Advancing Sustainable Agriculture through Resource Efficiency

Abhishek Saxena[1], Anandhi R J[2*], B Ramesh[3], Ashish Fande[4], Pradeep Kumar Chandra[5], Vandana Arora Sethi[6], Mohammed Al-Farouni[7]
[1]Department of Mechanical Engineering, ABES Engineering College, Ghaziabad-201009, UP, India
[2]Department of Information Science Engineering, New Horizon College of Engineering, Bangalore, India
[3]Institute of Aeronautical Engineering, Dundigal, Hyderabad
[4]Department of Mechanical Engineering, Nagpur Institute of Technology, Nagpur, India
[5]Lloyd Institute of Engineering & Technology, Knowledge Park II, Greater Noida, Uttar Pradesh 201306
[6]Lloyd Institute of Management and Technology, Greater Noida, Uttar Pradesh, India-201306
[7]The Islamic university, Najaf, Iraq

*Corresponding author: *r_janandhi@hotmail.com*

Abstract. Efficiency in technology, distributive effectiveness, and environmental effectiveness all have the potential to be included in the general concept of "resource use efficiency in agriculture." An effective farmer distributes his resources, including labourers, water, and land, appropriately in the best possible way to enhance his revenue while minimising expenses over time. Multiple research studies, however, demonstrate that farmers frequently make inadequate use of their resources. This study presents a comprehensive analysis of various farming practices and technologies, highlighting their impact on agricultural efficiency and resource use. Also, this review investigates the incorporation of advanced technologies such as the Internet of Things (IoT) into agriculture, emphasising the significance of environmental and economic factors in achieving sustainable agricultural productivity. With a focus on the ASEAN region and specific case studies, it assesses how carbon emissions, deforestation, renewable energy, and biodiversity affect farming efficiencies. The paper underscores the value of biodiversity, including underutilized and neglected species, and the potential of IoT and associated technologies to enhance agricultural operations. Moreover, it discusses about how resource optimization models can be used to increase agricultural yields and address environmental issues. A fundamental necessity for strategic management of water resources and joint utilization of water resources to support sustainable agriculture is also emphasized in the evaluation.

Keywords-: Advanced technologies, Economic factors, Agriculture, Internet of Things (IoT), Environmental factors, Sustainable agricultural productivity.

1 Introduction

The agriculture industry, which is seeing a major transition towards data-centric operations despite its familiarity with conventional farming methods, needs more accurate and advanced technologies. Agriculture has advanced technologically primarily due to information and communication technology, especially the internet of things. A qualitative method to agriculture has given way to a quantitative one because of the increasing application of those technology in the area. This shift, regardless of obstacles, has revolutionized conventional farming practices and developed new opportunities. This thorough study looks at the promise of IoT in advancing agriculture and the challenges of fusing this technology with conventional farming strategies. It talks about the form of sensors suitable for particular agricultural tasks, like pest control, irrigation systems, and site practise, while highlighting the significance of optimal control techniques [1]. Major crops had a large rise in manufacturing for the duration of the "green revolution," with average yields nearly tripling and certain grains experiencing rises of four to five times. Millions of lives were saved as a result of this sudden improvement in the ability to meet the world's food demand and prevent widespread hunger. For example, despite more than doubling in population during this time, Asia managed to move from being at risk of widespread famine and starvation in the mid-1960s to becoming self-sufficient in staple foods in around 20 years. Nonetheless, population growth persisted despite the noteworthy improvement in food production. It is ironic that despite this significant increase, global hunger persisted. Based purely on calorie and protein deficits, official figures from the past few years have estimated that between 920 and 1,020 million people were undernourished and consistently hungry.

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

Nevertheless, the actual number is likely much higher. When considering other forms of nutritional deficiencies, such as those resulting from inadequate intake of vitamins and minerals, an estimated 3.7 billion people are deemed malnourished [2]. Innovation methods change along with the circumstances of agricultural development. In response to the rapid shifts over time, a number of techniques have been developed, such as the Public-Private Partnerships (PPP), farmer-first and farmer-last approaches, Participatory Rural Appraisal (PRA), Agriculture Knowledge and Information System (AKIS), and National Agricultural Research System (NARS). However, a number of variables mean that contemporary agricultural research endeavours frequently fail to ignite meaningful social and economic revolutions. Innovative strategies are essential for successfully navigating and thriving in the face of new obstacles. A novel framework for examining the contribution of science and technology, as well as their relationships with other stakeholders, to the production of products and services is provided by the Agriculture Innovation System (AIS) method. It recognizes the importance of particular connections and links for promoting information sharing in dynamic social and biophysical contexts. Agricultural Innovation System success stories abound in developed and developing countries alike. Examples include the small-scale food processing and shrimp farming in Bangladesh, the processing of pineapples and cassava in Ghana, the medicinal plant and vanilla industries in India, and the production and selling of agricultural commodities in the United Kingdom by U.K. cooperatives [3].

