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AGRICULTURE, ENVIRONMENT AND ENERGY SUSTAINABILITY

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Contents

Preface

Sustainability is founded on the straightforward tenet that everything we need for our life and well-being relies on nature, either directly or indirectly. Agriculture directly contributes to the sustainable management of the land, the air, and the water. In order to meet our nation's demands for food, feed, and fibre as well as the social, economic, and other needs of both the current and the future generations, it is necessary to develop and preserve the circumstances that allow people and nature to coexist in productive harmony.

At the global level, buildings account for around 40% of all yearly energy usage. The majority of this energy is used to provide heating, cooling, lighting, and air conditioning. A revived interest in ecologically friendly cooling and heating systems has been sparked by growing awareness of the negative environmental effects of CO2, NOx, and CFC emissions. Governments agreed to phase out chemicals used as refrigerants that have the potential to harm stratospheric ozone under the terms of the 1997 Montreal Protocol. Therefore, it was deemed desirable to limit energy use, the pace of depletion of global energy supplies, and environmental damage. Designing structures that use less energy for heating, lighting, cooling, ventilation, and hot water delivery is one technique to reduce the energy consumption of buildings.

Passive techniques, especially the use of natural or hybrid ventilation as opposed to air conditioning, may significantly lower the amount of primary energy used. However, using renewable energy in structures and agricultural greenhouses may also make a major difference in lowering reliance on fossil fuels. Therefore, encouraging cutting-edge renewable applications and supporting the market for renewable energy would help to preserve the environment by lowering emissions both locally and globally. By substituting renewable energy for conventional ones that release greenhouse gases and air pollutants, this will also help to improve the environment. The supply of a healthy indoor environment while ensuring energy and financial efficiency in the operation of the heating, ventilation, and air-conditioning (HVAC) plants in buildings is a complex issue. Many environmental factors, such as air speed, temperature, relative humidity, and quality, in addition to lighting and noise, affect how comfortable building occupants are. Providing the necessary environmental conditions while using the least amount of energy is referred to as energy efficiency.

Cost efficiency measures the amount of money spent on energy in relation to the degree of productivity and comfort the building's inhabitants experienced. By increasing a building's energy efficiency and interior environmental quality, the total cost efficiency may be raised. In response to the urgent demand for a cleaner energy technology, this book analyses the possibilities for such integrated systems in the stationary and portable power market. This document discusses in detail anticipated patterns of future energy usage and the resulting environmental effects (acid precipitation, ozone depletion, and the greenhouse effect or global warming). Throughout the subject, a number of concerns pertaining to sustainable development, the environment and renewable energy sources are looked at from both present and future viewpoints.

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CHAPTER 1

INTRODUCTION TO ENERGY AND AGRI-ENVIRONMENT

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The practise of raising crops with the aid of land, water, seeds, and other resources is known as agriculture. Agriculture is crucial to human existence since it supplies us with food and other necessities for a healthy lifestyle. Additionally, agriculture contributes significantly to our everyday lives and offers a host of advantages. As a result, agriculture becomes more significant in our lives. Particularly in nations like India, where the agricultural industry provides employment for more than 60% of the population [1]–[3]. Because almost 70% of the people in India relies on the agricultural sector for their survival and farming is their primary occupation, India is an agriculturally oriented country.

Particularly in rural regions where you will see that the majority of the population is entirely reliant on farming. This is due to two factors. First, they have inherited their ancestors' agricultural skills and wisdom. The absence of industries and other sectors in rural areas—they are only present in large cities—is the second factor.

Natural catastrophes including hurricanes, floods, fires, earthquakes, and tornadoes pose a yearly threat to agricultural productivity. Agriculture is readily damaged by natural disasters and catastrophes since it depends on the weather, climate, and availability of water to survive. Natural catastrophes and their effects on agriculture most often cause:

- pollution of water sources,
- damage of irrigation systems
- other agricultural infrastructure
- loss of harvest or animals
- increased vulnerability to disease

These effects may have long-term implications on agricultural productivity, such as crop growth, forest development, and the development of arable lands, all of which need time to mature. Learning how to prevent and recover from natural disasters and occurrences can lessen their long-term consequences on the environment and agriculture. Despite the fact that natural catastrophes and occurrences may have a disastrous effect on agricultural productivity, this does not justify breaking state and federal environmental rules [4]–[6].

All nations must be equipped to successfully avoid and lessen the effects of any disasters, regardless of their financial level, according to the 2030 Agenda for Sustainable Development. Countries should take action to lessen the destructive consequences on people and the economy if catastrophes cannot be prevented. Given its extensive linkages with the environment and its dependence on natural resources for production, agriculture must be at the centre of these efforts. Strategies for disaster risk reduction (DRR) are necessary to prevent governments and people from falling into a cycle of poverty as a result of more frequent hazardous events. It is necessary to organise political and financial support for DRR via effective policy frameworks. This necessitates the creation of a solid evidentiary basis.

A crucial first step is to conduct a detailed examination of current trends in agricultural output and associated distortions in production quantities and patterns as a result of catastrophes. A DRR, sustainable development, and emergency response planning choice may be made with the use of such analysis, which helps close the information gap. The inaugural study, titled "The Impact of Disasters on Agriculture and Food Safety," was released by the Food and Agriculture Organization of the United Nations (FAO) in 2015.

It revealed that the agricultural sector alone absorbed a startling 22% of all losses and damages caused by natural disasters in developing nations. The research also emphasised the need for more rigorous data collection, in-depth analysis, and information system development. For effective risk reduction policy and practise, as well as for directing investment in climate-resilient agricultural systems, a better knowledge of the extent and type of catastrophe impact on particular sectors is essential. The FAO is issuing the second periodic report in 2017 as part of an ongoing endeavour to close the information gap and create a better understanding of how the agricultural sector is impacted by catastrophes.

In sub-Saharan Africa, where agriculture contributes on average a quarter of GDP and up to a half when agribusiness is taken into account, drought has a particularly negative effect, resulting in almost 90% of output losses. According to a conservative estimate, between 1991 and 2013 in the area, agricultural and animal production losses as a result of severe droughts were more than $30 billion.

As seen in Kenya between 2008 and 2011, when it caused huge losses in the food processing business, notably in the grain milling and coffee and tea processing sectors, drought often has a significant cascading impact on national economies. The effects of floods and storms may be extremely devastating in many Asian nations. For instance, cotton ginning, rice processing, flour manufacturing, and sugar milling were severely impacted by agricultural output losses brought on by Pakistan's 2010 floods, while imports of cotton and rice increased. In this instance, the agricultural industry bore the brunt of around half of the $10 billion in overall damages and losses.

It is essential to comprehend the effects of various catastrophes in order to apply the best practises and policies. Crops are very sensitive to storms and drought, and more than half of all damage and loss is due to floods. Drought is responsible for around 85% of the damage to cattle, while hurricanes, cyclones, and tsunamis have a significant negative impact on fisheries. Storms and floods are mostly to blame for the timber industry's severe economic effects. In addition to production losses, the research demonstrates how catastrophes may impair earnings, particularly for small-scale family farmers, endangering rural livelihoods. For instance, almost 70% of farmers lost more than half of their projected income as a result of the 2010 floods in Pakistan, which impacted 4.5 million people, 2/3 of whom worked in agriculture.

Around the world, 2.5 billion people rely on agriculture for their livelihoods, yet between 2003 and 2012, only 4.2 percent of all official development assistance—less than half the United Nations objective of 10 percent—was allocated to this sector. Only around 0.4 percent of official development money was spent on disaster risk reduction in 2010 and 2011.

FAO emphasises that help should more accurately reflect how catastrophes affect the agricultural industry. In nations that experience frequent catastrophes and where agriculture is a vital source of livelihoods, food and nutrition security, as well as a crucial economic engine, investments made into disaster response and recovery should also help develop resilience to future shocks.

