Readers Shelf

VOLUME No. :21	ISSUE NO: 06	March 2025
No. of Pages in this issue		32 pages
Date of Posting: 10-11 at RMS, Jodhpur		

Editorial Office

J.V. Publishing House, 15, Gajendra Nagar, Near Old FCI Godown, Shobhawaton Ki Dhani, Pal Road, Jodhpur-5

Website: www.readersshelf.com

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Typesetting: Ankita, Jodhpur

Printed by: Manish Kumar, ManakOffset, Jodhpur

Published by

Smt. Neeta Vyas

For J.V. Publishing House, Jodhpur

RNI No.: RAJENG/04/14700

ISSN No.:2321-7405

Subscription Charges: Single Copy: Rs.50.00

Annual Subscription: Individual: Rs.**500.00**

Annual subscription: Institution: Rs.900.00

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Challenges in Rural Marketing

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Introduction

India's rural market concept is still developing, and the industry faces several difficulties. The lack of retail locations and distribution expenses are two of the biggest issues facing marketers. In the rural Indian market, a brand's success is as erratic as the weather. Numerous brands that ought to have succeeded have utterly failed. This is due to the fact that most businesses attempt to adapt their urban marketing strategies to rural markets. At the product planning stage, the distinct demands, preferences, and consumption patterns of rural consumers should be examined to ensure that they are met (Mohammad and Syed, 2013). However, there are relatively few examples of comprehending the rural 'mindset' and simply the 'practice' of rural marketing. Assumptions, generalizations and stereotypes replace insights and the extra effort is needed to 'think rural'. Rural marketing is marketing to a rural 'mindset'; not a rural market (Rafiuddin and Ahmed, 2011).

Addressing the rural markets, presents a number of complications for businesses, some of the most important of which are understanding rural consumers, delivering goods and services to isolated rural areas and interacting with wildly diverse rural audiences. Unfortunately, not many businesses have spent enough time in the field and money on research to fully understand rural consumer's requirements, beliefs, goals and usage patterns. The main goal of marketing is "getting to know your customer", yet most businesses in rural areas have failed to achieve success because they have mostly disregarded this fundamental idea (Kumar and Naruka, 2015).

India is a nation with many different languages, customs, and civilisations. Because of these conditions, it is now difficult for manufacturers to tailor their products to the Indian market (Ashu, 2015). The source of income, the frequency of income receipt, the seasonality of income, and consumption are the most important socioeconomic aspects that determine the differences between rural and urban markets. Small, non-contiguous settlement units of villages, rural marketplaces have comparatively few infrastructure amenities, a low population density, and distinct lifestyles. Farmers who rely on the whims of nature for their income constitute the majority of rural customers (Kaur, 2015; Meenakshi and Takkar, 2015; Nisha, 2016).

Challenges in Rural Marketing

The most common factors, which the marketers of different sectors are facing in marketing their products/services in rural markets, are as follows (Jain and Saini, 2012; Arora, 2015; Meenakshi and Takkar, 2015):

1. **Seasonal demand**: Since agriculture is the primary source of income in rural markets, demand for commodities is influenced by agricultural conditions. Since agriculture is heavily reliant on the monsoon, demand and purchasing power are neither consistent or stable.
2. **Transportation**: Market accessibility is reduced in rural India due to inadequate transportation infrastructure. Rail travel does not connect many remote locations. During the monsoon, *Kacchha* routes become impassable, and settlements in the interior get cut off. Other issues include the lack of bus or truck services in rural areas as a result of inadequate road construction.
3. **Warehousing**: Storage facilities are needed to fill the gap between production and consumption. Rural areas lack adequate storage infrastructure to fulfil seasonal demands. Proper storage is necessary to safeguard grains against insects, pests, and birds. Therefore, one of the biggest obstacles facing marketers in rural areas is the absence

of sufficient and scientific storage facilities.

4. **Communication issues**: There are several barriers to marketing communication in rural markets. It is caused by a number of causes, including economic backwardness, traditional practices, and low literacy rates. Despite this, there is still another issue, which is that the languages differ from one state and location to another. There is no common language in rural markets. Due to this, the rural consumer, unlike urban consumer do not get exposure to new products. Moreover, lack of proper physical communication facilities like telephone, fax and telegram are poor in rural areas.
5. **Traditional life**: The village system itself causes issues in India. Rural communities are still dominated by antiquated traditions and conventions, and people there are slow to embrace contemporary technology. Additionally, the rural markets are widely dispersed, which makes distribution calls more frequent and makes it more difficult to reach rural customers.
6. **Purchasing decisions**: Rural consumers take their time and are cautious when making purchases. They prefer to try things first, and they only purchase a product once they are personally happy.
7. **Access to suitable media:** In rural households, formal media reach is limited. Modern communication facilities are available to only 30% of rural populations. According to an old survey, only 18% of Indians living in rural areas are exposed to print media. Although television is a common communication tool in rural areas, the lack of electricity prevents the rural population from benefiting from it. Data transmission to villages is being developed, but it is a gradual process that hinders the significant expansion of rural marketplaces. In rural locations, the market must thus engage in certain sales promotion activities, such as attending fairs, melas, or haats.
8. **Cultural factors**: A system of common values, ideas, and perceptions that shape consumer behaviour is called culture. Every group has an impact on how people behave in villages, and these groups vary according to factors including religion, caste, occupation, income, age, education, and politics.
9. **Others factors**: Additional factors include natural disasters and market conditions (price, supply, and demand); pests and diseases; drought or excessive precipitation; outdated farming practices; inadequate storage facilities that expose grain to rats and rain; market intelligence (villagers are informed of current market prices); a lengthy chain of middlemen (many middlemen between growers and consumers; wholesalers and retailers); and basic practices (market dealers and commission agents receive a good portion of sale of receipts).

