poses a direct threat to the unique biodiversity that defines Uttarakhand's ecological identity (Negi and Sharma, 2019). Also, the mountainous terrain of Uttarakhand renders it susceptible to natural disasters, with flash floods and landslides being recurrent challenges. Climate change exacerbates these risks, leading to altered precipitation patterns and glacial melt. The increasing frequency and intensity of such events pose significant threats to both human settlements and the delicate ecosystems of the region (Singh and Verma, 2020). At least 5,731 people lost their lives while over 2,000 suffered injuries during natural disasters, mainly triggered by flash floods and landslides, in Uttarakhand during last two decades (2000-2020), according to data collated by the state's disaster management department (https://timesofindia.indiatimes.com/ 21 Feb 2021).

Furthermore, Uttarakhand serves as the origin for major rivers, making water resource management a critical concern. Improper land use practices, deforestation, and pollution impact the quality and availability of water. The challenge lies in balancing the needs of a growing population with the imperative to preserve the integrity of these vital water sources (Joshi and Rawat, 2018). The management of solid waste poses a growing challenge in Uttarakhand's urban areas. Inadequate waste disposal practices can lead to soil and water pollution, threatening the ecological balance. Sustainable waste management strategies are imperative for mitigating these adverse environmental impacts (Sharma and Pant,2019).

As per report, Uttarakhand is the worst-performing state in the country in terms of processing solid waste. Every day, it generates 1,406 tonne solid waste and processes 0% of it. Besides Arunachal Pradesh, it is the only state in the country to have this abysmal performance. Neighbouring Himachal Pradesh generates just 342 tonne solid waste every day and is able to process 20% of it. Only 3% wards in Uttarakhand have facility of 100% waste segregation at source (https://www.hindustantimes.com). Along with these, rapid urbanization and infrastructure development in Uttarakhand bring forth a set of environmental challenges. Unplanned expansion can lead to habitat fragmentation, soil erosion, and increased pressure on natural resources. Striking a balance between development imperatives and environmental sustainability remains a pivotal challenge (Gupta and Negi, 2017).

Fig. 1. Environmental challenges in Uttarakhand: Waste dumping near Bageshwar; Land slide near Baliyanala Nainital and forest fire in the Chir-pine forests of Uttarakhand

Green Economy Initiatives in Uttarakhand

Renewable Energy Development: Uttarakhand has harnessed its abundant natural resources to promote renewable energy. The state has invested in hydropower projects, tapping into its rivers to generate clean energy. Small-scale hydroelectric plants have been established to provide electricity to remote areas, reducing dependence on traditional fossil fuels (Singh and Negi, 2018).

Afforestation and Biodiversity Conservation: Recognizing the importance of forests for ecological balance, Uttarakhand has undertaken extensive afforestation initiatives. Community participation is encouraged to ensure the sustainable management of forests, and biodiversity conservation programs aim to protect endangered species and preserve the unique flora and fauna of the region (Tiwari and Mehra2019).

Organic Farming and Sustainable Agriculture: In a bid to reduce the environmental impact of conventional farming practices, Uttarakhand has promoted organic farming. The state provides support to farmers transitioning to organic methods, emphasizing soil health, biodiversity, and sustainable water use (Joshi and Rawat, 2020).

Waste Management and Recycling: Uttarakhand has implemented comprehensive waste management strategies to minimize the environmental impact of solid waste. Recycling initiatives, waste segregation at source, and the promotion of eco-friendly practices are integral to these efforts (Gupta and Pant, 2017).

Ecotourism and Sustainable Development: The state recognizes the potential of tourism as a driver of economic growth and has embraced ecotourism principles. Sustainable tourism practices are encouraged to preserve the natural beauty of Uttarakhand while providing livelihood opportunities for local communities (Negi and Uniyal, 2016).

Challenges and Future Directions

While Uttarakhand has made commendable strides in promoting a green economy, challenges persist. Balancing economic development with environmental conservation requires continuous efforts and innovative solutions. Climate change, rapid urbanization, and population pressure remain key challenges that demand proactive strategies.Future directions for Uttarakhand's green economy initiatives should include:

Climate-Resilient Infrastructure: Developing infrastructure that is resilient to the impacts of climate change, especially in vulnerable areas prone to natural disasters.

Community Engagement and Education: Strengthening community engagement and raising awareness about the importance of sustainable practices to ensure the success and longevity of green initiatives.

Policy Integration: Integrating green economy principles into policy frameworks at the state and local levels to ensure a cohesive and coordinated approach to sustainability.

Research and Innovation: Investing in research and innovation to find sustainable solutions to emerging environmental challenges and leveraging technology for monitoring and conservation efforts.

Conclusion

Uttarakhand's journey towards a green economy showcases the potential for sustainable development in ecologically sensitive regions. By embracing renewable energy, biodiversity conservation, organic farming, waste management, and sustainable tourism, the state is setting an example for others to follow. The challenges faced by Uttarakhand underscore the need for a holistic and collaborative approach to environmental sustainability. As the state continues its efforts, it is positioned to not only preserve its natural beauty but also create a model for inclusive and sustainable development that can be replicated globally.

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Hydroponics farming and solar greenhouses: A sustainable solution for the water-energy-food nexus and bio-control strategies

Ongoing impacts of climate change poses a great threat to humanity and meeting global food security demands (Mirzabaevet al.2023). A stable climate, offering optimal abiotic factors seasonally, such as rainfall, temperature and salinity has been the key to ensure crop-productivityand human success (Grigorieva et al., 2023).

In Himalayan states, like Uttarakhand,facing the wrath of climate change, productivity of traditional farming methods are being increasingly challenged due to various ongoing climatological changes and natural disasters.