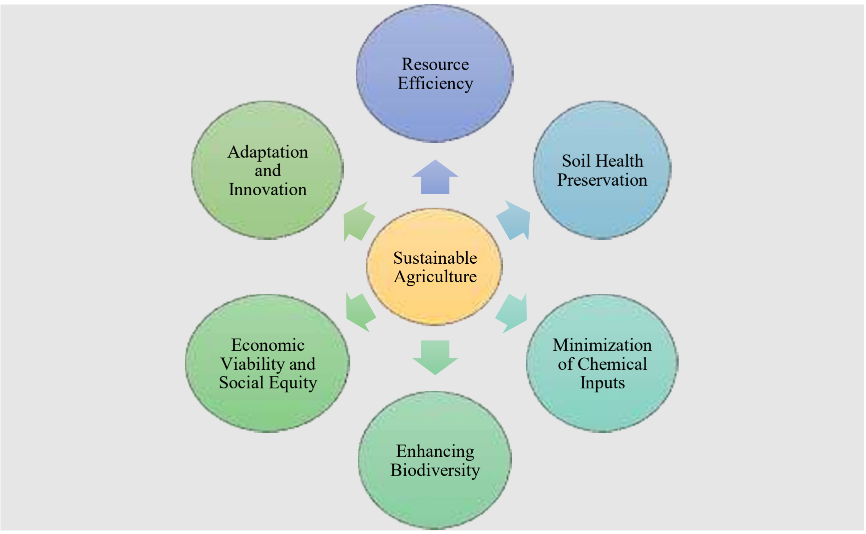

Fig. 1: Characteristics of sustainable agriculture

The core idea of sustainability is to satisfy current demands without endangering the capacity of future generations to satisfy their own. The world's current problems, which include hunger in the poor world, obesity in the rich world, growing food prices, climate change, increased fuel and transportation costs, shortages in the global market, widespread pesticide pollution, pest adaptation and resistance, declining soil fertility and organic carbon, soil erosion, declining biodiversity, and desertification, highlight how inadequate conventional agriculture is to meet human food needs while protecting ecosystems. As an alternate strategy to address basic and practical problems with food production in an environmentally responsible way, sustainable agriculture is emerging [4]. A full integration of biological, chemical, physical, ecological, economic, and social sciences is an attribute of sustainable agriculture (as depicted in Fig.1), in contrast to traditional agriculture, which places a premium on productivity and profit. It seeks to create farming techniques that are secure and do not harm the environment. According to the Farm Bill, sustainable agriculture is defined as an "integrated system of plant and animal production practices tailored to specific sites, with the long-term goal of meeting human food and fiber needs along with improving environmental quality and maximizing the efficient utilization of non-renewable resources and on-farm resources, while integrating suitable natural biological cycles and controls. It also aims at maintaining the economic viability of farm operations and enhancing the overall quality of life for farmers and society as a whole." [5]. numerous perspectives exist on how to enhance sustainability, with various individuals championing distinct principles with considerable passion and dedication. Generally, these principles offer valuable insights and tend to share commonalities, typically presenting as variations on a central theme. While each method has its place and potential benefits, the success of one approach for someone else doesn't guarantee it will be effective for everyone [6]. Compared to conventional or traditional farming methods, organic agriculture is frequently thought to be a more sustainable option. Organic farming generally produces less pollution than traditional methods with regard to climate change and environmental effect. Despite this, just 1% of agricultural land is being used for organic farming globally, and average yields are lower. Biological pest management, crop rotation, and the use of biofertilizers are a few of the sustainable natural resources and methods used in organic agriculture [6–8]. Organic farmers use natural pesticides and fertilizers as opposed to typical farmers that use synthetic fertilizers, insecticides, growth regulators, hormones, and antibiotics to raise crop yields and increase the output of animal meat and milk [9].