Conclusion

Rural marketing is essential to the growth of the national economy. Although there is no denying the complexity of the Indian rural economy, we must acknowledge some basic facts. Rural customers are extremely cost-conscious. If concentrated, they can influence the company's growth even though they might not have purchasing power. The purchasing power of rural areas increases exponentially with a slight rise in income. Businesses have a chance to swarm into rural areas thanks to the increasing purchasing power of rural consumers. Since the urban market has a smaller market share than the rural one, businesses will see a gain in sales and market share if they focus on the rural markets. The potential of the rural market is enormous and has not yet been realised. India's rural prosperity is the key to the country's overall prosperity, hence no rural area should be overlooked. Understanding rural market potential in relation to the nation's development priorities and formulating a plan where rural markets and industries play a significant part in the overall growth of the country are at the heart of today's scientific approach. In the end, the person who has the necessary time and financial resources as well as the much-needed creative ideas to reach the rural markets will win. For those who can comprehend the intricacies of rural markets, the future of rural marketing is therefore extremely bright.

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2. AGRICULTURE

Hydroponics: A New, Innovative and Advanced Method for Growing Plants

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Introduction

Hydro refers to water and ponic means "to labor or toil". Thus, Hydroponics means growing plants with the use of water. It is a modern method of growing plants without soil in which nutrient-rich water solutions are used. This is advanced and alternative agricultural technique and has become popular in recent years. It focuses on climate resilience and disease free production of crops. The popularity of hydroponics increased because of its ability to conserve space, water, and increase crop yields. Since hydroponic systems focus on climate resilience so they are used in different environments. Hydroponic systems are used not only by the small farmers but by the hobbyists and large-scale commercial farms too.

How Hydroponics Works

The plants are grown without use of soil and so in hydroponics, instead of soil plants receive a nutrient-rich water solution directly that provides them with the essential elements they need for growth. We see that the plants, for their growth, in traditional farming, depend on soil both for nutrient values they need and for the support. In hydroponics instead of using soil the support and nutrient both are provided by nutrient rich water for consistent growth. The nutrient water solution can include an aggregate substrate or growing media like vermiculite, perlite, coconut coir, gravel etc. The roots are submerged in the nutrient solution which provides proper nutrition and minerals for growth.

Types of Hydroponic Systems

1. **Nutrient Film Technique (NFT):** NFT, which is one of the most common hydroponic systems, involves a thin film of nutrient solution which continuously flows over the roots of the plants. The continuous flow allows the plants to absorb the nutrients efficiently. Under this system, plants are usually grown in slanted troughs or channels. The roots of the plants are suspended in the air with adequate access

to oxygen. As the nutrient solution is to be flown over the roots so a pump is used for the purpose that circulates the nutrient solution. This solution flows over the roots of the plant in a thin film or stream. NFT system is very prevalent among commercial growers and the system is best suited to the light weight plants and fruits like strawberry. However, with additional support to prevent the plants from falling the system may be used for heavier fruit plants too. Although it is the most common hydroponic system yet it requires careful management. Disruption in flow of nutrient or if the nutrient is not properly balanced then the plant may not prosper.

2. Deep Water Culture (DWC): The DWC system is a good system and the method is a perfect model for fast growing plants. Under this system plants are grown in net pots suspended in the air above a tank or a reservoir. The roots of the plant are dangled into the nutrient solution below. An air pump is used to oxygenate the water so that the plants are provided with proper oxygen which they need to develop. The plant roots are, thus, submerged directly in a nutrient-rich oxygenated water solution. The main benefit of this system is that they can be easily installed and set up. Since the method does not require soil so the same can be installed anywhere. Further, the plants are dangled in the air so they are comparatively safe from diseases and pests. DWC methods are used to grow leafy greens, herbs, and lettuces. The methods are not useful for slow-growing plants or anything that flowers.
3. Aeroponics: Under this system the plant roots are suspended in the air. The plant roots are sprayed with a fine mist or droplet of nutrient solution. The system is very efficient. The main benefit of the system is constant exposure to oxygen speeds up the growth of the plants. Thus, the system prompts faster growth by maximizing oxygen intake for the roots and the growth of plants is 3times more as compared to growth of plants in soil. It is also the most water efficient category of hydroponics.
4. Wick System: Under this system a wick is used for carrying water and nutrient from a pond, pool or reservoir (which contains nutrient rich water) to the roots of the plants. The wick may be of cotton, synthetic or natural fibers. One side of the wick is placed in the growing media and the other side is placed in the tank or the reservoir. The system is quite good. It does not require any pump or electricity for circulating water to the plants. The wick absorbs the nutrient rich water from the reservoir and transports the same to the soil when it dries out. This method is useful for smaller plants like herbs, lettuces and leafy greens etc. and is less used for larger crops.
5. Ebb and Flow: This system of hydroponic is also known as Flood and Drain method. The system involves periodic flooding and draining nutrient solution to the plants. It is a flexible system suitable for growing a variety of plants. With the flooding of nutrient solution the plants absorb the nutrients. Such absorption helps the plants to grow. The nutrient rich water is drained back to the tank or reservoir which can be reused.
6. Drip System: Under drip system of hydroponics the nutrient and water are delivered to the roots of the plants with the help of tubes. The pump and a series of tubes are used for transporting water and nutrients. Water is ten delivered to the plants trough emitters. The important fact is that the emitters are small device which release controlled quantum of nutrient rich water for growth of plants. This system is commonly used by commercial growers.

Advantages of Hydroponics

1. Improved Growth: Hydroponics systems result in improved growth of the plants. Faster growth and high yielding are possible due to supply of nutrient rich water in controlled manner with increased oxygen levels in the nutrient solution. Similarly, controlled environment conditions too contribute in growth of the plants. Since plants receive the exact nutrients they require so they tend to grow at a faster pace compared to soil-grown plants.
2. Water Efficiency: Although the

Hydroponics mainly depend on the water to grow plants yet it uses up to 90% less water than plants grown with traditional farming i.e. on the ground or in soil-based farming. This happens because in hydroponics the water immediately reaches to the roots whereas in traditional farming a major percentage of water evaporates and only a proportion of it reaches to the roots. Further the reuse and recycle is possible which make it a highly efficient method.