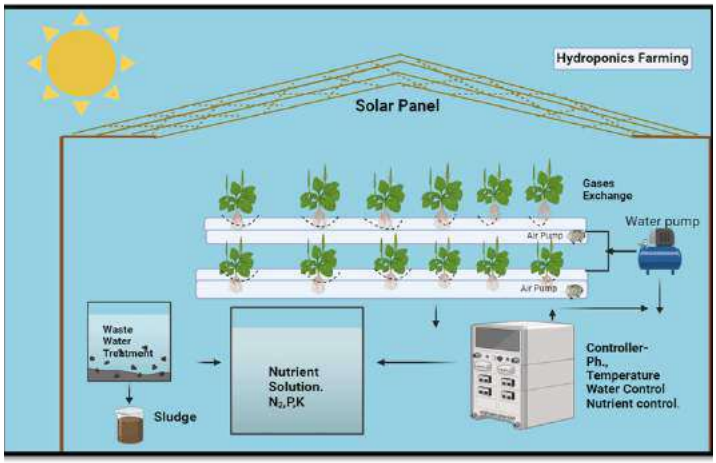
Indiscriminate use of land, water, and energy resources in the Himalayan regions has raised a significant burden on natural ecosystems leading to serious environmental degradations. In these regions, a critical emerging issue, is to meet the increasing demand of food security in coming decades,while minimizing resource depletion. An emerging strategy, to address these challenges and encourage sustainable agricultural practices is soilless cultivation via hydroponics farming. Hydroponics farming involves supplying plants with water and essential nutrientsin controlled conditions that can promotegrowth of plants in diverse environmental conditions. This system of cultivation promises to buffer impacts of adverse climatic conditions and abiotic stress conditions. Continuous recycling of water in this system plays a key role in reducing water stress when compared to traditional soil-basedagriculture.

Solar greenhouses, integrated in hydroponics farms as a renewable sourceof energy whichcan offer optimal conditions for the growth of plant under various abiotic stress factors due to climate change impacts. Solar hydroponics farmsdesigned for optimal heating, light and powering are essential that systems reduces the dependency on non-renewable sources of energy. These systemshelp in harnessing clean energy. This can be directed back to the grid or used in other agriculture processes. This innovative technology enhances efficient energy utilization and can help in reducing carbon footprints across commercial agriculture sectors operations.

Hydroponics farming can facilitate the production of crops throughout the year, as solar greenhouses helps in creating a controlled abiotic micro-environment that will extend our ability to grow crops throughout the year(Gillani et al.2023).This has promising ability to enhance crop productivity, in turn, food production per unit of land. Hydroponics farming saves space in comparison to soil-based farming. Saving of space to increase crop productivity is important, as this facilitates crop production near urban areas and helps in reducing carbon emissions related to logistics, thereby contributing towards localized food supply and sustainable farming.

A perennial problem of conventional soil-based agriculture, since green revolution in India, has been the indiscriminate usage of inorganic fertilizers, harmful pesticides and antimicrobials to increase crop productivity. When faced with climate change impacts, this strategy is now well known to degrade soil fertility and induce widespread systemic resistance among plant and human pathogens.
In hydroponics, delivery of nutrients are directly directed into the roots of plant in a controlled dosage, that eliminates the utilization of excessive chemical based fertilizers. As an example of precision agriculture, this way of delivering nutrients to plants, also declines the nutrients wastage in surrounding environments(Yamamoto *et al.*, 2023).

Nevertheless, plants and microrganisms share an intimate relationship that has evolved for millions of years and plays a key role during their growth, development and physiology. Due to paucity of studies, it is not clear how the controlled hydroponics environment in a soil-less environment, impacts their microbiome development around roots. This system still suffers from effective studies that addresses pathogen control. It is important to develop effective plant growth promoting microbial consortia and biocontrol strategies against common pathogens. This is essential to improve crop productivity. Further studies on hydroponics, when augmented with adequate research on microbiome dynamics is essential.
This holistic approach is essential to resolve the issues of water scarcity, increase the energy efficiency and enhance the food production in an eco-friendly manner. As global demands of water, energy and food will continue to rise and lead to a serious concern of social-environmental issues, adopting these innovative systems



of agriculture helps us experimenting alternative strategies to build a resilient and sustainable path for future generations.

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Uttarakhand's forest resource's: Nurturing a green economy for sustainable tomorrow

Forests play a crucial role in land-based ecosystems, especially in mountainous regions, providing essential contributions to the environment and the socio-economic well-being of communities. This significance is particularly pronounced in developing countries like India, where forests contribute to environmental stability, cultivation, and serve as ecosystems for a diverse range of flora and fauna. They also act as a natural defence against soil erosion. However, forests face threats such as fires, excessive grazing, pests, and encroachment for agriculture and urban development. The forest capital of a region also plays a pivotal role in evaluating the Gross Environmental Productivity (GEP), and the presence of biotic stress on forests can hinder this productivity. In recent times, forest conservation has gained significance due to its ecological and environmental roles, as well as its impact on the GEP of a region. Efficient management of forestry resources is crucial for ensuring sustainable development and economic valuation of forests. Key parameters essential for measuring sustainable forest management include forest cover, annual increment, growing stock, species composition, biomass, biodiversity, non-timber forest products, and regeneration status. Regarding GEP contribution, the state of Uttarakhand stands out with its rich variety of flora and fauna and diverse forest based natural resources. The inaccessibility of local people to modern technologies and their deprived socio-economic statuses contribute to the total dependence of local inhabitants on nearby forests. Additionally, the fact that these resources are free of cost implies that the rural people of Uttarakhand are directly reliant on forest resources (CEDAR, 2010) for fuelwood, fodder, and food. These resources fall under the domain of community forestry, managed by village community forest councils, commonly known as Van Panchayat, a concept introduced in 1920 (Phartiyal *et al.*, 2006). In Uttarakhand, approximately 38% of green feeds are sourced from fodder trees, while 31% of fodder is derived from grasslands. Marginal farmers in the temperate and subtropical grasslands rear livestock and obtain fodder from tree leaves (Sati and Bandooni, 2019). Additionally, various medicinal plants thrive across all altitudinal zones in this region. The challenges of fragmented and small land holdings, sloping terrains, and agriculture heavily reliant on rainfall, exacerbated by migratory grazing, contribute to very low crop yields in this area. In the Himalayan region, forests directly fulfill 87% of the fodder requirement, and around 70% of the state's economy is interconnected with agriculture, livestock, and forests (Singh *et al.*, 2021).