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CHAPTER 2

NATURAL DISASTERS: THREAT TO SUSTAINABLE AGRICULTURE AND DEVELOPMENT

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A natural catastrophe is described as a natural occurrence that significantly impairs a community's or society's ability to operate by resulting in extensive human, material, economic, and environmental losses that are greater than their capacity to recover using their available resources. Furthermore, according to the International Federation of Red Cross and Red Crescent Societies (IFRC), a natural danger might develop slowly over time or suddenly. Natural catastrophes are divided into three categories in this working paper: Geophysical events include landslides, earthquakes, tsunamis, and volcanic activity. Hydro-meteorological events include cyclones, storms, and wave surges. Diseases, pandemics, and pests are biological phenomena.

In development planning, especially in poorer nations, many calamities are not appropriately foreseen. As a result, its abrupt introduction has unanticipated negative effects on the advancement of sustainable development. Understanding the nature of each catastrophe, mitigation strategies, and recovery techniques become of utmost significance to limit the risk of disruption in attaining sustainable development in order to anticipate disasters in development planning properly [1]–[3].

Over the last ten years, natural disaster-related economic losses in Asia and the Pacific have exceeded USD 0.5 trillion, accounting for roughly half of all worldwide losses (ESCAP, 2015). Around 1.4 billion people in this area, or 80% of the world's victims, have been impacted by these natural catastrophes. As a result, it will be challenging to achieve sustainable development in Asia and the Pacific without including disaster management into the development strategy. The area has several significant obstacles to attaining the SDG objectives of eradicating hunger, providing food security and nutrition improvement, and promoting sustainable agriculture. They consist of the escalating severity of natural catastrophes exacerbated by climate change, brisk economic development, expanding population, the emergence of new cities, and the following effects of these interrelated processes on environmental services. Furthermore, since they cause significant social upheaval and financial losses, natural catastrophes act as a worldwide impediment to sustainable development.

Despite many efforts at the national and international levels, little is known about how catastrophes, food chain crises, and war affect agriculture and its subsectors, including crop, livestock, fisheries, aquaculture, and forestry. This is partly due to the lack of comprehensive data collection and recording about the effects of disasters on agriculture, including by subsector and at the regional, national, and subnational levels. The amount of disaggregation provided by the catastrophe damage and loss figures that are publicly accessible globally does not provide a thorough comprehension of the underlying dynamics [4]–[6].

PDNAs, which are often carried out in the wake of major catastrophes to guide humanitarian efforts, do provide some evaluation, mostly of the immediate consequences across pertinent sectors.

There are many viewpoints on the effect of agriculture due to the fact that needs assessments do not employ a standard technique for calculating damage and loss (some utilise livelihood or food economy methodologies, while others concentrate on the economic cost of physical damage). The generated information is often not routinely included into national catastrophe databases. At the national, regional, and international levels, little is known about the long-term effects and the development of the disaster's influence on the industry. This necessitates the development of a more solid evidence basis. A crucial first step is to conduct a detailed examination of current trends in agricultural output and associated effects of catastrophes on production quantities and patterns. A DRR, sustainable development, and emergency response planning choice may be made with the use of such analysis, which helps close the information gap. In order to create successful DRR policy and practise, it is essential to have a strong, sector-specific damage and loss data inventory.

The unique nature of the catastrophe's effect on the sector must be taken into account when developing national plans for disaster risk reduction (DRR) and climate change adaptation that promote resilience and sustainable agricultural growth. Adaptive, wise national and international plans and policies, evolving global market circumstances, and local reactions to climate stressors will ultimately determine how natural catastrophes, climate-related events, food chain dangers, and prolonged crises collectively affect society. In order to successfully offset the destabilising effects on sector development and food security, the challenges that offer the highest risk and the largest loss (such as wars and catastrophes connected to climate change, etc.) must be consistently addressed at all levels [7], [8].

Natural disasters' direct effects on the agricultural industry take the form of crop devastation. Agriculture land, irrigation works and dams, transportation, agricultural facility buildings and equipment, and the crops themselves may all be destroyed within hours after an incident. Additionally, there is indirect harm, which is the reduction in potential output as a result of the interruption of the flow of products and services, the loss of production capacity, and the rise in production costs. Long-lasting droughts, which greatly contribute to land degradation, and water shortages, which weaken traditional coping strategies, particularly for the poorest people who live on the most degraded land, are two examples of the long-term effects of natural catastrophes. Long-term environmental deterioration and damage to infrastructure will diminish productivity, leading to food shortages, price rises, and eventually posing a danger to the food security of low-income communities or nations.

Main threats to the resilience of agriculture

Agriculture is particularly vulnerable to hydro-meteorological dangers such typhoons, hurricanes, cyclones, droughts, and floods. Risks associated with climate change, including unpredictability and extremes, are present throughout the agricultural industry. Extreme weather events and other climate-related risks have a negative influence on agricultural systems, including crop output, farmers' needs for inputs and support services, and their capacity to repay loans. The supply chain's upstream purchasers and processors may potentially be impacted.

Wherever they strike, earthquakes and volcanic eruptions will damage agricultural infrastructure, resulting in direct and indirect losses as well as disruptions in production, processing, and distribution. Natural catastrophes often have an impact on the movement of products, services, and information by causing substantial short-term yield reductions, eventual market price rises, and asset destruction. For instance, earthquakes may harm irrigation infrastructure and farming fields, ultimately resulting in poor crop yields owing to water supply shocks.

There are several biological and environmental risks that the agricultural industry must deal with. Crops are subjected to pests, harmful chemicals, and illnesses (caused by bacteria and fungi). The majority of biological hazards are linked to declines in production and quality, but they may also obstruct the movement of commodities and services. Environmental risks for agriculture, in contrast, include pollution and deterioration of the environment and natural resources, as well as contamination and degradation of the production and processing processes. Future productivity, worker health, and access to downstream markets might all be negatively impacted by environmental deterioration (such as soil erosion, pesticide, or manufacturing effluent run-off into water sources). Over- or mass-fertilization damages agricultural ecosystem services by increasing air, soil, and water pollution.

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CHAPTER 3
IOT IN AGRICULTURE

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Our nation's economy is based on agriculture. Agriculture accounts for around 70% of India's income. In India, agriculture is still practised in a traditional manner and is slow to adopt contemporary technology. With just 15% of India's GDP coming from agriculture and related industries, which employ over 55% of the country's population, it is crucial for all parties involved to abandon traditional agricultural methods and modernise the sector utilising technology. Despite a vast number of people still working in the agricultural sector, the economic contribution of agriculture to India's GDP is continuously falling due to the nation's overall economic development. The system must be immediately improved in order to boost productivity and provide nutritious organic food. According to recent market surveys, agriculture is thought to use 85% of the world's freshwater resources, and this percentage will likely continue to be dominant due to population growth and rising food demand. Under such a scenario, agriculture would use a tremendous amount of water, particularly freshwater resources [1]–[3].

The manual process must be replaced immediately with automation in order to increase agricultural yield. Think about India's access to water as well. It is one of the important resources to safeguard and conserve for demands in the future. Farmers may use an inexpensive, simple-to-install embedded-based automated watering system. The farmers who give their crops water at precise times and amounts should benefit from this approach. The timing of the motors' ON and OFF operations is determined by the automatic irrigation system's observation of the crop area's moisture sensors and temperature fluctuations. Therefore, checking the soil moisture level automatically prevents human mistake [4]–[6].

The internet of things (IOT) permits remote system control from other locations. It has the ability to regulate sensors utilised in a variety of locations, including water management systems, railroad grids, and blinding roadways and railroads. Therefore, it can prevent both human and operating system problems. IOT is a new sector that has impacted other fields and increased their productivity. IOT is currently evolving due to the addition of new sensors, sensor networks, and RF-based communications. It may display sharp intelligence, exact sensing, and accurate identification. Technologies based on computer networks and mobile platforms have changed when cloud computing and IOT were included. Today's additional networks include 3G, LTE, GSM, WLAN, and Bluetooth, which let IOT grow into a smart system and function in distant locations.