3. Lesser space need: Hydroponic allows farming in less space. Thus, it is more suitable and ideal for urban areas where limited land is available for farming. The Vertical farming is one of example of that in which stacking multiple layers of plants are done. This multiple layering allows the farmers to maximize space.
4. Elimination of Soil Erosion: In traditional farming, where the soil is the main content for growing plants, soil erosion happens which badly affects the growth of the plants and even the cultivation, itself is adversely affected. Hydroponics, in which the soil is not used, eliminates this problem completely.
5. No use of Herbicides and pesticides: Hydroponic results into pest and Disease Control. As the plants are grown without soil so they are safe from weeds and insects. The need of pesticides and other harmful chemicals is reduced to a great extent.
6. Higher Yield: Hydroponics, as stated, use lesser space. Thus, this system gives more produce in small space which is not possible in case of traditional farming. It is estimated that hydroponics produce more than three to ten times food than conventional farming in the same space. Since lesser space is used for more production so hydroponics has become attractive and interesting option for commercial as well as home growers.
7. Acclimatize to extreme weather conditions: Hydroponic allows the plants to grow in poor or extreme weather conditions and even in harsh environmental conditions the plants can be grown with hydroponic systems. Even with poor soil and bad climatic conditions too growth of the plant is not affected.

Disadvantages

1. Expensive method: The initial cost of set up of hydroponic system is more as compared to traditional farming. Various equipments need to be purchased for set up of this system. However, in long run the system is cost-effective.
2. Technical Knowledge: The bacteria and moulds/fungus can pollute the water which is used in hydroponics. Such contamination may result into disease which can attack the plants. It is therefore required that proper and balanced nutrition is given. Imbalance in nutrition may lead to poor growth of the plant or even the plant may die. Thus, to make the hydroponic farming successful knowledge of plant biology and nutrient management is must. Similarly, various equipments and systems are used to the user should be well versed with the system maintenance otherwise the method will not work properly and the grower may end up with losses.
3. Dependency on electricity: Some hydroponic systems are dependent on power and power failure can disturb the entire hydroponic system. Such disturbance may result in harming the plants and finally loss to the growers.

Uses of Hydroponics

Hydroponic system is very effective. It uses less space, does not use soil, gives higher yield. The future of hydroponic, is therefore, very positive. In urban areas where the arable land is comparatively less the hydroponic system is a boon for such areas. Apart from that there are certain other applications of Hydroponic system which are as under:

- in urban farming;
- for Food security;
- for Research;
- for Educaiton;
- for commercial farming

Future of Hydroponics

The future of hydroponics looks promising since the country is now shifting from traditional farming to sustainable farming practices. It is more than simply a trend. Advancement in technology has improved the efficiency of system, reduced the costs and made it easy for people to adopt this method of farming. Besides, the automation, energy efficient lighting systems, use of censors and other tools, and use of advance technology has made the hydroponics more appealing and attractive. Moreover, the nutrient solutions too are available which has also made the system more accessible. The Government too has taken several initiatives to promote use of hydroponic systems. With these measures and available resources more and more farmers are expected to adopt this system in near future which would certainly increase the food productivity. The higher yield in food produce will in turn reduce dependence of our country on imported food and would increase the food security. According to a report Indian Hydroponic Market has reached USD 1.4 billion in 2022 and is expected to reach to 5.3 billion USD by 2031. The expected CAGR is 17.6% during the forecast period 2024-2031 (reference datamintelligence.com). Similarly, imarc group in its research report gave the projected statistics for the period 2025-2033. According to it Indian Hydroponic market has reached to USD 506.7 million in 2024 and is expected to reach to USD 5393.2 million by 2033 with CAGR of 16.91% (reference imarcgroup.com). Thus, the future of hydroponic system of farming looks very promising in the country.

Conclusion

Hydroponic farming offers great potential to India. It symbolizes an exciting and sustainable future for agriculture. Hydroponic farming allows efficient food production, ability to produce high quality products in lesser space, very efficient working in extreme weather, and above all cost effective in long-run. It can be labeled as essential part for future farming in India to meet demand of food produces with the increasing population. The hydroponic system of farming can be proved to be a worthy farming technique provided right investments are made, proper policies are framed and executed and above all appropriate expert advices are available. This technology can help our country to ensure food security and sustainability.

Five best plants to grow:

- Lettuce;
- Spinach;
- Strawbarries;
- Bell Peppers;
- Herbs

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3. AGRIULTURE

Time Series Analysis and Forecasting- A Statistical Tool

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Introduction

Time series analysis and forecasting are crucial for predicting future trends, behaviors, and behaviours based on historical data. It helps businesses make informed decisions, optimize resources, and mitigate risks by anticipating market demand, sales fluctuations, stock prices, and more. Additionally, it aids in planning, budgeting, and strategizing across various domains such as finance, economics, healthcare, climate science, and resource management, driving efficiency and competitiveness.

What is a Time Series?

A time series is a sequence of data points collected, recorded, or measured at successive, evenly-spaced time intervals.

Each data point represents observations or measurements taken over time, such as stock prices, temperature readings, or sales figures. Time series data is commonly represented graphically with time on the horizontal axis and the variable of interest on the vertical axis, allowing analysts to identify trends, patterns, and changes over time.

Time series data is often represented graphically as a line plot, with time depicted on the horizontal x-axis and the variable's values displayed on the vertical y-axis. This graphical representation facilitates the visualization of trends, patterns, and fluctuations in the variable over time, aiding in the analysis and interpretation of the data.

Importance of Time Series Analysis

Predict Future Trends: Time series analysis enables the prediction of future trends, allowing businesses to anticipate market demand, stock prices, and other key variables, facilitating proactive decision-making.

Detect Patterns and Anomalies: By examining sequential data points, time series analysis helps detect recurring patterns and anomalies, providing insights into underlying behaviors and potential outliers.