2 Resource efficiency

The scientific area is beginning to recognise the notions of circular economies and resource utilisation as facilitators for environmental sustainability on a agricultural level. In addition to playing a critical role in the economic growth of India, the agri-food sector has enormous potential to influence the timely achievement of the agenda for sustainable development. The efficiency with which resources, including labour, electricity, water, and the ground, are used in the cultivation of crops is known as resource usage efficiency. It is a key idea in the field of sustainable agriculture since it may minimise the detrimental effects that farming has on the natural environment while increasing output and profitability. Table 1 presents a comprehensive comparative analysis of various farming practices and technologies, highlighting their impact on agricultural efficiency and resource use. It summarizes research findings from several studies with an emphasis on automated irrigation and monitoring systems, integrated farming systems, and the application of climate-smart agriculture (CSA) techniques.

Table 1: Comparative analysis of agricultural efficiency and resource use across different farming practices and technologies

Study Reference	Cropping System	Key Findings	Resource Efficiency
[10]	Integrated Farming Systems (IFS, LI) vs. Conventional (CONV)	IFS and LI showed 31.4% and 32.7% higher energy use efficiency than CONV, with SOM inclusion boosting energy performance.	Wheat: 2.6 MJ/kg, Maize: 2.2 MJ/kg, Soybean: 4.1 MJ/kg. IFS and LI showed higher crop yield and system efficiency with reduced energy inputs.
[11]	Automated Monitoring and Irrigation System	Introduced efficient automated monitoring and irrigation, with power efficiency values : 1µA (sleep mode), 700µA (active mode), and 2.52mW (power consomption).	Improved water and fertilizer distribution efficiency through sensor-based monitoring, leading to optimized resource use.
[12]	OECD Agriculture	Identified a potential 72.3% savings in exergy consomption through improved technical efficiency and input selection, with significant différences in sustainable efficience across countries.	Potential for greatly improved overall resource efficiency, especially in energy and input utilization across agricultural practices.
[13]	Nitrogen Fertilizer Use Impact (China)	Found that a 60% reduction in nitrogen fertilizer use could cut national nitrogen yield and N2O emissions by approx. 50%, with only a minor 2% decrease in crop production.	Enhanced nitrogen use efficiency and reduced greenhouse gas emissions through optimized fertilizer application.
[14]	CSA in Cotton Farming (Pakistan)	CSA adopters showed higher mean technical efficiency (0.96 vs. 0.92), economic efficiency (0.88 vs. 0.79), and water use efficiency (0.84 vs. 0.70) compared to non-adopters.	CSA practices led to higher water use efficiency and better overall resource use among cotton farmers.
[15]	RM Planting Patterns in Maize (China)	RM significantly enhanced maize yield (+35%), water use efficiency (+32%), and other efficiencies compared to conventional planting, but additional inputs did not further enhance resource efficiency.	RM alone without additional inputs was recommended for sustainable and efficient resource use in maize production.

Important inferences include notable enhancements in energy efficiency and management of soil organic matter (SOM) via integrated farming, efficient distribution of water and fertilizer through automated systems, and possible energy savings in OECD agriculture. The study also highlights the advantages of China's decreased usage of nitrogen fertilizer and Pakistan's cotton producers' use of CSA techniques to improve water use efficiency. Additionally, without the need for extra inputs, China's ridge-furrow with plastic film mulching (RM) technology for growing maize shows notable increases in productivity and water use efficiency. This table clearly shows the variety of approaches to achieving sustainable agricultural production through innovative practices and technologies, each contributing to improved resource efficiency and environmental sustainability.