Farmers have a lot of issues when it rains heavily because their farmed crops are ruined or swept away. Therefore, in order to solve this issue, a project that helps to shield crops from strong downpours and collect rainwater for later use was created. Since agriculture is the major source of food grains and other raw resources, it is said to be the foundation of life for the human race. It is crucial to the development of the nation's economy. Additionally, it offers a large number of work options to the populace. For the improvement of the nation's economic situation, the agriculture sector must grow. Unfortunately, many farmers continue to cultivate their land using outdated techniques, which reduces the output of their crops and fruits. But in

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places where automation has been used and humans have been replaced by automated machinery, the yield has increased.

Therefore, in order to increase production, contemporary science and technology must be used in the agricultural sector. A wireless sensor network (WSN) is used in the majority of situations to gather data from various kinds of sensors and transmit it through wireless protocol to the main server. The information about various environmental elements provided by the acquired data is used to monitor the system. Therefore, in order to design integrated systems that will take into account all the variables impacting productivity at every step, such as cultivation, harvesting, and post-harvest storage, is important in order to give answers to all such difficulties. In order to give flexibility, this project also incorporates a system that is beneficial for tracking field data and managing field activities. Using automation and IOT technology, the initiative intends to make agriculture smarter.

A GSM modem does not have a keyboard or display to operate, unlike mobile phones. Through a serial interface, it just acknowledges for a limited set of instructions. These instructions are referred to as AT commands. The modem may be told to carry out certain tasks using a set of AT commands. A command always begins with "AT." Because of this, they are known as AT commands. AT is an acronym for attention.

The computer application is waiting for the keyboard user to input the cellphone number. The application tells the modem to deliver the text message using a series of AT commands when a mobile number with 10 digits is given. The goal of this project is to automatically cover the field in order to protect the crops from severe precipitation while also preserving the water that is collected. We employ a variety of technology in this system, including GSM, rain sensors, and soil moisture sensors, to do this. This device uses GSM technology, a moisture sensor, and a water pump to automatically manage the flow of water. Both water and energy are conserved by this technology, which uses less grid power and uses less water overall.

Temperature and humidity sensors are combined in the Temperature and Humidity Sensor (DHT11), which also has a calibrated digital signal output. It guarantees exceptional long-term stability and high reliability by using the unique digital-signal-acquisition approach and temperature & humidity sensor technology. This sensor connects to a high performance 8-bit microcontroller and has components for measuring temperature and humidity using resistive technology and NTC technology. It offers outstanding quality, quick reaction times, interference resistance, and cost efficiency.

Any of the rotating electrical devices in the DC battery class that convert direct current electrical energy into mechanical energy store the produced power. The most prevalent kinds depend on the forces generated by magnetic fields. Almost all kinds of DC motors contain an internal mechanism—either electromechanical or electronic—that allows them to sporadically shift the direction of the motor's current flow.

The DC battery is used to recuperate power during gloomy weather. This technology primarily relies on sensors; the automated roof operates when both sensors are turned on. Here, the rain sensor and soil moisture sensor are what the auto roof mostly relies on. When the soil moisture level is higher than usual, the rain sensor additionally goes ON as the rain begins. Additionally turning on, the soil moisture sensor then sends this information to the controller.

The controller transmits this data to the GSM and DC motor, which then turn on and cause the automated roof to open and a polythene/foam sheet to cover the field. The farmers who use GSM get a call or text message informing them that the system has been activated. As a result, this technology aids in both the utilisation of rainwater and crop protection. Through a mechanical roller, the automated roof may be manually manipulated. The roof may thus be manually opened anytime there is a problem with the system's operation. A 45-degree beam of infrared light is used in rain sensors to operate on the theory of complete internal reflection. In this project, an IR sensor will be used to control LEDs. The IR sensor is an IR receiver model 1838B.

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CHAPTER 4

NEED OF AUTOMATED AGRICULTURE

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Unpredictable weather has been caused by the growing interference with nature. The Arduino finds it challenging to protect their crops in such circumstances. A full system is necessary in order to protect the crops from wind and rain damage and to supply enough water in dry periods. With the help of this project, you may have autonomous watering equipment that adjusts its operation to the humidity and temperature. In addition, rain sensors are used to gather data on desirable or unwanted rain, allowing crops to be protected as necessary. For the Arduino, this approach offers some relief. A composite and efficient system that offers a high yield at a reasonable price is what is intended [1]–[3].

Weather conditions, water requirements for different crops, and water-retentive abilities of different soils all vary from place to location. Crops may be harmed by both excessive rainfall and water shortage. Crops may wilt as a result of a water shortage, which may impact their growth and weight. A lot of rain or water may have a leaching impact and lower the soil's nitrogen and phosphorus levels.

India has several sizable river systems and gets a lot of precipitation, yet barely a third of its total agricultural area is linked to an irrigation system via canals. Monsoons or tube wells are needed for the remainder of the remaining part. Over irrigation and water logging in areas with abundant water may cause problems with land sanity. Additionally clogging soil pores and destroying beneficial microbes, surface water collection also does both.

Instead, areas with few water supplies are unable to irrigate their land throughout the growing season because the demand for water exceeds the availability when using sprinkler irrigation or when letting water flow straight into water drainage pipes to irrigate the field adverse effects of erratic and excessive irrigation Salinity levels rise, water levels rise, plant roots are unable to communicate with the air, soil temperatures drop, the land becomes marshy, nitrate levels rise, and soil acidity rise [4]–[6].

It follows that the issue is with how water is being used. We employ drip irrigation for the best possible water usage. By directing water to a plant's roots, this irrigation technique helps to save water. In order to irrigate the fields, water must first be stored in an underground tank from all sources, including canals, tube wells, rainfall gathering, and others. An ultrasonic sensor is included inside the tank, which continually monitors the water level and sends an SMS to the user anytime the water level drops below the threshold.

Relative Humidity (RH) has an impact on crop productivity in addition to photosynthesis, pollination, and leaf development. Long-term dryness or high temperatures may cause the fragile sepals to dry out fast, killing the bloom before it has reached maturity. Controlling air humidity and temperature is therefore very important. For the purpose of measuring temperature and humidity, we instal sensors within the smart greenhouse. When the temperature exceeds a particular point, the microcontroller activates a switch connected to the fogger, which releases microscopic water droplets that stay suspended in the air and lower the temperature. Small water droplets will maintain the relative humidity if the air moisture falls below the predetermined level due to a similar process that will be activated (RH).

In greenhouses, controlling humidity might be the most challenging environmental aspect. The humidity level in greenhouses is impossible to completely manage, not even with the most advanced environmental control systems. Due to ongoing plant transpiration and variations in air temperature, humidity levels shift with those changes. These difficulties are amplified in the climatic regions of the north by a variety of elements, including the drier, colder outside air that makes air exchanges impossible.

The sluggish drying of the growth medium, plant stress, loss of quality, reduced yields, and other issues are all directly impacted by humid air. Therefore, more pesticides are required for disease management, and plants often grow weakly and spread out, making them less appealing. Plant development is often affected by low humidity since it takes longer for crops to mature to a size that is suitable for sale. Furthermore, growth is difficult, lower leaves often fall off, and overall quality is not very excellent. Whether the humidity is too high or too low, quality loss lowers crop selling prices and raises production expenses, both of which lower profitability.

Soil moisture is an important variable in the description of many hydrological and climatic processes, and it may be used to validate remote sensing soil moisture products with a distributed continuous hydrological model. For operational applications as well as for the management of water resources and climate, it is crucial. For instance, knowledge of soil moisture may increase the accuracy of flood forecasts by helping to estimate how rainfall-runoff would affect catchments. Although data might theoretically be used to track soil moisture, effort and money are spent on local observations. Soil moisture can only be estimated with comprehensive and frequent coverage using satellite remote sensing.

Remote sensing experiments in particular show a direct sensitivity to surface soil moisture at 5 cm at microwave bands where it effects the soil electrical permittivity and the atmosphere is thought to be quite transparent. An active plant wall system has been found in studies to be an efficient way to lower particulate matter and volatile organic compound concentrations in an indoor environment while stabilising the carbon dioxide concentration. However, the broad deployment of plant walls faces considerable difficulties since routine plant maintenance is geographically constrained and may be expensive in terms of both time and money.