Fig. 1. Use of forest resources by local communities

The Uttarakhand forests, safeguarding and preserving assets encompassing land value, timber stock, and carbon storage, are estimated to be valued in the range of Rs. 14,13,676.20 to 17,44,413.36 crores. These findings underscore that a substantial portion of the benefits derived, particularly those of an intangible nature, often go unnoticed in market transactions (Verma *et al.*, 2019). This underscores the significant role played by the state's forests in shaping the Gross Environmental Product (GEP), potentially leading to the economic assessment of the state's forests for monetary gains. The value of Non-Timber Forest Products (NTFPs) holds significance in contributing to the GEP, as the rural community in the state heavily relies on NTFPs for essential needs such as food, medicine, fiber, fuelwood, fodder, dye, and various other materials crucial for their livelihood. The utilization of NTFPs is deeply rooted in local culture. The state's forests offer a diverse range of NTFPs that are extensively collected to meet local demands. Wild food plants, for instance, are commonly gathered for household use. Similarly, a wide variety of medicinal and aromatic plants serve as cost-effective alternatives to expensive allopathic drugs in the state. Bamboo stands out as a valuable resource for crafting various utility items, with significant potential in constructing houses, floors, roofs, bridges, and a variety of other structures. Additionally, pine (Pinus roxburghii Sarg.) proves beneficial for producing low-smoke bio-fuel and various decorative items, contributing to the monetary value for local communities. Despite their importance, NTFPs have largely been perceived as freely accessible materials, often overlooked under the label of 'minor forest produce.'

Suggestions towards sustaining green economy and ensuring provision of GEP in the region: The inclusion of various key initiatives can significantly bolster the state's efforts to achieve a green economy through Gross Environmental Product (GEP). This entails the encouragement of ecotourism, home stays, and environmentally responsible tourism as low-impact and often small-scale alternatives to conventional mass tourism. Ecotourism, emphasizing socially responsible travel, personal development, and environmental sustainability, presents an opportunity to evaluate aesthetic and cultural ecosystem services. Forest-based ecotourism also proves advantageous in raising awareness about forest resource management and their significance in conservation based on natural resources. The promotion of Carbon farming/Oxygen parks, particularly with fast-growing species like Bamboo, for carbon sequestration to address climate change impacts and the establishment of Nature-based healing center's near forest areas can be beneficial. Carbon and oxygen, playing crucial roles in the evolution and sustenance of life on our planet, can contribute significantly to life's well-being. Creating specific secluded areas within pristine forests with distinctive features allows the realization of carbon's contributions in the form of recreational benefits.

Way forward: As the green economy is ascertained as the growth in income and employment which is driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services, it could play a vital role in enhancing the status of forest in the state of Uttarakhand. These investments need to be catalysed and supported by targeted public expenditure, policy reforms and regulation changes. This development path should maintain, enhance and, where necessary, rebuild natural capital as a critical economic asset and source of public benefits, especially for poor people whose livelihoods and security depend strongly on nature in the Himalayan region. As it is an emerging concept that visualizes use of plants and environment-friendly technologies to mitigate the environmental problems arising due to indiscriminate use of natural resources, it can be implied that use of natural resource management approaches and best management practices can be incorporated to ascertain the path of this economically and environmentally beneficial approach in the state of Uttarakhand.

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Dairy farming and Economic Growth in Nainital District

Introduction: Economic growth is an increase in the production of goods and services in an economy(Roser,2021). Increases in employment, income, technology, and human capital all contribute to economic growth. Main focus of any government in the world is economic growth and numerous measures and incentives are used to promote it. With the given socio geographic challenges, Uttarakhand state has embarked upon various initiatives to promote growth and development of state, one way of doing it by increasing farmers income. Animal Husbandry, Dairy Farming, and Fisheries has been chosen as the sector which can bring prosperity to state especially in uphill. Dairy farming is one of the focus area for employment and income generation in the state, because of its popularity and widespread nature. Dairy farming is branch of agriculture that encompasses the breeding, raising, and utilization of dairy animals like cow or buffalo for the production of milk and the various dairy products processed from it.

Dairy farming in Uttarakhand: Dairy farming contributes in some form or the other to household income and family nutrition, besides producing the much needed biomass and draught power for agricultural operations in Uttarakhand. This activity is carried out in hundred of household across the state and provides employment to the marginal and landless farmers.. State already have many dairy farmers but results are mixed, leaving huge scope for improvement. Rural Uttarakhand experience unemployment and lacks income generating activities. Widespread disguised unemployment and migration in search of jobs is common in rural Uttarakhand. Agriculture sector including animal husbandry, dairying etc is major employer in rural Uttarakhand. Uttarakhand has a high potential of dairying because of the following facts:
1. Practically, every household in the rural and semi-urban areas own livestock, a mixture of cows and buffaloes. 2. Small scale dairies and milk collection centres are coming up on their own throughout the region. 3. There is a dormant demand for fodder and grass, thus scope for enterprise to venture in this field.