3 Role of Resource efficiency in sustainable agriculture

Global attention has been drawn to sustainability challenges since the Sustainable Development Goals (SDGs) were adopted in 2015, with particular emphasis on the critical role that agricultural production plays in reaching these goals. There is discussion of the effects of a number of variables, including carbon emissions, deforestation, natural resource consumption, renewable energy consumption, and regional integration, on the agricultural production of the ASEAN member states as stated in Fig 2. Using Mean Group (MG) estimators, which take cross-sectional data dependencies into consideration, it was found that these countries' agricultural output is negatively impacted by environmental deterioration, particularly CO2 emissions. Moreover, the use of renewable energy has proven advantageous even if it has been discovered that forest covering and natural resources have a negative impact on agricultural output. It's interesting to note that even with ASEAN's high degree of regional integration, production in agriculture does not increase inside the bloc [16]. Biodiversity plays a crucial role in sustainable agriculture and food security worldwide, with a focus on the extensive variety of edible plants and the significant potential of neglected and underutilized species (NUS). Among the identified over 7,039 edible plant species, there is a vast contrast to the limited selection of crops that dominate global diets. The exploration of fungi as a means to diversify and enhance the nutritional value of diets further highlights the untapped potential within our natural resources. Despite the essential benefits these species offer for environmental sustainability and their multifaceted uses, a notable portion is endangered, emphasizing the urgent need for conservation efforts. The call for increased collaboration among stakeholders underscores the necessity to harness these resources effectively [17]. A wide range of people should get involved in order to start a "green revolution" that will utilize biodiversity to create resilient food systems, as the strategy for a biodiverse, sustainable agricultural future emphasizes the value of traditional knowledge and community building [17]. A significant global problem is sustaining and enhancing grain production (GP) while adhering to sustainability standards in the face of growing financial and environmental constraints. it is vital to recognize in this context how inputs related to finances, natural resources, and agricultural techniques interact to impact GP. The intricate connections between GP, WSRs, and economic input factors (EIFs) had been the subject of an inventive approach [18]. This case study focuses on Northeastern China specifically.

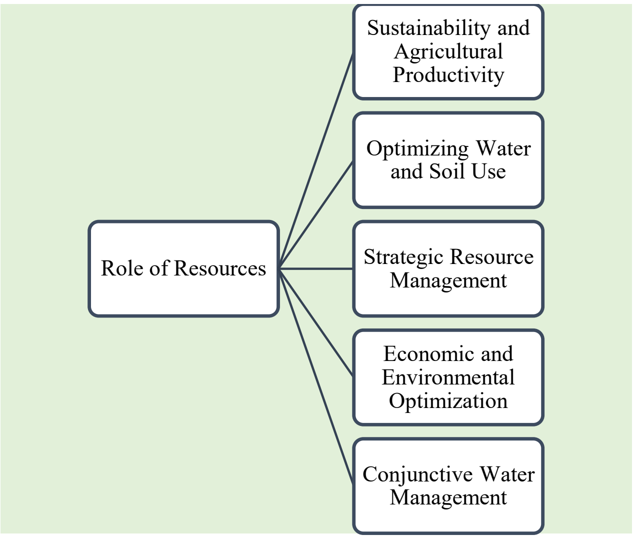

Fig. 2: Role of resources in agricultural sustainability

Through the use of regression and geographical analysis, a comprehensive index to evaluate the quality of the soil and water will be evolved, and the ways wherein these variables interact and influence GP will be examined (as shown in Fig. 2). The findings exhibit a complex interaction: while the advantages of using agricultural machinery decline and the importance of labour inputs increases with resource quality, a U-shaped relationship indicates that improvements in water and soil quality can result in greater advantages from fertilizer and irrigation. These results underline the need of taking environmental considerations into account while doing an economic evaluation of agriculture and pave the way for more focused approaches to reinforce GP efficiency [18].

The region's yearly net agricultural revenue climbed by more than 17%, from 812.21 million to 952.63 million, as projected by the model [19]. Following this, the sensitivity analysis showed that crop market prices were a significant factor in agricultural productivity, along with the area under cultivation and associated costs. The report recommends combining groundwater and canal water to improve farm incomes and address irrigation issues. In dry and semi-arid regions, this is an environmentally friendly method of raising agricultural productivity without depleting water supplies. This innovative methodological approach, which is unique in the study region and is distinguished by its efficacy and simplicity, provides a globally replicable solution for comparable problems, thereby making a substantial contribution to resource management and sustainable agriculture in the face of mounting environmental and climatic pressures.