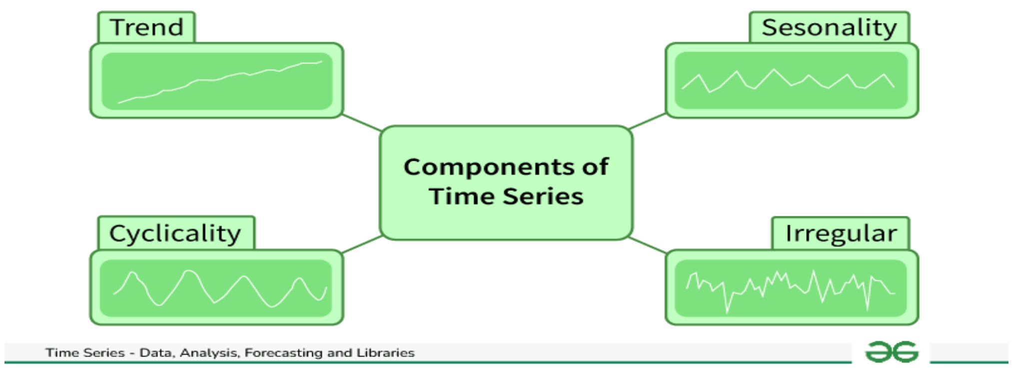
Risk Mitigation: By spotting potential risks, businesses can develop strategies to mitigate them, enhancing overall risk management.

Strategic Planning: Time series insights inform long-term strategic planning, guiding decision-making across finance, healthcare, and other sectors.

Competitive Edge: Time series analysis enables businesses to optimize resource allocation effectively, whether it's inventory, workforce, or financial assets. By staying ahead of market trends, responding to changes, and making data-driven decisions, businesses gain a competitive edge.

Components of Time Series Data

There are four main components of a time series:



Trend: Trend represents the long-term movement or directionality of the data over time. It captures the overall tendency of the series to increase, decrease, or remain stable. Trends can be linear, indicating a consistent increase or decrease, or nonlinear, showing more complex patterns.

Seasonality: Seasonality refers to periodic fluctuations or patterns that occur at regular intervals within the time series. These cycles often repeat annually, quarterly, monthly, or weekly and are typically influenced by factors such as seasons, holidays, or business cycles.

Cyclic variations: Cyclical variations are longer-term fluctuations in the time series that do not have a fixed period like seasonality. These fluctuations represent economic or business cycles, which can extend over multiple years and are often associated with expansions and contractions in economic activity.

Irregularity (or Noise): Irregularity, also known as noise or randomness, refers to the unpredictable or random fluctuations in the data that cannot be attributed to the trend, seasonality, or cyclical variations. These fluctuations may result from random events, measurement errors, or other unforeseen factors. Irregularity makes it challenging to identify and model the underlying patterns in the time series data.

Time Series Visualization

Time series visualization is the graphical representation of data collected over successive time intervals. It encompasses various techniques such as line plots, seasonal subseries plots, autocorrelation plots, histograms, and interactive visualizations. These methods help analysts identify trends, patterns, and anomalies in time-dependent data for better understanding and decision-making.

Different Time series visualization graphs

Line Plots: Line plots display data points over time, allowing easy observation of trends, cycles, and fluctuations.

Seasonal Plots: These plots break down time series data into seasonal components, helping to visualize patterns within specific time periods.

Histograms and Density Plots: Shows the distribution of data values over time, providing insights into data characteristics such as skewness and kurtosis.

Autocorrelation and Partial Autocorrelation Plots: These plots visualize correlation between a time series and its lagged values, helping to identify seasonality and lagged relationships.

Spectral Analysis: Spectral analysis techniques, such as periodograms and spectrograms, visualize frequency components within time series data, useful for identifying periodicity and cyclical patterns.

Decomposition Plots: Decomposition plots break down a time series into its trend, seasonal, and residual components, aiding in understanding the underlying patterns.

These visualization techniques allow analysts to explore, interpret, and communicate insights from time series data effectively, supporting informed decision-making and forecasting.

Preprocessing Time Series Data

Time series preprocessing refers to the steps taken to clean, transform, and prepare time series data for analysis or forecasting. It involves techniques aimed at improving data quality, removing noise, handling missing values, and making the data suitable for modeling. Preprocessing tasks may include removing outliers, handling missing values through imputation, scaling or normalizing the data, detrending, deseasonalizing, and applying transformations to stabilize variance. The goal is to ensure that the time series data is in a suitable format for subsequent analysis or modeling.

Handling Missing Values : Dealing with missing values in the time series data to ensure continuity and reliability in analysis.

Dealing with Outliers: Identifying and addressing observations that significantly deviate from the rest of the data, which can distort analysis results.

Stationarity and Transformation: Ensuring that the statistical properties of the time series, such as mean and variance, remain constant over time. Techniques like differencing, detrending, and deseasonalizing are used to achieve stationarity.

Different Time Series Analysis & Decomposition Techniques

1. Autocorrelation Analysis: A statistical method to measure the correlation between a time series and a lagged version of itself at different time lags. It helps identify patterns and dependencies within the time series data.
2. Partial Autocorrelation Functions (PACF): PACF measures the correlation between a time series and its lagged values, controlling for intermediate lags, aiding in identifying direct relationships between variables.
3. Trend Analysis: The process of identifying and analyzing the long-term movement or directionality of a time series. Trends can be linear, exponential, or nonlinear and are crucial for understanding underlying patterns and making forecasts.
4. Seasonality Analysis: Seasonality refers to periodic fluctuations or patterns that occur in a time series at fixed intervals, such as daily, weekly, or yearly. Seasonality analysis involves identifying and quantifying these recurring patterns to understand their impact on the data.
5. Decomposition: Decomposition separates a time series into its constituent components, typically trend,

seasonality, and residual (error). This technique helps isolate and analyze each component individually, making it easier to understand and model the underlying patterns.