Dairy farming as Income and Empyment Generator in Nainital district: Dairying has always been quoted as one of the means for poverty alleviation and improvement of nutritional security (Kumar and Shah, 2016). Milk production is a very important part of the agricultural economy in Nainital district, which is the largest milk producing district of Uttarakhand (Bureau, 2022). Potential of Nainital district dairy industry can be gauged by the following table, which shows continuous growth in number of dairy cooperatives and its member. Table also showcase increased milk production over the years by dairy cooperatives under Nainital Dugdh Utpadak Sahakari Sangh Ltd (NDUSSL).Dairying reduces the farmer's risk by mitigating the strain when rains are not good, keep income flowing which fulfills the aim to provide the income to the farmers throughout the year rather than on seasonal basis only (Singh and Kumari, 2017). Ever increasing demand for milk, create numerous opportunities in dairy sector like more employment direct and indirect. This in turn help in income generation in rural and urban areas. Various job opportunity are offered by dairy industry(Selvakumar and Ramaraja, 2017). Like milk production, milk collection, milk transportation. Process and Chilling plant also offer job to significant number of people. On the other hand with growing demand for milk and milk products, packaging and marketing, whole sale and retail sale segment also provide direct employment to various people from rural and urban areas. Apart from it indirect employment can be generated in extension services and feed production etc. With minimum investment along with subsidy offered by govt, dairy business can be started. Proper planning can save time and yield good returns. It offer plenty opportunities to educated and uneducated both. Thus providing regular income throughout year.

Conclusion: Dairy farming in Nainital has potential to grow into major employment provider. Nainital is one of the economically developing regions of Uttarakhand. Subsistence agriculture holds very little potential for further development in this region, primarily because a significant proportion is covered by hills. State government has been promoting animal husband, dairy farming and tourism by providing subsidies and incentives, as sources of income and employment, still lot remain unachieved. Small landholders, comprising the majority of mountain farmers, are accustomed to rearing some animals as an essential component of the farming systems they have evolved. But now dairying is also evolving as commercial activity in Nainital district with size of dairy farms becoming bigger. The surplus fodder and agricultural by-products is gainfully utilised for feeding the animals. Since agriculture is mostly seasonal, there is a possibility of finding employment throughout the year through dairy farming. Dairy farming is capable of providing regular income to people involved in it. Government and state cooperative can also work together for further promotion of dairy farming among people of Uttarakhand. People from all walk of life with various socio economic condition can be involved in dairy industry. Thus dairy farming can be source of employment in rural as well as urban area of Nainital district, providing income to people associated with it and promoting economic growth.

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Table 1. Year wise comparision of Cooperative Societies under NDUSSL

S.No	Description	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 Upto Aug 22
1	Total Societies	551	568	582	593	603	628	632
2	Total working Society	526	534	545	550	561	577	578
3	Total member	27520	28250	29075	29375	29375	30035	30179
4	Working member	20145	20600	20905	21320	22867	23332	23370
5	Total milk collection of societies (Daily Avg in kg)	79679	84350	88250	81913	84469	94974	96508
6	Milk collection by each Society (Daily Avg in kg)	151.48	157.96	161.93	148.93	150.57	164.60	166.97

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Livelihood opportunities in Himachal Pradesh

Introduction: India consist of 28 states and 8 Union Territories (UTs) which face a diverse set of socio-economic, cultural, and ecological issues, simultaneously also offering good practices and local solutions for global challenges and objectives such as achieving the Sustainable Development Goals – SDGs (Khalid et al., 2020). Himachal Pradesh is one of the major mountain states of India situated in Northern part of the country sharing borders with several Indian states and China. The state was a centrally administered union territory in 1948 and became a full-fledged state on 25 January1971 (Attri, 2006). The state covers an area of 55,673 square kilometres which is majorly rural (~90%) and is organized into 12 districts, 78 developmental blocks, 3432 gram panchayats with two municipal corporations: Shimla and Dharamshala, and has 55 urban local bodies (GoHP, 2019).

Livelihood is the opportunity, collection of skills, resources, and activities needed to support one's way of life (Chambers and Conway 1992; Ellis, 1998).In Himachal Pradesh the activities performed by people for the generation of livelihood are associated with several activities such as agriculture, horticulture, animal husbandry, fishing and Tourism. Himachal Pradesh economy is classified into three broad sectors, viz., Primary, Secondary and Tertiary (Fig. 1). The primary sector includes industries such as agriculture, forestry, logging, fisheries, mining, and quarrying. The secondary sector includes industries including manufacturing, electricity, gas, water supply, and other utility services, as well as the construction industry. The Tertiary Sector consists of the following industries: Trade and Repair Services; Hotels and Restaurants; Transport (including Railways, Road, Water, Air, and Services Incidental to Transport); Storages; Communication and Services Related to Broadcasting; Financial Services; Real Estate, Ownership of Dwellings & Professional Services; Public Administration; and Other Services. In the financial year 2021-22 the state economy grew by 7.6 percent . The growth of 7.6 per cent is mainly attributed due to 4.6 per cent increase in primary sector, 7.8 per cent increase in secondary sector, 15.6 per cent increase in transport, communication, trade hotel and restaurants sector and 7.9 per cent increase in Community and personal services sector of the economy (Economic Survey of Himachal Pradesh 2022-2023).