With the requirement to produce 60% more food by 2050 for a predicted 9.5 billion people, the sustainability of water resources is becoming more and more important. This is because demand is growing from the agricultural, industrial, and home sectors. Water scarcity brought on by pollution, urbanization, climate change, and the adoption of more water-intensive lifestyles and diets aggravate this problem. Particularly in arid and semi-arid areas that are vital to economic growth, irrigation is essential for ensuring food security. However, it also carries dangers, including the loss of biodiversity and environmental degradation, which includes common problems like waterlogging and secondary salinization [20]. More than 70% of the freshwater used worldwide is used for irrigated agriculture, therefore effective management and use are crucial. In addition to enhancing water usage efficiency and the surrounding environment in irrigated areas, the combined use of surface and groundwater provides a solution to water scarcity. It relieves the constraints of depending on a single source of water and is essential for irrigation from a hydrologic and economic standpoint, especially in areas where ecological stability is in question [21-23]. Conjunctive water usage, as demonstrated in Central Asia and other parts of the world, not only lessens the impact of water shortages but also enhances crop productivity and the availability of water in cities. It can also result in notable water savings. A strategic approach to water resource management is crucial for sustainable development, since it is becoming more and more required to fulfill the rising needs for water and deal with the effects of climate change [24-25].

4 Strategic Resource Management

The elimination of biowaste and assistance in cleaning up the natural environment [26]. In order to accomplish organisational goals, strategic scheduling, allocating resources, utilisation, and evaluation are referred to as strategic management of resources, or SRM. This is an in the long run, strategic procedure that aims to match the organization's resource utilisation with its overarching sustainable agriculture strategy [27].
Strategic planning is a managerial responsibility that ensures an organization's growth and future direction. It involves collaboration between stakeholders and decision-makers to align the organization with its environment [28-31]. The SWOT analysis is used to assess strengths, weaknesses, opportunities, and threats, considering the organization's mission, vision, and surroundings. Strategic planning is done both from the outside in and the inside out, and must align with the organization's mission. After Strategic Planning, Resources Detection and Assessment is the second phase of Strategic Resource Management (SRM) [32-35]. The purpose of this stage is to identify the resources that are available inside an organisation and evaluate how well they are currently being used, as depicted in Fig. 3.

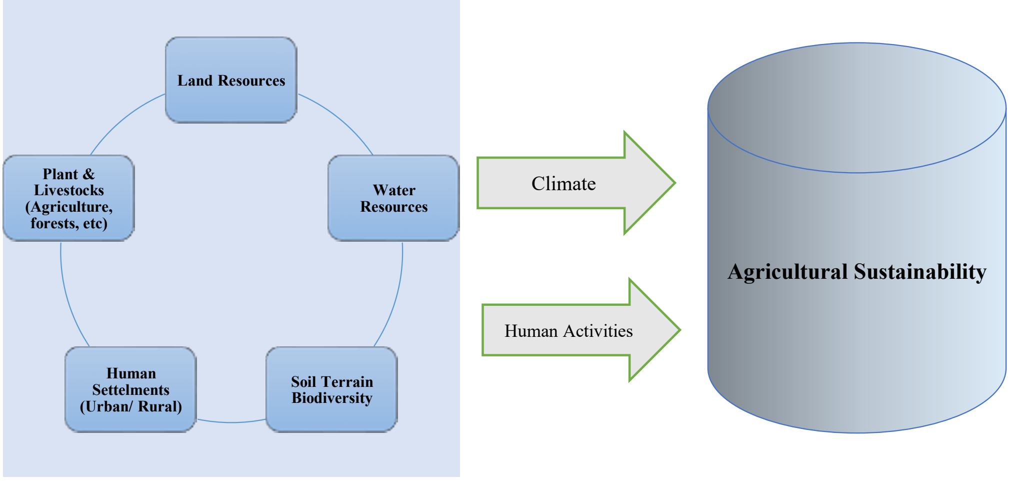

Fig. 3: Resource Management for Sustainability in Agriculture

Following is an in-depth examination at each step in this procedure. Identification of Resource i.e; Finding out what resources in the organisation are available is the first step [36-38]. Resources can be intangible (such as intellectual property, image of the company, as well as connections with collaborators and customers) or tangible (such as financial, physical, technological, and human resources) [39]. Organisations can frequently identify tangible resources by looking through financial sheets, personnel files, inventory management systems, etc. However, the quantification of intangible resources, such as unique knowledge, value for the brand, and customer loyalty, may require a more sophisticated approach [40-42].