6. Spectrum Analysis: Spectrum analysis involves examining the frequency domain representation of a time series to identify dominant frequencies or periodicities. It helps detect cyclic patterns and understand the underlying periodic behavior of the data.
7. Seasonal and Trend decomposition using Loess: STL decomposes a time series into three components: seasonal, trend, and residual. This decomposition enables modeling and forecasting each component separately, simplifying the forecasting process.
8. Rolling Correlation: Rolling correlation calculates the correlation coefficient between two time series over a rolling window of observations, capturing changes in the relationship between variables over time.
9. Cross-correlation Analysis: Cross-correlation analysis measures the similarity between two time series by computing their correlation at different time lags. It is used to identify relationships and dependencies between different variables or time series.

   10.Box-Jenkins Method: Box-Jenkins Method is a systematic approach for analyzing and modeling time series data. It involves identifying the appropriate autoregressive integrated moving average (ARIMA) model parameters, estimating the model, diagnosing its adequacy through residual analysis, and selecting the best-fitting model.
10. Granger Causality Analysis: Granger causality analysis determines whether one time series can predict future values of another time series. It helps infer causal relationships between variables in time series data, providing insights into the direction of influence.

What is Time Series Forecasting?

Time Series Forecasting is a statistical technique used to predict future values of a time series based on past observations. In simpler terms, it's like looking into the future of data points plotted over time. By analyzing patterns and trends in historical data, Time Series Forecasting helps make informed predictions about what may happen next, assisting in decision-making and planning for the future.

Different Time Series Forecasting Algorithms

1. **Autoregressive (AR) Model**: Autoregressive (AR) model is a type of time series model that predicts future values based on linear combinations of past values of the same time series. In an AR(p) model, the current value of the time series is modeled as a linear function of its previous p values, plus a random error term. The order of the autoregressive model (p) determines how many past values are used in the prediction.
2. **Autoregressive Integrated Moving Average (ARIMA):** ARIMA is a widely used statistical method for time series forecasting. It models the next value in a time series based on linear combination of its own past values and past forecast errors. The model parameters include the order of autoregression (p), differencing (d), and moving average (q).
3. **ARIMAX**: ARIMA model extended to include exogenous variables that can improve forecast accuracy.
4. **Seasonal Autoregressive Integrated Moving Average (SARIMA)**: SARIMA extends ARIMA by incorporating seasonality into the model. It includes additional seasonal parameters (P, D, Q) to capture periodic fluctuations in the data.
5. **SARIMAX**: Extension of SARIMA that incorporates exogenous variables for seasonal time series forecasting.
6. **Vector Autoregression (VAR) Models:** VAR models extend autoregression to multivariate time series data by modeling each variable as a linear combination of its past values and the past values of other variables. They are suitable for analyzing and forecasting interdependencies among

multiple time series.

7. **Theta Method**: A simple and intuitive forecasting technique based on extrapolation and trend fitting.
8. **Exponential Smoothing Methods:** Exponential smoothing methods, such as Simple Exponential Smoothing (SES) and Holt-Winters, forecast future values by exponentially decreasing weights for past observations. These methods are particularly useful for data with trend and seasonality.
9. **Gaussian Processes Regression:** Gaussian Processes Regression is a Bayesian non-parametric approach that models the distribution of functions over time. It provides uncertainty estimates along with point forecasts, making it useful for capturing uncertainty in time series forecasting.
10. **Generalized Additive Models (GAM):** A flexible modeling approach that combines additive components, allowing for nonlinear relationships and interactions.
11. **Random Forests:** Random Forests is a machine learning ensemble method that constructs multiple decision trees during training and outputs the average prediction of the individual trees. It can handle complex relationships and interactions in the data, making it effective for time series forecasting.
12. **Gradient Boosting Machines (GBM):** GBM is another ensemble learning technique that builds multiple decision trees sequentially, where each tree corrects the errors of the previous one. It excels in capturing nonlinear relationships and is robust against overfitting.
13. **State Space Models:** State space models represent a time series as a combination of unobserved (hidden) states and observed measurements. These models capture both the deterministic and stochastic components of the time series, making them suitable for forecasting and anomaly detection.
14. **Dynamic Linear Models (DLMs):** DLMs are Bayesian state-space models that represent time series data as a combination of latent state variables and observations. They are flexible models capable of incorporating various trends, seasonality, and other dynamic patterns in the data.
15. **Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) Networks:** RNNs and LSTMs are deep learning architectures designed to handle sequential data. They can capture complex temporal dependencies in time series data, making them powerful tools for forecasting tasks, especially when dealing with large-scale and high-dimensional data.
16. **Hidden Markov Model (HMM):** A Hidden Markov Model (HMM) is a statistical model used to describe sequences of observable events generated by underlying hidden states. In time series, HMMs infer hidden states from observed data, capturing dependencies and transitions between states. They are valuable for tasks like speech recognition, gesture analysis, and anomaly detection, providing a framework to model complex sequential data and extract meaningful patterns from it.

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https://www.geeksforgeeks.org/time-series-analysis-and-forecasting/

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4. AGRIULTURAL ENGINEERING

Bioplastics from Food Waste: A Path to Sustainable Plastics and Waste Reduction

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Abstract

The growing concern over plastic pollution has accelerated the search for sustainable alternatives, and bioplastics have emerged as a promising solution. Bioplastics, derived from renewable resources, offer an environmentally friendly alternative to conventional plastics made from petrochemicals. Food waste, a major environmental issue globally, can serve as a valuable feedstock for producing bioplastics. This article explores the preparation of bioplastics from food waste, focusing on the process, benefits, challenges, and potential applications. Utilizing food waste not only reduces environmental impact but also adds value to materials that would otherwise contribute to landfill accumulation.

Keywords

Bioplastics, Food Waste, Sustainable Materials, Green Chemistry, Polymers, Plastic Pollution, Renewable Resources, Environmental Sustainability.