In order to affect the plant's growth and development, speed up the metabolism, and complete photosynthetic processes, light control predominates in the red and blue channels of panels put within the greenhouse. Because farmers will have access to information on phytosanitary traits and seedling development parameters, the Internet of Things offers a tool that will have an effect on agricultural practises. These factors will affect the quality and safety of the produce. Our study focuses on creating a traceability system with a long-term, sustainable solution that ensures the seedling complies with local good agricultural practise standards.

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CHAPTER 5
DISASTER RISK REDUCTION

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To reduce poverty, provide food security, and create sustainable livelihoods, disaster risk must be addressed. As a result, it is essential to include disaster risk reduction (DRR) into strategies for rural and agricultural development and vice versa. DRR in agriculture aims to reduce risks, prevent catastrophes from happening, and provide assistance once disasters have struck. Before calamities strike, precautions and mitigation strategies are implemented. Eliminating pests is one example of how to prevent an event from occurring. By cultivating pest-resistant types or diversifying crops for a certain amount of time, mitigation aims to reduce the risk. A coping strategy is how the agricultural system (households and infrastructure) adjusts to the post-disaster circumstances, such as by beginning to farm with commodities that fit the conditions and available resources [1]–[3].

Framework for DRR in agriculture

A DRR framework explains how the entire community can cooperate to prevent and mitigate disaster risks through the adoption of an integrated, exclusive policy that decreases or eliminates hazard exposure and vulnerability to disasters, improves preparedness for response and recovery, and boosts capacity [4]–[6]. The five-stage framework below is taken into consideration, and it is in accordance with the Sendai Framework for Disaster Risk Reduction:

1. Building of institutions and frameworks

2. Establishing a DRM strategy and DRR planning 3. Information and forewarning

4. Avoidance and reduction

5. Reacting and recovering

The following is a description of each of these steps:

Building of institutions and frameworks

At this step, which is often at the national level, institutional preparations are made to provide an overarching plan for controlling catastrophe risks in the specified administrative regions. The framework might define the legal positioning of DRR actions at various levels of general national development planning and governance, delineate the roles of pertinent organisations with a central coordination body, identify pertinent stakeholders, specify the terms of their participation and partnership agreements, and mobilise the necessary funds, among other things. This aids in the maintenance and long-term sustainability of the ecosystems as well as the realisation of strong economic and social growth on a national level.

DRR planning and DRM strategy setup

A sectoral DRR plan for agriculture should be created within the broader institutional framework to guarantee that DRR in agriculture is an essential part of the planning for national development and has precise goals, priority activities, and targets. The strategies for execution should account for regional circumstances. All parties involved would also benefit from having knowledge on strategy and preparation when assessing the deeds and lessons discovered in post-disaster scenarios.

Knowledge and early alert

A framework for information and early warning aims to expand capacity in hazard information collection via the creation of climate predictions, vulnerability risk assessments, and the dissemination and interpretation of early warnings to raise awareness before catastrophes occur. Having a clear understanding of the risks allows for the creation of management strategies and plans. These steps should help agriculture be better prepared for natural catastrophes and climate change. The framework will serve as a resource for anyone involved in creating early warning systems, particularly for researchers who have hazard data to share.

Avoidance and reduction

The execution of preventative and mitigation techniques is the basis of the DRR framework for agriculture. This calls for research to create crop types resistant to environmental stress brought on by natural catastrophes and climate change, as well as sustainable farming techniques, such as soil, water, insect, and plant management. In addition to offering advice on planning and implementing mitigation strategies, the DRR agricultural framework also provides advice on budgeting and "who is doing what" in the national scope of the DRR system. The participation and comprehension of the whole community in the execution of preventative and mitigation measures is essential for the DRR agricultural framework to be implemented effectively.

Reacting and recovering

The DRR agricultural framework improves disaster response via national networks during the emergency phase in order to save lives that are in immediate risk. The national response structure is anticipated to be based on scalable, adaptive, and flexible ideas. The DRR agricultural recovery framework is a manual that offers efficient recovery assistance for agriculture in disaster-affected regions, including assistance on how to effectively recover, reconstruct, and reinvigorate farm-based livelihoods. The response and recovery framework is anticipated to provide direction on fundamental response and recovery principles, a coordinating structure that makes it easier for all stakeholders to communicate and work together, and direction for pre- and post-disaster recovery planning.

Population expansion, a rise in natural disasters, the negative effects of climate change, and environmental degradation are just a few of the new and enormous issues that agriculture is now experiencing. Agriculture's production will continue to fall in the absence of technological innovation.

The stability and even growth of agricultural output is maintained through technological innovation, which increases agricultural resistance to biotic and abiotic challenges. Physical infrastructure, machinery, equipment, biotechnology, and software that addresses knowledge and skills, crop varieties, and farming techniques are examples of technical innovations that may be used in disaster management. Crop productivity, food supply, food security, and sustainable lives are all made possible during and after catastrophes thanks in large part to agricultural technical innovation. Agriculture may now be more productive, resilient, and eco-friendly thanks to technology. There are more and more reports of promising outcomes from the use of technology innovation in agriculture. Physical infrastructure, machinery and equipment, knowledge and skills, and biotechnology are the main areas of agricultural innovation technology's continuous endeavours.

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CHAPTER 6

IOT IN CROP PROTECTION

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The crop protection system may be improved in several ways and is applicable to a variety of agricultural practises. It may be used in any environment and under any set of circumstances to grow any form of plant. For further improvement, other energy sources like solar panels may be employed. It is possible to farm without using soil to further increase the nutritional content. The addition of more IOT capability to farming may greatly increase its productivity and profitability. Crop protection will bring about a shift in India's agricultural practises. By carrying out this project, we can prevent crop damage from excessive heat and rain, as well as produce a decent harvest [1]–[3].

Future generations of farmers will be able to monitor and operate their farms from home using different technologies including the internet and mobile devices thanks to this technology. Animals, fire, and unauthorised individuals accessing the field may all be prevented from harming the farm. Bugs may be found and avoided. Because they offer food, animal feed, fuel, as well as the basic building blocks for clothing and shelter, crops are necessary for human survival. In order to fulfil the demand of a rising population while improving food quality and lowering production inputs, crop productivity must double in 2050 compared to 2009. Closing agricultural output gaps, decreasing food waste, altering eating patterns, and lowering inefficient resource use are a few potential improvements to global food security. By continually monitoring crops, soil, and microclimate, as well as effectively managing inputs, it is possible to reduce inefficiencies in input resources (such as water and nitrogen) without compromising crop production and quality. In this case, the Internet of Things (IoT) emerges as a crucial technology that makes continuous monitoring and control possible. One key benefit of IoT systems is their capacity to provide quantitative data in (almost) real-time with great spatiotemporal resolution.

IoTs are regarded as big data systems because of the quantity, speed, and variety of data that they produce. To better understand the connections between inputs and outcomes, these data are mined and modelled. To arrive at insightful control choices, correlation, trend analysis, categorization, and numerical prediction are used to the data. In contrast to traditional wireless sensor networks, IoT technology's all-encompassing approach enables users to apply data analytics to the massive amounts of data generated by IoT sensor devices. The inputs are typically controlled by associated actuators to achieve specified application rates. For instance, a cloud-based data analysis platform receives data from an internet-connected soil water content (SWC) sensor network, which detects the plant's water deficiency. In order to choose the appropriate timing and amount of irrigation water application, the study will identify the trend of the soil water deficiency [4]–[6].

In the last 20 years, the development of IoT applications for agriculture (Ag-IoT) has exploded, especially in the areas of crop, soil, and microclimate monitoring. However, the commercial implementation of Ag-IoT is still in its infancy. For different stakeholders to sketch the future

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Ag-IoT landscape, a better and more comprehensive knowledge of the growth of the present IoT systems is essential.

As a result, the main goal of this paper is to review the essential AgIoT components, such as sensors, actuators, data processing, and data transmission, summarise how they are used to monitor crops, soil, and microclimates, and pinpoint the research gaps that must be filled before IoT can be successfully implemented in the future.