5 Conclusion

The development of sustainable agriculture depends on the investigation of cutting-edge technology and the wise use of natural resources. The results show that although environmental degradation presents major obstacles, agricultural output can be positively impacted by the use of renewable energy sources and effective resource management. Biodiversity offers unrealized promise for improving food security and nutritional diversity, especially when applied to NUS and fungus. Furthermore, the Jhajjar district's use of optimization models shows promise in enhancing agricultural yields and reducing environmental problems. Reaching sustainable agriculture necessitates are an intensive approach that blends generation with efficient useful resource control and biodiversity renovation. The paper highlights the cost of biodiversity, inclusive of underutilized and unnoticed species, and the potential of IoT and related technologies which contributes to improve agricultural businesses. We additionally talk how resource optimization fashions can be used in growth agricultural yields and resolve environmental issues. The evaluation also highlights the important need for strategic water management and sharing to assist sustainable agriculture.

Sustainable Agriculture Development and Technology

a. A comprehensive method mixing generation, beneficial aid control, and biodiversity maintenance is must. The paper holds the value of biodiversity and IoT in the direction of enhancing agricultural operations.
b. It's been already mentioned that cooperative use and intentional management of water sources are essential to sustainable agriculture.
c. Smart usage of natural sources and progressive technology are the fundamentals of sustainable agriculture. there's a possibility that the productivity of agriculture should get impacted by means of renewable power and powerful aid control.
d. Biodiversity enhances food and meal security, specifically for NUS and fungi. using models for optimization Jhajjar districts decorate agricultural output and lessen environmental problems.

References

[1] Khan N, Ray RL, Sargani GR, Ihtisham M, Khayyam M, Ismail S. Current Progress and Future Prospects of Agriculture Technology: Gateway to Sustainable Agriculture. Sustainability. 2021; 13(9):4883. https://doi.org/10.3390/su13094883
[2] Swarna, K. S. V., Vinayagam, A., Ananth, M. B. J., Kumar, P. V., Veerasamy, V., & Radhakrishnan, P. (2022). A KNN based random subspace ensemble classifier for detection and discrimination of high impedance fault in PV integrated power network. Measurement, 187, 110333.
[3] Sharma, R., Peshin, R., Khar, S., & Ishar, A. K. (2014). Agriculture innovation system approach for sustainable agriculture development: A review. Agro-Economist, 1(1), 1-7.
[4] Lichtfouse, E., Navarrete, M., Debaeke, P., Souchère, V., Alberola, C., & Ménassieu, J. (2009). Agronomy for sustainable agriculture: a review. Sustainable agriculture, 1-7.
[5] Velten S, Leventon J, Jager N, Newig J. What Is Sustainable Agriculture? A Systematic Review. Sustainability. 2015; 7(6):7833-7865. https://doi.org/10.3390/su7067833
[6] Wezel, A., Casagrande, M., Celette, F., Vian, J. F., Ferrer, A., & Peigné, J. (2014). Agroecological practices for sustainable agriculture. A review. Agronomy for sustainable development, 34(1), 1-20.
[7] Thakur, N., Kaur, S., Kaur, T., Tomar, P., Devi, R., Thakur, S., ... & Yadav, A. N. (2022). Organic agriculture for agro-environmental sustainability. In Trends of applied microbiology for sustainable economy (pp. 699-735). Academic Press.
[8] Khan, Amir, and Kuldeep Kumar Saxena. "A review on enhancement of mechanical properties of fiber reinforcement polymer composite under different loading rates." Materials Today: Proceedings 56 (2022): 2316-2322.
[9] Durán-Lara, E. F., Valderrama, A., & Marican, A. (2020). Natural organic compounds for application in organic farming. Agriculture, 10(2), 41.
[10] Keilbart, P. (2021). Integrating organic farming into the Indonesian bioeconomy? Sustainable agriculture between productivism and deep ecology. ASIEN: The German Journal on Contemporary Asia, (160/161), 87-117.
[11] Alluvione, F., Moretti, B., Sacco, D., & Grignani, C. (2011). EUE (energy use efficiency) of cropping systems for a sustainable agriculture. Energy, 36(7), 4468-4481.
[12] Arun, V., Shukla, N. K., Singh, A. K., & Upadhyay, K. K. (2015, September). Design of all optical line selector based on SOA for data communication. In Proceedings of the Sixth International Conference on Computer and Communication Technology 2015 (pp. 281-285).
[13] Srisruthi, S., Swarna, N., Ros, G. S., & Elizabeth, E. (2016, May). Sustainable agriculture using eco-friendly and energy efficient sensor technology. In 2016 IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT) (pp. 1442-1446). IEEE.
[14] Singh, P., Singh, A. K., Arun, V., & Tripathi, D. K. (2024). Comparative study of all-optical INVERTER and BUFFER gates using MZI structure. Journal of Optical Communications, 44(s1), s253-s261.
[15] Goyal, Deepam, Rajeev Kumar Dang, Tarun Goyal, Kuldeep K. Saxena, Kahtan A. Mohammed, and Saurav Dixit. "Graphene: a path-breaking discovery for energy storage and sustainability." Materials 15, 18 (2022): 6241.
[16] Tian H, Lu C, Pan S, Yang J, Miao R, Ren W, Yu Q, Fu B, Jin FF, Lu Y, Melillo J. "Optimizing resource use efficiencies in the food–energy–water nexus for sustainable agriculture: From conceptual model to decision support system." Current Opinion in Environmental Sustainability 33 (2018): 104-113.
[17] Imran, M. A., Ali, A., Ashfaq, M., Hassan, S., Culas, R., & Ma, C. (2019). "Impact of climate smart agriculture (CSA) through sustainable irrigation management on Resource use efficiency: A sustainable production alternative for cotton." Land Use Policy 88 (2019): 104113.