Introduction

The global plastic pollution crisis has spurred significant interest in finding biodegradable and sustainable alternatives to conventional plastics. Among these, bioplastics, made from natural and renewable sources, have shown considerable potential. Food waste, which constitutes a significant portion of global waste and contains complex organic materials, can be utilized as an excellent raw material for bioplastic production. Food waste includes discarded items like fruit and vegetable peels, rice husks, and potato starch, all of which are rich in starch and cellulose – key components in bioplastic manufacturing.

Materials Used for Bioplastic Production

Several types of food waste can be processed into bioplastics. These include:

1. **Starch-Based Materials:** Starch, present in many food waste products (e.g., potato peels, corn, and rice), is an ideal raw material for bioplastic production due to its ability to form a gel-like structure when heated with water.
2. **Cellulose:** Found abundantly in fruit and vegetable peels, cellulose is a polymer that can be extracted and used to produce bioplastics. It provides strength and rigidity to the material.
3. **Proteins and Lipids:** Some food waste, such as from soybeans, peanuts, or corn, contains proteins and lipids, which can also be used in the synthesis of biodegradable plastics.

Methodology

The process for preparing bioplastics from food waste involves several steps:

1. **Collection of Food Waste:** Food waste materials, such as fruit peels, vegetable scraps, and starch-rich waste (e.g., potato skins), are collected from households, markets, or food processing industries.
2. **Pre-Treatment and Extraction:** The waste materials are washed, dried, and sometimes ground to facilitate the extraction of starch or cellulose. In some cases, enzymes are used to break down complex carbohydrates into simpler sugars.
3. **Polymerization:** The extracted starch or cellulose is mixed with a plasticizer (e.g., glycerol or sorbitol) and water to form a homogenous mixture. The mixture is then heated to allow the polymers to interact and form a plastic-like material.
4. **Molding and Drying:** The plastic material is poured into molds or spread into thin sheets, where it is dried to remove excess moisture, resulting in a flexible or rigid bioplastic, depending on the formulation.
5. **Testing and Characterization:** The produced bioplastics are subjected to tests for their mechanical properties, biodegradability, and thermal stability to ensure they meet industry standards.

Results and Discussion

The production of bioplastics from food waste has shown promising results in terms of both sustainability and functionality. The key findings include:

1. **Biodegradability:** Unlike conventional plastics, bioplastics made from food waste are biodegradable and can decompose naturally, reducing their environmental impact.
2. **Strength and Durability:** The strength of the bioplastics can be enhanced by adjusting the ratio of starch or cellulose and incorporating plasticizers. Food waste-derived plastics can achieve tensile strength comparable to some petroleum-based plastics, making them suitable for various applications.
3. **Environmental Impact:** Using food waste as a raw material significantly reduces waste sent to landfills, helping to mitigate environmental pollution. Additionally, food waste-based bioplastics have a smaller carbon footprint compared to traditional plastic production, as they utilize renewable resources and require less energy to produce.
4. **Cost-Effectiveness:** The cost of producing bioplastics from food waste is often lower than from other raw materials such as corn or sugarcane, making it an economically viable option for sustainable plastic production.

However, challenges exist, including scalability, the variability of raw material quality, and the need for additional research to optimize production processes and properties.

Applications of Food Waste Bioplastics

Bioplastics derived from food waste can be used in a wide range of applications, such as:

1. **Packaging Materials:** Biodegradable packaging made from food waste bioplastics can replace single-use plastic packaging, reducing plastic pollution.
2. **Agricultural Films:** Bioplastics can be used as mulch films or seedling trays, offering a more sustainable alternative to conventional plastics in agriculture.
3. **Disposable Cutlery and Tableware:** Bioplastics made from food waste can be molded into cutlery, plates, and cups, providing a sustainable alternative to plastic disposables.
4. **Biomedical Applications:** Food waste bioplastics can also be used for making wound dressings, drug delivery systems, and other medical products due to their biocompatibility and biodegradability.

Conclusion

The preparation of bioplastics from food waste represents a promising and sustainable alternative to conventional plastics. By utilizing food waste materials, we can reduce the environmental burden caused by plastic pollution while creating valuable biodegradable products. This approach not only tackles the issue of food waste but also offers an innovative solution for producing eco-friendly plastics with a wide range of applications. Continued research and technological advancements in bioplastic production will be key to optimizing the process and making it scalable for global use.

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5. AGRIULTURE

Improved Water Management Technology for Rice Production System

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Abstract

Rice (Oryza sativa L.) is the most important staple food crop in the world and also provides livelihood to millions of rural households. Conventional transplanted rice production requires significant amounts of irrigation water, labour, and energy. With the growing population and the challenges of climate change there is a need to enhance rice production sustainably. The declining per capita availability of freshwater necessitates production of rice with limited water, using alternate water management options, which can increase the water-use efficiency or water productivity with marginal or no reduction of grain yield. There are various alternative methods of rice production that can enhance water productivity like aerobic rice, system of rice intensification, direct seeded rice, alternate wetting and drying, drip irrigation and saturated soil culture. In this article, different water-saving technologies is reviewed and examines how these technologies improve water use efficiency in rice production.

sIntroduction

Rice is the staple food for over half of the world's population and it is a water-guzzling crop.In general, between 3000 and 5000 litres of water required to produce 1 kg of rice. Hence, rice crop is considered one of the least efficient users of water. The increasing water crisis in rice-growing countries has become a significant concern. The rising demand for rice production combined with a limited water supply has resulted in a serious water crisis in rice-growing countries. According to the Food and Agriculture Organization (FAO), rice cultivation consumes 34–43% of the world's irrigation water [1]. In the next two decades, there is a need to produce around 25% more from 10-15% reduced share of water. Additionally, Climate change has further exacerbated the challenge of water availability for rice cultivation. Traditional rice cultivation is highly labour intensive, time consuming and causes environmental degradation like degradation of soil structure, higher accumulation of harmful substance, methane emission. There is need to sustainable use of agricultural water resources for ensuring global food security. Sustainable rice production plays a crucial role in achieving the Sustainable Development Goals (SDGs), especially for countries like India. In the coming decade, there will be a need for effective water management practices and the adoption of water-saving technologies in rice cultivation. These include aerobic rice, system of rice intensification, direct seeded rice, alternate wetting and drying, drip irrigation and saturated soil culture. These technologies enhance water productivity, profitability, reduce water consumption and climate resilience in rice systems. Hence, shifting gradually from traditional rice production system to these water saving technologies can mitigate the challenges related to water.