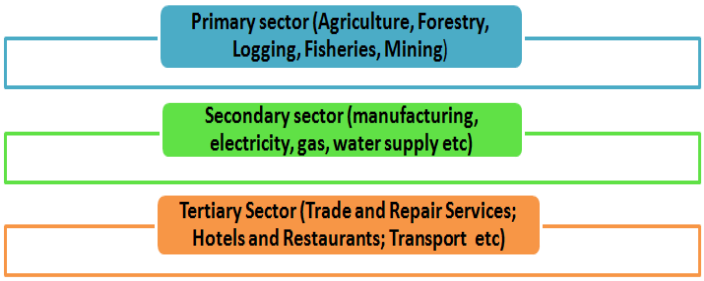

Fig. 1. Economy Sectors in Himachal Pradesh

Existing livelihood opportunities

Himachal Pradesh offers several livelihood opportunities across various sectors. Some of existing livelihood opportunities in Himachal Pradesh are as-

1. Tourism: Tourism is one of the most significant contributors to Himachal Pradesh's economy. The state is known for its scenic beauty, hill stations, adventure sports, and cultural heritage. Opportunities exist in hospitality, travel agencies, trekking, mountaineering, and handicrafts.

2. Agriculture and Horticulture: Agriculture is a crucial sector in Himachal Pradesh. The state is known for apple production, along with other fruits like cherries, peaches, and plums. Opportunities exist for farmers, agricultural laborers, and those involved in processing and marketing of agricultural products.

3. Handicrafts and Handlooms: Himachal Pradesh is rich in traditional arts and crafts. Handwoven textiles, carpets, wooden artifacts, and metalwork are popular products. There are opportunities for artisans and entrepreneurs in this sector.

4. Hydroelectric Power: Himachal Pradesh has a significant hydropower potential, and many hydroelectric projects are operational in the state. Employment opportunities exist in the construction, maintenance, and operation of these projects.

5. Education and Healthcare: With an increasing focus on education and healthcare, there are opportunities for teachers, healthcare professionals, and support staff in various institutions and hospitals.

6. Information Technology (IT): Cities like Shimla and Dharamshala are emerging as IT hubs, providing opportunities for IT professionals and startups.

7. Food Processing: There are opportunities in food processing industries, especially related to fruits and vegetables, due to the abundance of agricultural produce.

8. Sericulture and Apiculture: Sericulture (silk production) and apiculture (beekeeping) are practiced in some areas of Himachal Pradesh and offer livelihood opportunities to those engaged in these activities.

9. Retail and Trade: As the state's economy grows, there are opportunities in retail and trade businesses catering to the increasing consumer demands.

10. Livestock Farming: Livestock rearing, including dairy farming, sheep and goat farming, and poultry, can be a source of livelihood for rural communities.

Fig. 2. Some of existing livelihood opportunities in Himachal Pradesh which includes Handloom and fish farm

Future livelihood opportunities in Himachal Pradesh

The future livelihood opportunities in Himachal Pradesh were likely to be influenced by several factors, including advancements in technology, changing economic trends, and the state government's policies. Certain livelihood opportunities which can be used to generate more source of income are as-

Seeds of change: A glance at sustainable agriculture practices in the Himalayan foothills

1. Eco-tourism and Adventure Tourism: With growing awareness of sustainable travel and ecotourism, Himachal Pradesh could see an increase in eco-friendly and adventure tourism opportunities. Activities like nature walks, birdwatching, sustainable trekking, and eco-resorts may gain popularity.
2. Renewable Energy: As the world moves towards a greener future, Himachal Pradesh's abundant renewable energy potential, especially in hydro and solar power, could attract investments and create job opportunities in the renewable energy sector.
3. Skill Development and Education: As technology continues to advance, there will be a growing demand for skilled professionals in various sectors. Initiatives focusing on skill development and education could be promoted to prepare the workforce for emerging industries.
4. E-commerce and Online Businesses: The growth of e-commerce and online businesses could open up opportunities for local artisans, entrepreneurs, and small businesses to reach a broader market beyond the state's borders.
5. Organic Farming and Agri-tourism: With increasing health-consciousness and demand for organic products, there could be potential in organic farming and agri-tourism, allowing tourists to experience and participate in farm activities.
6. Healthcare and Wellness: The demand for healthcare and wellness services is likely to increase, creating opportunities for healthcare professionals, wellness centers, and alternative therapy providers.
7. Remote Work and Digital Nomadism: As remote work becomes more mainstream, people may choose to live in places like Himachal Pradesh for its natural beauty while working for companies located elsewhere.
8. Startups and Innovation: Supportive policies and initiatives to encourage startups and innovation could lead to the growth of a vibrant entrepreneurial ecosystem in the state.
9. Food Processing and Packaging: The food processing industry could see growth with increased demand for packaged and processed foods, especially from the urban population.
10. Waste Management and Recycling: As environmental consciousness rises, waste management and recycling initiatives may gain momentum, leading to livelihood opportunities in this sector.
New initiatives such as waste management and recycling will generate livelihood in an eco friendly way. Traditional livelihood practices along we new livelihood practice can enhance the economic growth of the region and will lead to sustainable development in the region.

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Introduction: Agriculture, often referred to as the backbone of India's population, not only provides sustenance but also represents a way of life deeply rooted in tradition. Historically, Himalayan agriculture has followed a 'subsistence-based' or 'family farming' system, with agricultural production cantered around families and intended primarily for local consumption (Schroeder 1985). Agriculture in the Himalayas is conducted on marginal rainfed and limited irrigated land, constituting 15.8% (53.8 million hectares). More than 80% of the rural population relies on this land for their livelihoods (Pratap, 2011). In the Himalayan foothills, where the undulating landscapes narrate tales of resilience and adaptation, traditional farming practices have sustained communities for generations.