[18]Xiong, Li, and Wei Wu. "Can additional agricultural resource inputs improve maize yield, resource use efficiencies and emergy based system efficiency under ridge-furrow with plastic film mulching?." Journal of Cleaner Production 379 (2022): 134711.
[19] Alam, Md Absar, Rajan Kumar, Deepen Banoriya, Anil Singh Yadav, Geetesh Goga, Kuldeep K. Saxena, Dharam Buddhi, and Ravindra Mohan. "Design and development of thermal comfort analysis for air-conditioned compartment." International Journal on Interactive Design and Manufacturing (IJIDeM) 17, 5 (2023): 2777-2787.
[20]Chopra, R., Magazzino, C., Shah, M. I., Sharma, G. D., Rao, A., & Shahzad, U. (2022). "The role of renewable energy and natural resources for sustainable agriculture in ASEAN countries: do carbon emissions and deforestation affect agriculture productivity" Resources Policy 76 (2022): 102578.
[21]Ulian, T., Diazgranados, M., Pironon, S., Padulosi, S., Liu, U., Davies, L., Howes, M.J.R., Borrell, J.S., Ondo, I., Pérez-Escobar, O.A. and Sharrock, S.,"Unlocking plant resources to support food security and promote sustainable agriculture." Plants, People, Planet 2.5 (2020): 421-445.
[22]Zhang, F., Wang, H., Qin, T., Rojas, R., Qiu, L., Yang, S., Fang, Z. and Xue, S.,"Towards sustainable management of agricultural resources: A framework to assess the relationship between water, soil, economic factors, and grain production." Journal of Environmental Management 344 (2023): 118401.
[23]Singh, Ajay. "Judicious and optimal use of water and land resources for long-term agricultural sustainability." Resources, Conservation & Recycling Advances 13 (2022): 200067.
[24]Singh, Ajay. "Conjunctive use of water resources for sustainable irrigated agriculture." Journal of Hydrology 519 (2014): 1688-1697.
[25] Ram, N. Raghu, V. V. Madhav, Manoj Kumar Agrawal, Prasanta Kumar Mohanta, Kuldeep K. Saxena, Ch Sri Chaitanya, and Barno Sayfutdinovna Abdullaeva. "Tensile Behaviour of Natural Polymer Composite Materials at Ambient and Elevated Temperatures." (2023).
[26] Alkorbi, A. S., Kumar, K. Y., Prashanth, M. K., Parashuram, L., Abate, A., Alharti, F. A., ... & Raghu, M. S. (2022). Samarium vanadate affixed sulfur self doped g-C3N4 heterojunction; photocatalytic, photoelectrocatalytic hydrogen evolution and dye degradation. International Journal of Hydrogen Energy, 47(26), 12988-13003.
[27] Raji, Atchudan, Jebakumar Immanuel Edison Thomas Nesakumar, Shanmugam Mani, Suguna Perumal, Vinodh Rajangam, Somanathan Thirunavukkarasu, and Yong Rok Lee. "Biowaste-originated heteroatom-doped porous carbonaceous material for electrochemical energy storage application." Journal of Industrial and Engineering Chemistry 98 (2021): 308-317.
[28] Reddy, Kasara Sai Pratyush, Y. Mohana Roopa, Kovvada Rajeev LN, and Narra Sai Nandan. "IoT based smart agriculture using machine learning." In 2020 Second international conference on inventive research in computing applications (ICIRCA), pp. 130-134. IEEE, 2020.
[29] Naresh, Muthunoori, and P. Munaswamy. "Smart agriculture system using IoT technology." International journal of recent technology and engineering 7, 5 (2019): 98-102.