Aerobic Rice

Bouman et al. (2005) [2] observed that highest yield under aerobic condition was recorded in the dry season with improved upland variety Apo (5.7 t/ha) and the lowland hybrid rice Magat (6 t/ha) with 32-88% higher water productivity than that of flooded condition. Under agroclimatic conditions of mid-hills of NEH Region, **Patel et al. (2010)**[3] suggested that variety Sahsarang 1 with its moderate values of Water Use Efficiency along with higher grain yield potential both under normal as well as aerobic condition seems to be better choice for farmers. Aerobic rice varieties with minimum yield gap compared to flooded rice is the key for success of aerobic rice cultivation. **Balamani et al. (2012)**[4] demonstrated that in aerobic rice higher grain yield (3.04 t/ha) and water use efficiency is achieved by adopting bed furrow method of irrigation scheduled at 1.5 IW/CPE up to panicle initiation and 2.0 IW/CPE for the remaining period during *kharif* season. **Jinsy et al. (2015)**[5] recorded 60.7 per cent higher water productivity in aerobic rice as compared to conventional flooded rice. Out of four varieties tested, variety MAS 946 – 1 found better in terms of yield for aerobic condition in southern Kerala. **Nayak et al. (2016)**[6] concluded that economically higher grain yield, FWUE and benefit: cost ratio were achieved when crop was irrigated at 5-day interval along with application of N at 80 kg/ha under aerobic culture in rainfed and water-scarce west central table land zone of Odisha. **Keerthi et al. (2018)**[7] investigated that significantly higher grain (5419 kg/ha) and straw (6906 kg/ha) yield were observed in IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage along with application of nitrogen at 150 kg·ha−1 in 5 equal splits at 20, 35, 50, 65 and 80 DAS. Meanwhile, maximum WUE (8.4 kg/ha-mm) was recorded in IW/CPE 1.0 throughout the growth period along with application of nitrogen at 150 kg·ha−1 in 5 equal splits at 20, 35, 50, 65 and 80 DAS in aerobic rice.

System of Rice Intensification (SRI)

Thakur et al. (2011)[8] reported that significantly higher water productivity (0.68 g/l) and grain yield (6.51 t/ha) were recorded in SRI-AWD which save water up to 22% compared to continuously flooded SMP (Standard Management Practice). **Narolia et al. (2014)**[9] revealed that SRI technique proved better due to increase in grain yield and saving of water up to 37.2% and 51.4% respectively, over farmers practice. **Duttarganvi et al. (2014)**[10] observed that significantly higher grain yield produces under SRI, which is 46.23% higher as compared to NTP (Normal Traditional Planting) with on an average 31–34% of reduction in irrigation input. **Rapolu et al. (2023)**[11] reported that 50% higher grain yield was obtained in SRI compared to NTP. In terms of water productivity SRI found significantly superior over NTP irrespective of the season (5.32-6.85 kg/ha-mm Vs 5.32-6.85 kg/ha-mm).

Direct Seeded Rice

Humphreys et al. (2011)[12] reported that irrigation water productivity of DSR-20 kPa threshold surpassed PTR-20 kPa while reducing irrigation input by 30–50% through maintaining yield. **Ullah and Datta (2018)**[13] revealed that Pathumthani 1 performed better under DDS in all moisture regimes. The grain yield difference between DDS and TP was 17% at 0 kPa, 51%, 39%, and 24% at −5, −15, and −30 kPa, respectively. In comparison to continuous flooding conditions, the soil moisture regime of 0 kPa, which kept the soil moist without standing water, saved up to 12% of the water. While −5, −15, and −30 kPa saved 38%, 47%, and 62% more water, respectively, compared with flooded conditions.

Alternate Wetting and Drying (AWD)

Paul et al. (2013)[14] reported that in AWD applying irrigation after 15 cm depletion of water below soil surface saved 20% irrigation water over continuous standing water and gave higher grain yield. **Mote et al. (2017)**[15] pooled mean result showed that different AWD irrigation regime save water up to 13.8 to 36.4% and recorded 6.8 to 43.6% and 11.8 to 72.6% WP_{TWI} and WP_{IW} indices, respectively when compared to CS (Continuous submergence) without any significant yield decline. **Mondal et al. (2017)**[16] observed that concluded that higher grain (5.65 t/ha) and straw (6.97 t/ha) yield with 32.78% water saving over FCP (Farmers Common Practice) were recorded under AWD Irrigation at soil hair crake stage during vegetative phase + 2-3 cm of standing water at active tillering, panicle initiation and flowering stage only. **Punyawansiri et al. (2021)**[17] significantly higher water productivity observed in rice grown under AWD (1.19 kg/m3 Vs 0.89 kg/m3) method. AWD reduced total water input by 27.2% and 18.2% when compared to CF (continuous flooding). AWD treatments increased yields by 10.6% in 2016 and decreased by 4.5% in 2017 compared with CF (continuous flooding).