There are no IoT systems for raising cattle or for other areas of agriculture (such postharvest). The manufacturing sector, consumer goods, retail, finance and marketing, healthcare, transportation and logistics, smart cities, military applications, and supply chains are all areas where IoT is present. The perception layer, network layer, and application layer are the three primary levels of a general Internet of Things architecture. The gateways, mobile devices, sensors, actuators, power, and energy storage components make up the perception layer.

Sensing, controlling, actuation, energy harvesting, energy storage, data transmission, and power management are tasks carried out on the perception layer. The Ag-perception IoT's layer must overcome obstacles including severe climatic conditions, heterogeneity of the applications, unavailability of connectivity infrastructure, and a lack of constant power sources, to name a few. The perception layer of Ag-IoT is consequently highlighted in this research. The network layer comprises of network components as well as data processing and transmission capabilities. Data storage, processing, and decision-making are all handled by the application layer, along with user-specific apps like dashboards for actuator control and data visualisation. By adding a transport layer after the network layer and a business layer after the application layer, the three-layer IoT architecture may be increased to five levels. While the business layer handles the whole IoT system in accordance with the user's business model, the transport layer is in charge of data transfer.

Comparing Ag-IoT applications to IoT applications in other sectors, these issues are distinct. The issues that are most crucial for academics and developers working on Ag-IoT systems are briefly covered in this section. Ag-IoT difficulties may be broadly divided into three categories: technological difficulties, sectoral difficulties, and commercial difficulties.

Technical difficulties are caused by the limitations of technological progress. They would probably be successfully handled as tools and technology develop through time. The three levels of the IoT architecture—the perception layer, the network layer, and the application layer—are examined in relation to the Ag-IoT technological problems.

The perception layer of ag-IoT systems has particular difficulties due to the demands it must fulfil during crop and environmental monitoring in challenging conditions. b. The infrastructure for energy and communications is insufficient on agricultural fields. Using wired power and communication channels to link IoT nodes in the field is neither practicable nor economical. Therefore, the Ag-IoT perception layer has significant issues relating to power management, device lifetime, and ergonomic design.

Ag-IoT node-level power production, techniques for lowering energy use, and energy storage are all included in power management, internet coverage, standard interception, interference, propagation losses, communication range, wireless connection quality, network growth, network administration, communication protocols, latency, and throughput are the most frequent Ag-IoT network layer concerns.

It is very difficult to connect farms to the internet since the majority of farms are situated in rural, isolated, or mountainous areas, where there is little internet infrastructure. Making a local network, which is analogous to a hybrid cloud, might be one approach. Despite not having an internet connection, this kind of architecture nonetheless enables local servers to carry out the fundamental IoT functions. Internet communication through satellite may soon be available because to recent advancements in low earth orbit (LEO) satellites.

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CHAPTER 7

INTRODUCTION TO PREDICTIVE ANALYSIS

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Predictive analytics uses methods from data mining, statistics, machine learning, mathematical modelling, and artificial intelligence to make future predictions about unknowable occurrences. It creates forecasts using historical data. Predictive analytics are a common tool that we utilise without much thinking. For instance, forecasting the sales of a product (let's say flowers) on a certain day in a market There would be a lot more rose sales if it were Valentine's Day! It seems obvious that flower sales would be greater on special days than on everyday days [1]–[3].

To anticipate the future, predictive analytics seeks to identify the contributing elements, collects data, and applies machine learning, data mining, predictive modelling, and other analytical approaches. Insights from the data include patterns and relationships between several aspects that may not have been understood in the past. Finding such hidden ideas is more valuable than you may realise. Predictive analytics are used by businesses to improve their operations and achieve their goals. Predictive analytics may make use of both structured and unstructured data insights.

The principal electrical energy-consuming systems in modern industry are the driving systems. What's more, three-phase squirrel-cage induction motors find more use in centrifugal pumps, milling machines, and lathe machines because to their affordability and durability. Induction motors are a desirable option to alternatives because to their high torque to volume ratio, minimal maintenance costs, and great efficiency. Several criteria outlined by national and international standards governing performance parameters, including as starting torque, peak torque, and minimum rated efficiency, must be met by induction motors designated for general use [4]–[6].

As a result, the scenario requires that induction motor operating be as efficient since feasible, as this would result in large energy savings. Despite all the standards requirements for various performance parameters, research is primarily focused on creating alternative techniques to forecast (i) efficiency, (ii) torque, and (iii) rotor speed. The calculation of torque and speed is mainly designed for the application of control techniques to guarantee a quick transient behaviour, even if efficiency is important for operating at steady state.

Numerous studies have focused on the measurement of torque and speed since these machine properties are crucial. Attempts are made to gather data and analyse it in this study. The performance is determined using the well-known circuit for a squirrel-cage equivalent. Torque, speed, and slip are three objective functions that are analysed and predicted using the genetic algorithm. This comprises of nonlinear regressions, and "Scikit-learn" is used to analyse the data. Pandas, Numpy, and Matplotlib are used to visualise data while imposing induction motor characteristics and motor performance. Results from computer simulations are provided to illustrate the prediction.

This study suggests a "LKPCA-RNN" model for learning analytics and educational data mining to predict student performance automatically (LA). One of the most important study topics in the fields of educational data mining (EDM) and learning analytics in recent years has been the evaluation of student performance (LA). Educational institutions have been using EDM and LA techniques to forecast student performance, which enables these institutions to support students in improving their academic performance, allows instructors and decision-makers to monitor individual students, identify students at risk, and take prompt action. EDM and LA have been used by several researches to forecast student performance, engagement, and at-risk of dropping out or retention. The researchers are motivated to create forecasting models that can predict student performance reliably and effectively by taking into account the importance of prediction of student performance in today's educational environment.

The categorization of the student's performance in the suggested LKPCA-RNN model uses a hybridization of the optimization and deep learning technique. The "Open University Learning Analytics Dataset" (OULA) was utilised as the dataset for the proposed research project and was developed using MATLAB. First and foremost, the data is saved in the MATLAB environment after being submitted to the backend. The data is prepared for feature extraction when uploading is complete. Following the feature extraction, the training procedure's instance selection is carried out and assessed.

KPCA is utilised in this research project to extract the feature vector. Following feature vector extraction, it is optimised via instance selection, which is carried out using weights, the Gini index, and information gain. To extract the relevant examples from the data, instance selection is helpful. Following the feature extraction and instance selection steps, an RNN deep learning classifier is used to train the network, allowing it to learn the technique and provide an optimum model. The test phase, which concludes the process, is when the test data (unknown data) is uploaded and the operations that result in the prediction are carried out. The model's accuracy is increased by the accurate predictions. The student's performance is evaluated using pass and fail ratings. Utilizing the performance measures of sensitivity, specificity, accuracy, and the F-measure, the suggested model's performance is assessed. The suggested method has obtained 91.22% accuracy.

In order to compare the performance of the proposed LKPCA-RNN Model for predicting student performance, performance measures such as accuracy, specificity, sensitivity, and F-measure were used. It has been shown that the suggested LKPCA-RNN model has accuracy that is 10.84% greater than NN and 13.74% higher than k-NN. When compared to NN and k-NN, the specificity is increased by 3.3% and 13.3%, respectively. When compared to NN and k-NN, the suggested LKPCA-RNN model's sensitivity rose by 14.1% and 13.1%, respectively. When compared to NN, the suggested model's Fmeasure shows an increase of 9.6%, and when compared to k-NN, it shows an increase of 12.6%. The comparative performance study clearly shows that the suggested LKPCA-RNN model performs better than the k-NN and NN.

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CHAPTER 8

MACHINE LEARNING FOR ENERGY PREDICTION

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Building energy use has a long-term influence on both costs and the environment. Building utility metres provide an increasing amount of energy data, and this data is essential for sustainability and energy budgeting. By putting in place different energy conservation measures, the majority of businesses strive to lower energy use and expenditures. This is crucial for two key objectives:

(1) Lowering costs

(2) Lowering carbon emissions for the environment.

Energy data should be thoroughly studied in order to conserve energy, and actions should be done in light of the conclusions drawn from the analysis. Basic statistical methods, however, are no longer adequate to assess energy use and provide insightful results. Ideally, cutting-edge applications or more sophisticated strategies like Artificial Intelligence and Machine Learning approaches exist. Machine learning is a subfield of artificial intelligence (AI) that aims to create software that, without being explicitly coded, learns from data over time and improves its accuracy. That indicates that AI does not need a person to provide insights since it learns from data by evaluating it [1]–[3].