[30] Yadav, Shambhoo, Pooja Sharma, Prathima Yamasani, S. Minaev, and Sudarshan Kumar. "A prototype micro-thermoelectric power generator for micro-electromechanical systems." Applied Physics Letters 104, 12 (2014).
[31] Vijayakumar, Y., P. Nagaraju, Veeraswamy Yaragani, Saidi Reddy Parne, Nasser S. Awwad, and MV Ramana Reddy. "Nanostructured Al and Fe co-doped ZnO thin films for enhanced ammonia detection." Physica B: Condensed Matter 581 (2020): 411976.
[32] Dikshit, Mithilesh K., Vimal K. Pathak, Reeya Agrawal, Kuldeep K. Saxena, Dharam Buddhi, and Vinayak Malik. "Experimental Study On The Surface Roughness And Optimization Of Cutting Parameters In The Hard Turning Using Biocompatible Tialn-Coated And Uncoated Carbide Inserts." Surface Review and Letters (2023): 2340002.
[33] Spandana, Kancheti, and VR Seshagiri Rao. "Internet of things (Iot) based smart water quality monitoring system." International Journal of Engineering & Technology 7, 3.6 (2018): 259-262.
[34] Telagam, Nagarjuna, Nehru Kandasamy, and Menakadevi Nanjundan. "Smart sensor network based high quality air pollution monitoring system using labview." International Journal of Online Engineering (iJOE) 13, 08 (2017): 79-87.
[35] Devi, M. Dharani, A. Vimala Juliet, K. Hariprasad, V. Ganesh, H. Elhosiny Ali, H. Algarni, and I. S. Yahia. "Improved UV Photodetection of Terbium-doped NiO thin films prepared by cost-effective nebulizer spray technique." Materials Science in Semiconductor Processing 127 (2021): 105673.
[36] Vallabhuni, Rajeev Ratna, S. Lakshmanachari, G. Avanthi, and Vallabhuni Vijay. "Smart cart shopping system with an RFID interface for human assistance." In 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS), pp. 165-169. IEEE, 2020.
[37] Kumari, Soni, Meet Shah, Yug Modi, Din Bandhu, Kishan Zadafiya, Kumar Abhishek, Kuldeep K. Saxena, Velaphi Msomi, and Kahtan A. Mohammed. "Effect of various lubricating strategies on machining of titanium alloys: a state-of-the-art review." Coatings 12, 8 (2022): 1178.
[38] Kumar, C. P., Raghu, M. S., Prathibha, B. S., Prashanth, M. K., Kanthimathi, G., Kumar, K. Y., ... & Alharthi, F. A. (2021). Discovery of a novel series of substituted quinolines acting as anticancer agents and selective EGFR blocker: Molecular docking study. Bioorganic & Medicinal Chemistry Letters, 44, 128118.
[39] Srinivasan, K., Porkumaran, K., & Sainarayanan, G. (2009, August). Improved background subtraction techniques for security in video applications. In 2009 3rd International Conference on Anti-counterfeiting, Security, and Identification in Communication (pp. 114-117). IEEE.

[40] Ashwini, S., Prashantha, S. C., Naik, R., & Nagabhushana, H. (2019). Enhancement of luminescence intensity and spectroscopic analysis of Eu3+ activated and Li+ charge-compensated Bi2O3 nanophosphors for solid-state lighting. Journal of Rare Earths, 37(4), 356-364.
[41] Manohar, T., Prashantha, S. C., Nagaswarupa, H. P., Naik, R., Nagabhushana, H., Anantharaju, K. S., ... & Premkumar, H. B. (2017). White light emitting lanthanum aluminate nanophosphor: near ultra violet excited photoluminescence and photometric characteristics. Journal of Luminescence, 190, 279-288.
[42] Al-Agele, H. A., Nackley, L., & Higgins, C. W. (2021). A pathway for sustainable agriculture. Sustainability, 13(8), 4328.