Keywords: Sustainable agriculture, terrace farming, seed preservation, traditional farming practices, seed banks

Challenges of the Himalayan terrain: The Himalayas, with their majestic peaks and sweeping foothills, present a dichotomy of beauty and challenges for agriculture. The steep hilly slopes, mountainous terrain, and climatic variations create a unique set of hurdles. The region's remoteness, inaccessibility, and fragility, exacerbated by factors like moisture stress and poor soil conditions, pose significant barriers to agricultural productivity. Additionally, socio-economic constraints such as small landholdings, labour shortages, and inadequate infrastructure contribute to the underutilization of resources and limited surplus generation. The Himalayan farming communities primarily rely on subsistence farming, cultivating marginal rainfed and some irrigated farmlands to sustain themselves. Climate change, manifesting in floods, landslides, and other environmental disruptions, adds another layer of complexity to the agricultural challenges in the Himalayas. These factors have contributed to a rise in the abandonment of agricultural land in the Himalayan region (Tiwari and Joshi, 2015). The fragility of the ecosystem becomes evident as natural and human-induced factors take a toll on both the environment and the livelihoods of the local inhabitants. In this delicate balance, sustaining agriculture becomes not only an economic necessity but a crucial aspect of preserving the cultural and social fabric of the Himalayan communities.

Eco-friendly farming practices: To navigate these challenges, the Himalayan region embraces eco-friendly farming practices that align with its unique topography. Terrace farming, a timeless technique etched into the landscape, experiences a modern revival. Ingenious adaptations, such as rainwater harvesting on terraces, showcase the ability to blend ancient wisdom with contemporary innovation. These practices not only conserve water but also contribute to sustainable land use, preventing soil erosion and ensuring a flourishing ecosystem. The success stories extend beyond the fields; community-supported agriculture programs strengthen connections between farmers and consumers. Through farmers' markets and direct-to-consumer models, locals gain access to fresh, seasonal produce, while farmers receive fair compensation, fostering a sense of community and shared responsibility.

Beyond terracing, agroforestry emerges as a beacon of sustainability. Integrating fruit and nut-bearing trees with crops not only enhances soil fertility but also provides an additional source of income for farmers. Crop rotation and intercropping, time-honoured techniques, foster biodiversity, reduce pests, and promote sustainable agricultural practices that respect the delicate balance of the ecosystem. Traditional water harvesting systems, such as kuhls and tanks, showcase the resourcefulness of Himalayan communities in sustaining irrigation in the face of challenging hydrological conditions. Organic farming practices, avoiding synthetic inputs, not only maintain soil health but also minimize the environmental impact, contributing to a holistic and eco-conscious approach to agriculture, meanwhile the low-cost organic farming paves way for the environment-friendly income generating practices.

Fig. 1. Terrace farming in the Himalayas

Preserving Biodiversity and Indigenous Crops: Central essence to the sustainability narrative is the preservation of biodiversity and indigenous crops. The mixed system of crop cultivation, deeply ingrained in the agricultural practices of Himalayan communities, plays a crucial role in maintaining crop diversity. Low-input agriculture becomes a guiding principle, emphasizing not just production but the long-term sustainability of agriculture in the region. Seed festivals, seed fairs, and farmers' seed exchanges become more than social events; they transform into cultural instruments for the conservation and promotion of traditional crop diversity, moreover the local seed storage banks and seed activists such as Vijay Jaddhari are an integral part of the rural economy of this region.

Seed banks, nestled in the mid-Himalayan region of Uttarakhand, emerge as custodians of indigenous seeds. These repositories not only safeguard unique plant varieties but also serve as hubs for community engagement and knowledge exchange. The need to preserve indigenous seeds becomes imperative as they ensure the resilience of local agriculture. The seeds become carriers of centuries-old agricultural wisdom, adapting to the changing climate and evolving agricultural landscape of the Himalayas.

Success Stories: Sustainable Farming in Action: Within the cradle of the Himalayan foothills, success stories illuminate the transformative impact of sustainable agriculture. Organic farming cooperatives, sprouting amidst the undulating landscapes, prioritize environmental health. By embracing chemical-free cultivation methods, these cooperatives not only contribute to a healthier ecosystem but also yield premium-quality produce, creating a niche market for organic Himalayan goods.

Community-driven seed-saving initiatives in regions like Kumaon become the custodians of indigenous crop varieties. Seed banks, through meticulous curation and dissemination, safeguard genetic diversity, ensuring the resilience of crops against the backdrop of a changing climate. These initiatives become testaments to the profound connection between biodiversity conservation and sustainable agriculture, fostering a harmonious relationship between humanity and nature.

Conclusion: As we traverse the evolving landscape of agriculture in the Himalayan foothills, the diversity of the agricultural practices indicated the value of plant based economy that underscore the potential of sustainable practices to address environmental challenges, empower communities, and revitalize traditional knowledge and plays a vital role in livelihood generation for the rural poor. The challenges posed by the Himalayan terrain demand adaptive and eco-friendly solutions, and the region's farmers are rising to the occasion with resilience and innovation.

In conclusion, as we nurture the seeds of change in the Himalayan foothills, sustainable agriculture emerges as a flare of hope, promising a future where the harmony between humanity and nature flourishes amidst the majestic peaks and rolling foothills of this unique region. Preserving biodiversity, conserving indigenous seeds, and embracing sustainable farming practices are not mere choices; they are imperatives for ensuring food security, environmental sustainability, and the preservation of the unique agroecological tapestry of the Himalayan foothills.