Recent research have shown the versatility of AI and ML across a range of dataset types and application areas. Machine learning has several uses, one of which is forecasting, or simply predicting future values. In light of these research, it is now feasible to forecast future energy usage, which has significant budgetary and energy-saving potential. For energy forecasting, machine learning is a crucial tool. Over the last ten years, machine learning algorithms' accuracy has increased with the growth of digitization and computer power. The chapter discusses machine learning in general, along with time series, neural networks, and recurrent neural networks.

Forecasting's underlying presumption is that the future will follow some kind of pattern or distribution that is related to the past. Accurate projections depend on finding hidden patterns or information in past data. The development of machine learning and artificial intelligence (AI) technology unquestionably helps to enhance energy forecasting. In reality, for more than 30 years, AI/ML algorithms have been used for energy forecasting. The development of computer technologies has been a major factor in the current excitement around the field of AI/ML [4]–[6]. Several cutting-edge AI/ML approaches, including deep learning, reinforcement learning, and transfer learning, have been used into energy forecasting.

Deep learning has the drawback of requiring a much longer and more sophisticated training procedure than regression models. The optimization of the hyper-parameters is also a factor in addition to the sheer quantity of parameters (weights) to estimate (network structure, activation functions, stopping conditions,regularization, etc.). Applications of deep learning methods depend on the ongoing expansion of computational power and data storage. It should be underlined that machine learning-based methods for load, wind, solar, and price forecasting may benefit by integrating the physical features of the associated processes, both for modelling and variable selection. Utilizing exogenous data does not only include adding raw meteorological data to machine learning algorithms. The inherent traits, significant aspects, and limits of this data should instead be investigated in more detail.

Machine learning is the study of and development of techniques, models, and algorithms that utilise data to enhance performance of certain activities. It typically has something to do with artificial intelligence. Models are often created using machine learning algorithms using example data. As training data, this is. The models aren't specifically trained to learn a task, so to speak. As digitalization has grown, so have the applications for machine learning. It is used in voice recognition, email filtering, and computer vision. In these areas, using traditional algorithms is challenging. Artificial intelligence is thought of as a subset of machine learning.

There are many different subsets of machine learning, including computational analysis, data mining, neural networks, predictive analysis, etc. Algorithms primarily function on the assumption that historical tactics, formulas, and conclusions that have proven successful in the past will continue to do so in the future. The implications may be evident, as in the case of the sun rising in the east every morning for the last 10,000 days or the planting of wheat seeds producing wheat harvests for 100 years, among other examples. Additionally, they may be complex, e.g., X% of families have geographically distinct species with colour variations, therefore there is a Y% probability that unknown black swans exist, X% have significant resistance to a certain illness but Y% are not robust to the same disease, etc.

A crucial stage in machine learning is model training utilising data. One strategy is to designate a proper response in regions where the greatest number of possible solutions exist. For the computer to learn from and become better at finding the right answer, this will be utilised as training data. The capacity of a machine learning algorithm to execute correctly on fresh, untried cases after having learned from a data collection is known as generalisation. In order to deliver reliable results, the learner must construct a generic model of this space. Such training examples may originate from unknown probability distributions.

The performance of machine learning algorithms is evaluated by computational learning theory, a part of theoretical computer science, using the Probably Approximately Correct Learning (PAC) model. The performance of the algorithms cannot be guaranteed by learning theory since training sets are limited and the future is unpredictable. For optimal generalisation performance, the complexity of the hypothesis should coincide with the complexity of the underlying function. When the function is more complicated than the hypothesis, the model has underfitted the data. The training error lowers if the model's complexity is raised in response. However, if the hypothesis is very complicated, the model is vulnerable to overfitting, and generalisation will be less successful.

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CHAPTER 9

COMPARISON OF DIFFERENT ENERY FORECAST APPROACHES

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Although there is a tonne of research, such as the ones above, discussing various building energy forecast methods, there is very little material that compares more than two or three algorithms in order to establish which the best is. We may profit from such literature that establishes a solid comparison principle since this thesis will compare two techniques. Examples of this kind of investigation include. Several techniques are compared, which roughly categorises them as sophisticated or simple engineering methods, statistical methods, and artificial intelligence methods [1]–[3].

Complex engineering procedures call for a lot of data that may not be easily accessible to the consumers. These approaches often demand information on the structure of each and every room in a big building, as well as information about the space conditioning. This implies that putting this strategy into practise will take a lot of time and work. Simulation modelling is the primary approach used in engineering. However, there is a problem with simulation modelling. To the greatest extent feasible, input calibration must mirror the real-time energy behaviour of buildings. After several calibration stages, energy models exhibit remarkable accuracy. However, calibrating takes a lot of time and might be tiresome for the user. This chapter has already covered a number of literatures that illustrate the use of regression energy modelling. Regression uses a model that has been trained using previous data to forecast the future. There must be enough historical data collected before the model can be trained. Regression is severely degraded in these situations since energy consumption patterns may constantly show abnormalities that may not have occurred in the past [4]–[6].

Neural networks are an efficient method for applications with complex data structures and are excellent for tackling non-linear issues. When seeking to understand or enhance sub-level components and associated 22 behaviour, neural networks may be very helpful. In the last ten years, they have been utilised to analyse HVAC systems. Additionally, it was shown that neural networks were excellent choices when there was significant variation from the mean in the yearly energy usage.

In situations where the user is unaware of the mathematical connection between a number of variables, neural networks may be employed. Less extensive previous information recommends using neural networks. However, utilising neural networks has the drawback of not describing the model as effectively as a regression model would. For instance, the link may be determined using the p-values of the various variables in the regression analysis. However, neural networks only produce what is predicted in response to the relevant input. As a result, neural networks are more often utilised as classifiers than as regressors.

SVMs are best suited for resolving non-linear connections with little available data on which to train the model. It has been shown that SVMs can operate well on annual and monthly building energy. SVMs performed the best of all available prediction algorithms when it came to predicting the yearly energy consumption of buildings and may thus be used to forecast data of that kind. Similar to regression modelling, SVMs have drawbacks in that demonstrating a link does not prove causation.

One of the best machine learning methods for classification and regression is the support vector machine (SVM), which is based on a variety of statistical learning theories. When SVM results are compared to those of other strong data-driven empirical techniques like RBF, IIR-LRNN, ARIMA, and MLP, they outperform or are on par with those provided by other learning machines.

Support vector machines, which are motivated by geometric interpretation, use kernel functions to optimise margin discrimination. These two studies demonstrate the emergence of a trend in which machine learning is used to forecast various aspects of the energy industry, such as power usage. To calculate the amount of energy used by a building, one combines machine learning and deep learning. The other forecasts how much electricity will be used by both residential and commercial buildings using deep recurrent neural networks. Support Vector Regression (SVR) is used to forecast how long it will take to go a distance, and the outcome is contrasted with actual road traffic data. Although some claim that Support Vector Machines (SVM) provide higher generalizability and guarantee a global minimum for a specific training set, Support Vector Machines are regarded to perform well for time series analysis. Hyper-parameter estimation in Support Vector Machines (SVMr) regression is one of the main concerns with this method of solving learning problems. In a range of applications in areas like banking, manufacturing, the internet of things, etc., the most modern techniques have achieved positive outcomes. This topic is well-liked.

Different evolutionary strategies have been investigated to combine with SVMr, but the most often used ones are those that deal with continuous problems, such as evolutionary algorithms or particle swarm optimization. There is a yearly rise in the demand for electricity. When it comes to the electrical load sector, households and commercial buildings account for 30% to 40% of the total energy demand in industrialised countries, but this would not be the case if alternative energy sources were not readily available. The energy crisis is thus plausible. In recent years, research has focused on developing future power networks with intelligent technology to meet people's needs.