The story of sustainable agriculture adoption in the Himalayan foothills is one of resilience, and coexistence. It is a testament to the fact that, even in the face of daunting challenges, humanity has the capacity to cultivate a future where the roots of tradition intertwine with the shoots of innovation, nurturing a landscape where sustainable agriculture becomes the bedrock for a thriving and harmonious tomorrow.

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Green economy of Himachal Pradesh: Nurturing sustainable development

Introduction: The Himalaya stands as one of the most recently formed mountainous ranges globally, and within India, it is the most recently formed. These mountain ranges act as habitats for a wide array of species and indigenous cultures, providing a unique and diverse environment (Sharma et al., 2014). Moreover, they play a crucial role in delivering essential necessities and ecosystem services (Yadav et al., 2023). Himachal Pradesh, nestled in the lap of the Himalayas, is renowned for its pristine landscapes, biodiversity, and unique cultural heritage. It encompasses sections of the Trans and North West Himalaya, spanning a total geographical area of 55,673 Km2 (Chauhan et al., 2016). It sustains a distinctive, diverse, and socio-economically significant biodiversity. Forests and alpine meadows serve as crucial habitats for wildlife. The climate and vegetation display notable diversity according to elevation, encompassing glaciers at the highest altitudes to subtropical forests in the lower regions. The state's forests function as a primary bio resource, meeting the needs of various living beings. Numerous floral and faunal species inhabit these forested areas. As the state envisions a future that balances economic growth with environmental conservation, the concept of a green economy emerges as a cornerstone for sustainable development. The concept of a green economy gained prominence in the late 20th and early 21st centuries as a response to growing concerns about environmental degradation, climate change, and unsustainable resource use (UNEP, 2009). The roots of the green economy concept can be traced to various environmental movements, discussions, and global initiatives that emphasized the need for a more sustainable and environmentally friendly approach to economic development. Forests and bio resources play a crucial role in the green economy by contributing to sustainability, biodiversity conservation, and environmental well-being.

Green Economy

A green economy is an approach to development that integrates economic, social, and environmental dimensions, aiming to enhance human well-being and reduce environmental risks and ecological scarcities (Khanfar, 2014). In the context of Himachal Pradesh, this involves transitioning towards a low-carbon, resource-efficient, and socially inclusive economic model.

Green economy of Himachal Pradesh

Renewable Energy: The state has harnessed its abundant hydropower potential, making significant strides in clean energy production. Ongoing projects and investments in solar and wind energy further bolster the state's commitment to reducing carbon emissions and ensuring energy security.

Sustainable Agriculture: Himachal Pradesh promotes organic farming practices and emphasizes the cultivation of traditional, climate-resilient crops. Initiatives such as water conservation, watershed management, and adoption of agro ecological principles contribute to increased agricultural sustainability.

Source: https://haiphongnews.gov.vn/news/green-economy-ct2121.html

Biodiversity Conservation: The state is committed to preserving its rich biodiversity through protected areas, wildlife sanctuaries, and afforestation programs. Conservation efforts not only safeguard ecosystems but also support ecotourism, offering economic opportunities while ensuring the long-term health of the environment.

Waste Management and Circular Economy: Himachal Pradesh is actively working towards reducing waste generation and promoting recycling. The implementation of waste-to-energy projects, waste segregation at source, and awareness campaigns contribute to building a circular economy that minimizes environmental impact.

Eco-Tourism: The state leverages its natural beauty and cultural heritage to promote sustainable tourism. Initiatives focus on responsible tourism practices, community involvement, and the preservation of local ecosystems, ensuring that tourism becomes a driver for economic growth without compromising environmental integrity.

Challenges and Opportunities: Infrastructure Development: Balancing the need for infrastructure development with environmental conservation remains a challenge. The state must adopt innovative, eco-friendly construction practices and technologies.

Climate Change Impacts: This mountainous state is vulnerable to climate change impacts, such as erratic weather patterns and glacial retreat. Adaptation measures, including early warning systems and climate-resilient infrastructure, are crucial.

Community Engagement: The success of green economy initiatives relies on active community involvement. Ensuring that local communities are stakeholders in decision-making processes and benefit from sustainable practices is paramount.

Mountains exhibit a unique characteristic in which the climate undergoes rapid changes with increasing elevation over relatively short horizontal distances. This phenomenon also extends to influence patterns in vegetation and hydrological systems. Changes in vegetation sequences occur alongside rapid transitions from vegetation and soil to snow and ice.

Conclusion: Himachal Pradesh's journey towards a green economy is a commendable effort to achieve sustainable development. By integrating environmental considerations into economic policies and practices, the state is not only safeguarding its natural resources but also setting a precedent for other regions to follow. The ongoing commitment to a green economy ensures a harmonious balance between economic growth and environmental well-being in Himachal Pradesh.

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Carbon farming: A possibility

Carbon: Plant photosynthesis is necessary for agricultural output because it transports CO2 from the atmosphere into the plant, where it is converted into food, flora, fuel, and fibre. As a result, it is acknowledged as a significant energy unit in biological systems.

Carbon Farming: Carbon farming or carbon sequestration is a system of agricultural management that helps the land store more carbon and reduce the amount of GHG that it releases into the atmosphere. It involves techniques that are known to increase the rate at which CO2 is taken out of the atmosphere and converted into plant matter and soil organic matter. When carbon losses outweigh carbon gains due to improved land management or conservation practises, carbon farming is effective. Carbon farming is seen as a practise to help restore balance within the carbon cycle. Additionally, it naturally boosts agricultural productivity while helping the soil become more drought-resistant.

Agriculture and Carbon Emissions:More than half of the Earth's land area is covered by agriculture, which also accounts for around one-third of the planet's total GHG emissions. The livestock industry (54.6%) and the use of nitrogenous fertilizers (19%) account for the majority of agricultural emissions in India.

Carbon credits (CC): When landowners or farmers start a project that can reduce the amount of carbon in the atmosphere through long-term carbon sequestration, one CC symbolises ownership of the equivalent of one MT of carbon that can be traded, sold, or retired. CCs are expressed in metric tonnes (MT) and measured in CO2 equivalents.

Carbon offset: A carbon offset generates a CC by actually reducing the amount of CO2 in the atmosphere. Most of the time, carbon offsets result in reductions that are generated outside of the organisation and, more importantly, outside of any legal requirements. Because CO2 affects the world as a whole rather than just locally, both credits and offsets result in the same decrease in CO2 emissions and the same benefit to the environment in terms of reducing climate change.

Carbon Markets: Carbon markets seek to minimise GHG emissions by allowing the trading of emission units (CCs), which are certificates signifying emission reductions.Carbon markets can be divided into two basic categories: cap-and-trade and voluntary. Cap-and-trade imposes a mandatory limit (cap) on GHG emissions, and companies that exceed these limits must either acquire additional allowances or pay a fee. Voluntary markets allow CCs to be traded outside of the regulated framework.

Approaches of Carbon Farming

Forest Management: Healthy forests capture and store CO2 emissions from other sources. Avoiding deforestation, long-term land conservation, reforestation and replanting initiatives, and improved forest management all contribute to the creation of carbon offsets.

Grasslands Conservation:It involves conserving native plant life via long-term conservation of land and preventing the conversion of grasslands for intensive farming or commercial development.

Mixed Farming: Raising cattle and crops together in a climate-friendly manner, like cattle pasture rotation, helps grasses recover from grazing while also regenerating soil carbon through animal faeces and grazing effects.

Using Cover Crops: These crops are grown to cover the land in addition to being harvested. They return more carbon to the soil and support soil microorganisms that perform critical functions in carbon storage.

Reduction of Soil Tillage: Tillage is typically done to aerate and loosen the soil as well as eradicate the early weeds. Tillage, however, boosts carbon mineralization, which causes soil CO2 emissions.

Wetland Restoration: Due to the fact that wetlands retain 14.5% of all soil carbon in the world, wetland soil plays a significant role as a natural carbon pool or sink

Significance of Carbon Farming

Multidimensional Benefits: Through a variety of techniques, increasing Soil Organic Carbon (SOC) can enhance soil health, agricultural productivity, food security, water quality, and lessen the need for chemicals. Along with improving other planetary limits like fresh water, biodiversity, land, and nitrogen use, it would not only address carbon mitigation.

Offsets Carbon Emissions: A global programme named "4 per 1000" demonstrated that boosting soil carbon by just 0.4% per year may balance out the new growth in CO2 emissions from fossil fuel emissions in a given year. At the Paris climate summit in 2015, the French government announced the "4/1000" plan. The initiative aims to show how agriculture, and specifically agricultural soils, can play a significant role in addressing both food security and climate change.

Acts as an Intermediate Mitigation Strategy:Increasing soil carbon has a number of additional advantages, and it also buys time until other technologies can support the global transition to a zero-carbon lifestyle.

Helps Restoring the Carbon Cycle: Globally, soils are thought to contain around ten times the amount of carbon in the atmosphere, significantly more than normal plants.

Benefits of promoting low-carbon technologies: The main advantages include a reduction in greenhouse gas emissions, savings on labour and energy used for irrigation, higher water and nutrient usage efficiency, increased soil health, and increased income.

Major Challenges

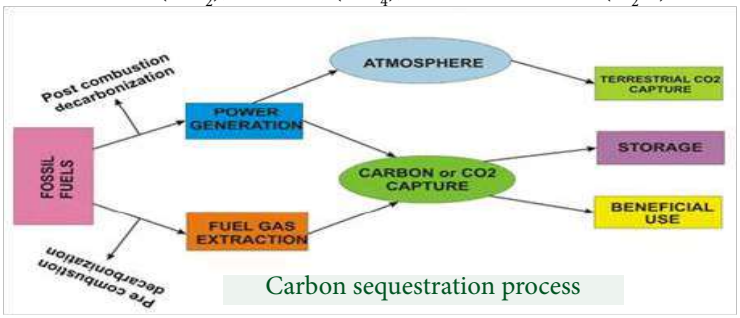
Requires Participation at a Larger Level: The overall structure for carbon farming would need to have sound rules, public-private partnerships, precise measurement methodology, and supportive financing to effectively implement the concept. It requires maintaining healthy soils that absorb and store carbon, as well as doing it at a scale that allows for quantifiable carbon capture.

Limited Benefit: Carbon farming is feasible in regions with extended growing seasons, adequate rainfall, and extensive irrigation.

However, in hot and arid regions of the earth, carbon farming is probably more difficult. Furthermore, many farmers might need financial aid in order to cover the expense of implementing environmentally advantageous practises.

Way Forward: Due to its ability to absorb atmospheric CO2, the land sector is essential for achieving a climate-neutral economy. Direct incentives for adopting climate-friendly practises must be established, though, in order to support the agriculture and forestry industries.

Farmers may get compensation in the form of internationally marketable CCs, and "carbon banks" may be established to buy and sell CCs from farmers. In comparison to other materials, fertilisers with a broad C:N ratio, including compost and solid manure, will have a slower carbon turnover. They ought to be integrated into the farming system. Using biofuel (mostly biodiesel and bioethanol) to replace fossil fuels allows farmers to diversify their income, decrease expenses, and contribute to the reduction of global GHG emissions, namely carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).



Carbon sequestration process

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