A straightforward set of rules has been used in the past to segment data using decision trees. The goal of segmentation is to break the dataset up into more manageable parts so that more effective prediction models may be created for each subset. Chi-squared automatic interaction detection (CHAID), classification, and regression trees are the techniques employed in decision trees most often (CART). The main benefit of decision trees is that they offer answers based on reasoning that is simple to comprehend. Therefore, it is feasible to explain to plant staff how the prediction method works. The primary one among decision trees' 23 drawbacks is that they struggle with non-linear data. Because of the dataset's noise, they are more prone to mistakes. Random forests are often better at predicting categorical variables.

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CHAPTER 10

FUTURE OF AI IN ENERGY PREDICTION

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The fourth industrial revolution (4IR) is a time when disruptive technologies are continually erasing physical, digital, and biological borders around the planet. Every business and sector is seeing a transformation thanks to these sophisticated technologies, which are also breaking through previously unthinkable barriers. Technology is driving the changes in the globe. Artificial intelligence (AI) is one of the key forces behind the fourth industrial revolution. AI is the programming of clever, perceptive robots that use real-time data to carry out activities and solve issues with a minimum of human participation. In every industry, advances in AI are upending conventional methods, and the energy sector is no exception [1]–[3].

Energy industry AI-driven solutions

There is no denying that AI has had a significant influence on several industries, especially the energy industry. To improve energy efficiency and provide original solutions to sector challenges, businesses are starting to incorporate AI technologies into the energy industry. Governments throughout the world are starting to invest in the potential of incorporating AI into their energy businesses. The Knowledge and Innovation Covenant (KIC), for instance, was created by the Dutch government to invest in Dutch businesses and focuses on critical enabling technologies like the use of AI in the energy transition. The Hague, the administrative centre of the Netherlands, in particular, is quickly becoming into a global hub for "new energy" operations, with AI unmistakably at the heart of this objective.

Because of the sharp increase in global awareness of the need for a more sustainable future, demand for renewable energy has been expanding rapidly. Additionally, as public awareness of climate change has grown, several governments have pushed for efforts to promote more sustainable activities. Numerous countries have promoted sustainable programmes, and climate change awareness has also grown. These two factors have caused a spike in the production of renewable energy, and adopting more sustainable techniques has been high on the agenda. This is particularly evident in developed nations with the largest amount of renewable energy, such as Germany, the United Kingdom, Sweden, Spain, Italy, Brazil, etc [4]–[6].

However, even if you are not in these nations, seeing solar panels and wind turbines shouldn't surprise you since their use is now commonplace worldwide. The concept of renewable energy also has certain drawbacks, which the energy industry has identified as one of its top objectives for solving. Primarily, how to strike a balance between energy production and consumption achieving systemic supply and demand balance. Why have energy use and production grown to be so crucial? To be more specific, because of the nature of energy itself, balancing supply and demand has always been and will continue to be a top issue for the industry.

Unfortunately, unlike other commodities, energy is very costly to store in big amounts. Therefore, maintaining a balance between its creation and usage has always been important. Finding the right balance between the two is crucial for anybody who depends on energy, but it is particularly relevant for:

The Balance Responsible Parties (BRPs) are market participants who are in responsible of balancing power supply and demand as well as organising the day-to-day operations of the electrical network administrators. Let's look at the energy trading procedure to completely comprehend how the energy market works.

Energy Market

The energy market is a system in which several people sell and purchase electricity at competitive prices like a market for various items. In an ideal world, the market offers affordable, dependable power to customers. However, the market is subject to a few restrictions.

Capacity Market (CM)

A system known as the capacity market ensures payment to power plants for capacity, or energy that will be provided in the future.

To make this clear, let's look at an example. When a client requests 100 megawatts of power from a provider but only uses 70, the customer is still responsible for paying the supplier for the remaining 30 megawatts.

What causes this? This agreement makes sure that customers don't take advantage of the system or request excessive amounts of power "just in case." The market is balanced and guarantees that consumers order the precise quantity required so that providers do not create superfluous quantities of power, which would result in a loss of revenue for them.

Energy traders may purchase or sell power on the day-ahead market one day prior to the operational day. By using this method, buyers and sellers may negotiate and fix prices a day in advance while avoiding price fluctuation.

Day-to-Day Market

In the intraday market, as opposed to the day-ahead market, negotiations take place at energy exchange rates that are in effect for the same day as energy delivery.

There is no reciprocal exclusivity in relation to these two markets. The intraday market often collaborates with the day-ahead market to maintain the essential equilibrium between power supply and demand. As it is a last-minute order, the prices on the intraday market are much higher. By examining the aforementioned circumstances, it is obvious that forecasting energy demand and production is essential for the efficient management of supply and demand from all market players.

With the use of various techniques, artificial intelligence has been able to close this knowledge gap.

The time series, which is a collection of data in chronological order, is used to predict future events using observational data. In our situation, the time series is crucial for the forecasting of the capacity for power production based on meteorological data. We can predict what the potential power output of renewable energy devices is by looking at previous climatic data relating to humidity, wind speed and direction, cloud cover, sun irradiance, etc. As consumption tends to fluctuate throughout these times, time series are also used to forecast what the electrical demand would be dependent on the particular time period, such as weekends, holidays, weekdays, etc.

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CHAPTER 11

COMPONENTS OF ENERGY SAVING SYSTEM-PART I

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A component is a structurally distinct element of any system. It serves some purpose and could need input or give out output. Conceptual abstractions known as Electrical Elements serve to depict idealised electrical components [1]–[3].

Need for hardware

1. Power Source
2. LCD Display
3. Arudino UNO
4. IR Sensor
5. I2C Module
6. DHT 11
7. A power metre

8 AC Dimmer

9. Relays

Power source

A power supply is a kind of electrical equipment used to provide electricity to an electrical load. Converting electric current from a source to the proper voltage, current, and frequency to power the load is the primary function of a power supply. Power supplies are hence also referred to as electric power converters. Power supplies come in a variety of forms. Some are independent standalone devices, while others are integrated into the load appliances they power. Instances of the latter include the power supply used in consumer gadgets and desktop computers. Other tasks that power supplies may carry out include setting a safe limit on the current that the load can draw, cutting off the current in the event of an electrical fault, power conditioning to keep electronic noise or voltage surges from the input from reaching the load, power-factor correction, and energy storage so that it can keep the load powered even if the source power is temporarily interrupted. Power supply spans from 100 to 240 volts, and the most common frequencies are 50 and 60 hertz [4]–[6].

Liquid-crystal display (LCD)

A liquid-crystal display (LCD) is a flat-panel display or other electronically controlled optical device that employs polarizers in conjunction with liquid crystals to change the wavelength of light. Liquid crystal displays don't directly generate light; instead, they create pictures in either colour or monochrome via a backlight or reflector or both. There are LCDs that can show fixed pictures with little information content that may be seen or concealed, or arbitrary graphics (as on a general-purpose computer display). Preset words, numbers, and seven-segment displays, such those seen in digital clocks, are a few examples of devices that use these displays (Table 1).

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Table 1: Pin Descriptions

Sl.	Pin No.	Pin Name	Pin Type	Pin Description	Pin Connection
1	Pin 1	Ground	Source Pin	This is a ground pin of LCD.	Connected to the ground of the MCU/Power source.
2	Pin 2	VCC	Source Pin	This is the supply of the voltage pin.	Connected to the supply pin of the Power source.
3	Pin 3	V0/VEE	Control Pin	Adjust the contrast of the LCD.	Connected to the variable POT that can source 0-5V.
4	Pin 4	Register select	Control Pin	Toggles between command or data	Connected to aMCU pin and gets either 0 or 1.
5	Pin 5	Read/Write	Control Pin	Toggles the LCD between Read/Write Operation.	Connected to a MCU Pin and gets either 0 or 1
6	Pin 6	Enable	Control pin	Must be held high to perform Read/Write operation.	Connected to MCU and always held high.
7	Pin 7	Data Bits (0-7)	Data/command pin	Pin used to send command or data to LCD.	In 4 wire mode only 4 pins (0-3) is connected to the MCU, in 8 wire mode all 8 pins (0-7) are connected to MCU.
8	Pin 15	LED positive	LED pin	Normal LED like the operations to illuminate the LED.	Connected to +5V
9	Pin 16	LED negative	LED pin	Normal LED like the lilluminate the LCD connected with GND.	Connected to theground.

Arduino UNO

A microcontroller is a tiny computer that does a pre-programmed job and is constructed from a single coordinated circuit with a processor at its core, a memory chip, and programmable information peripherals. With ATmega328P, the Arduino Uno is the one we used. The device has 14 digital pins, 6 analogue pins, and can be programmed using the Arduino IDE. An external 9 volt battery or a USB cable linked to a computer may power an Arduino board. The ATmega328P has a bootloader that is pre-programmed and enables straightforward code dumping without the need for external discs, unlike the 8051 microprocessors. As a result, it is an efficient microcontroller for creating intricate circuits and carrying out demanding tasks.

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CHAPTER 12

COMPONENTS OF ENERGY SAVING SYSTEM-PART II

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ADRIANO PWM PINS

GPIO pins on the development board total 14. On the other hand, only six of them contain pulse width modulation. PWM output is available on pins 5, 6, 9, 10, and 11. The resolution for each of them is 8 bits [1]–[3].

ARUDINO UNO'S MEMORIES

The program's picture as well as any initialised data are stored in flash memory. Flash memory allows for the execution of computer code, but it does not allow for the modification of data stored there. It must first be transferred into SRAM before the data can be modified [4]–[6]. SD cards and thumb drives both use the same flash memory technology. Your software will remain in place even if the system is turned off since it is non-volatile. With regard to 100,000 write cycles, flash memory has a limited lifespan. Therefore, if you upload 10 apps every day for the next 27 years, you risk wearing it out.

A programme that is running may read from and write to a 2 KB SRAM, also known as static random-access memory. A running software uses SRAM memory for a number of things. The global and static variables from your application are all stored in a block of SRAM memory called "static data." The initial value for variables having initial values is copied from Flash when the application first launches by the runtime system. Data objects that are dynamically allocated are stored in the heap. As data pieces are allocated, the heap climbs upward from the static data area's top.

Local variables, interrupts, and function calls are stored on the stack, which is also used to store data. From memory's highest point down to the heap, the stack expands. The stack increases with each interruption, call to a function, and/or allocation of a local variable. All stack space used by an interrupt or function call is released upon returning from that call. When the stack and the heap intersect, memory issues often arise. This will result in the corruption of either one or both of these memory regions, with unexpected consequences. It may sometimes result in a crash that happens right away. In other cases, the corruption's consequences may not become apparent for a while.

EPROM KB

Another non-volatile memory type that may be read from or written to by a programme that is currently running is EEPROM. It may be a bit difficult to use as it can only be read byte-by-byte. It has a limited lifespan of roughly 100,000 write cycles, is slower than SRAM, and is also more expensive (you can read it as many times as you want).

Key Features:

1. A 16 MHz crystal oscillator.

2. The operating voltage is 5 V and may be supplied by a USB port or an external converter.

3. Support for a removable micro-SD card

4. This board has a built-in voltage regulation mechanism that regulates voltage when it is linked to other external devices. This feature protects the board from harm by maintaining voltage under control.

5. Simple USB interface, which enables immediate usage of your device after plugging it into the port. The benefit of using a virtual serial port on your computer to communicate with your board is that this interface is also utilised for that purpose.

6. It is fast enough for the majority of applications at 16 MHz frequency.

7. An onboard LED that allows for quick and simple code debugging.

If our project's functionality or nature becomes complicated, Micro SD cards may be utilised.

IR SENSOR

With wavelengths longer than those of visible light, infrared (IR), often known as infrared light, is electromagnetic radiation (EMR). As a result, the human eye cannot see it. The wavelength range of infrared radiation is often thought to range from about 1 millimetre (300 GHz) to the notional red edge of the visible spectrum, which is around 700 nanometers (430 THz). - a spectrum of radiation that is a portion of the terahertz range. Nearly all of an object's near-room-temperature black-body radiation is infrared. With characteristics similar to both those of a wave and a particle, the photon, infrared radiation (IR) propagates energy and motion. It has long been known that flames produce intangible heat; yet, Edme Mariotte, a pioneering researcher, demonstrated in 1681 that radiant heat could pass through glass while remaining transparent to sunlight. By observing the impact of infrared radiation on a thermometer, the astronomer Sir William Herschel in 1800 found that infrared radiation is a form of invisible radiation in the spectrum with a lower energy than red light. It was subsequently discovered via Herschel's research that slightly more than half of the energy from the Sun arrived on Earth as infrared. The balance of infrared radiation that is absorbed vs that that is released significantly influences the temperature of the planet.

I2C MODULE

The I2C (Inter-Integrated Circuit), sometimes spelled I2C or IIC, is a synchronous, multi-controller/multi-target (controller/target), packet switched, single-ended, serial communication bus developed by Philips Semiconductors in 1982. For short-range, intra-board communication, it is often used to connect slower peripheral ICs to CPUs and microcontrollers.

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CHAPTER 13

COMPONENTS OF ENERGY SAVING SYSTEM-PART III

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DHT11

The DHT11 is a simple, very affordable digital temperature and humidity sensor. It measures the ambient air using a capacitive humidity sensor and a thermistor and outputs a digital signal on the data pin (no analogue input pins needed) [1]–[3]. DHT11 temperature sensor, seen in Figure 1 below.

Figure 1: Represent the DHT11 Digital temperature and humidity sensor

ENERGY METER

When a deeper examination of the obtained data is not necessary, an energy metre is one of the most practical and straightforward tools for measuring electrical power. The most significant power results are derived by measuring the voltage (V) and current (A).

AC DIMMER

Dimmer simulation outcomes the dimmer's goal was to optimise voltage at various lighting settings. The dimmer, an optoisolator, was linked to the sine wave generator of 50Hz 480V peak to peak as the input signal (same as ZCD input) and then its output to an interactive lamp in order to control lighting levels. The input signal was also delayed when the LCD was changed in accordance with the predetermined programme guidelines. The waveforms at the dimmer's two main terminals and the anode nodes were seen using the oscilloscope. There was no delay when the light level was below 250 lux, and the waveforms at the two main terminals were identical [4]–[6].

DUAL CHANNEL RELAY

Relays can be easily integrated into a project run by a micro controller thanks to the dual-channel relay module's inclusion of switching relays and the necessary driving circuits. Two terminal blocks are located on the left and are used to connect mains wires to the module without soldering. when we want to utilise an Arduino to control ac-powered objects like lights, fans, or other household objects. However, since the Arduino only runs at 5 volts, it cannot directly control these higher voltage devices (Table 1).

Table. 1: Dual Channel Relays Module PIN Out description.

Pin Number	Pin Name	Description
1	JD-Vcc	Input for isolated power supply for relay coils
2	Vcc	Input for directly powering the relay cells
3	GND	Input ground reference
4	GND	Input ground reference
5	IN1	Input to activate the first relay
6	IN2	Input to activate the second relay
7	Vcc	Vcc to power the optocouplers, coil drivers

A NEED FOR SOFTWARE

- Compiler for Arduino IDE
- Embedded C

The Arduino IDE compiler

For authoring, compiling, and uploading code to practically all Arduino Modules, Arduino.cc created the open-source Arduino IDE programme. The code compilation process is so simple thanks to the standard Arduino software that even a layperson with no previous technical understanding can get started. Each of them has a micro controller built into the board that can be programmed and takes data in the form of code. The primary code, often referred to as a sketch, written on the IDE platform eventually produces a Hex File, which is transported to and uploaded into the controller on the board. The Editor and Compiler are the two primary components of the IDE environment. The Editor is used to write the necessary code, while the Compiler is used to compile and upload the code into the designated Arduino Module. The languages C and C++ are supported in this environment.

EMBEDDED C

The most widely used programming language in the software industry for creating electrical devices is embedded C. Embedded software is connected to each processor utilised in an electronic system. The processor's ability to carry out certain tasks depends heavily on embedded C code. Everyday items like a cell phone, washing machine, digital camera, etc. are all electrical equipment that we use. All of these devices run on microcontrollers that are coded in embedded C.

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