Drip irrigation

Sonit et al. (2015)[18] found that highest seed yield was registered in drip irrigation at 1.4 IW: CPE ratio which was at par with traditional flooding. For summer rice, WUE across all the drip irrigation treatments (1.0, 1.2 and 1.4 IW: CPE ratio) was in the range of 2.5-2.9 kg/ha-mm whereas it was lower 0.11 kg/ha-mm in flooding. The findings of **Kombali et al. (2016)**[19] suggested that significantly maximum water productivity (78.1 kg/ha-cm), grain (6598 kg/ha) and straw yield (11084 kg/ha) by saving 45% of irrigation water compared with surface irrigation with soil application of RDF. **Rao et al. (2017)**[20] concluded that grain yield (7.07 t/ha), straw yield (4.60 t/ha), water productivity (0.90 kg/m3) and B:C ratio (5.81) were significantly higher with SRI management with drip irrigation emitters spaced at 20 cm as compared with conventional practice. **Mariyappillai et al. (2022)**[21] observed that higher yield (6,062 kg/ha) and WUE (8.72 kg/ha-mm) were registered with combination of drip fertigation of 100% RDF with irrigation of 120% PE.

Saturated Soil Culture (SSC)

Borrell et al. (1997)[22] In Australia, SSC use about 32% less water in both seasons (wet and dry) over traditional flooded rice production, with no significant difference in yield and quality. **Kima et al. (2014)**[23] reported that weekly application of a 3 cm water depth appeared suitable as it led to low yield sacrifice with 40% of water saving. In later study, **Kima et al. (2020)**[24] further suggested that greater irrigation productivity (0.69 kg/m3), rainwater productivity (1.02 kg/m3), and water-saving (90.53%) with less production penalty (5 × 10−3 kg/m3) can be achieved through Weekly soil saturation at 120% as compared to irrigation at 200% saturation (farmers practices).

Conclusion

Rice is a water-intensive crop. However, farmers are still facing difficulties in cultivating rice profitably to satisfy the rising food demands of the global population. As water resources become scarcer, it is crucial to explore and adopt other sustainable agricultural practices that require less water. Several water-efficient rice production technologies have been introduced, such as DSR, SRI, aerobic rice, AWD, SSC, drip-irrigated rice, and others. The introduction of water management technologies can significantly reduce water usage in rice production, while maintaining or only marginally affecting grain yields.

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6. VETERINARY SCIENCE

Top Feed Resources for Goats

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India possesses the second largest goat population (148.9 million) in the world. Goat is the choice of animal due to its wide adaptability, high fertility, fecundity and feed conversion efficiency. Goat rearing is a very common practice in rural as well as semi-urban areas as it ensures marketability and provides livelihood security. It also plays a major role in fulfilling the nutritional requirement of the family members.

Goat farming is highly recommended as it requires low initial investment and ensures good remunerations in a short period. But the major problem encountered by most of the goat farmers in India is, low production performance of the animals. Generally, goat farmers in India, following extensive rearing system, in which the goats are allowed for open grazing in natural grasslands. The availability and nutritive value of the natural grasslands will vary depending upon the season. In addition to this natural grazing, the animals are fed with low quality crop residues based on the local availability. These results in poor body weight gain, reproductive disorders etc.

Supplementing the animals with protein rich concentrate mixture to overcome this issue is not possible for all goat farmers as the current market price of concentrates is unaffordable. In this situation, it is imperative to think about an alternate solution to overcome the poor production performance of animals without increasing the feed cost which is the most significant variable cost in goat farming. Here comes the role of tree fodders in goat feeding management.

Goats are selective browsers and have the ability to feed on wide variety of feedstuff mainly tree leaves. Goats exhibit bipedal stance (standing on its hind limbs) and pluck the leaves of small trees. Goats can relish wide variety of plants than the other species and have a higher tolerance for bitter taste. Goats are very efficient in digesting crude fibre and can make good use of pasture top feed and agricultural by-products. They can also digest lignin to a great extent, which is not digested by other domestic animals. Tree leaves contains more amount of protein and calcium which are essential for the growth of the goats. To achieve maximum body weight gain in goats, 50 percent of their green fodder should constitute 3-4 types of tree leaves.

Top feed resources

The leaves of certain tree species utilized in animal feeding are called as top feed resources. In most of the cases, sheep and goats are fed with tree leaves, though cattle have also fed during lean period. About 60% of total feed available to sheep and goats comes from top feeds only. In arid and semi-arid regions of the country, tree leaves are harvested, sun dried at appropriate stage and stored. These stored tree leaves are used as supplements in addition to grazing during lean period when scarcity of feeds becomes a problem. The dry matter content of the top feed ranges from 20 to 40 percent with 10 to 15% crude protein on dry matter basis, however as high as 21.45 percent in subabul has also been reported. In early stage of growth, tree leaves are rich in CP and low in fibre, in contrary, protein content decreases with maturity. As the tree leaves matures, the palatability, digestibility and other nutritive values will decrease.

Value of Tree Fodder

1. Tree fodders are the cheapest source of protein to the animals
2. During the dry periods, trees remain green for a longer period than grasses because of their deeper rooting system. So it provides green fodder round the year.
3. Trees can be grown either in combination with agricultural crops, horticultural crops or on separate land usually not fit for agriculture.
4. Trees can produce as much, if not more, green fodder per unit area as agricultural fodder crops.
5. It is easy to establish tree fodder
6. Exhibit a good competitive ability against weeds
7. Remain productive under repeated grazing and browsing.
8. Be well adopted to the particular climatic features of the environment
9. Require, no or little fertilizer
10. Be resistant to local pests and diseases
11. Have good nutritive value and reasonable palatability and acceptability to animals.

Goats are particularly fond of tree leaves, especially the followings

Subabul (Leucaena leucocephala): It is a leguminous tree gives profuse foliage. It is one of the highest quality and most palatable fodder trees. Leaf meal prepared from dried subabul leaves can be supplemented to the goats during drought conditions. Subabul as green fodder should not be used more than 33 percent of total ration. Subabul contains mimosine which may cause shedding of hair if fed alone. The leaves contain 25.6% of protein.

Agathi (Sesbania grandiflora): The leaves are highly palatable and well relished by goats. It contains about 25 percent protein. Under irrigated condition, it can be grown throughout the year. The seed rate is 7.5 kg/ha. Seeds can be sown at a spacing of 100 cmx100 cm. the leaves can be harvested first at 8 months and subsequently in an interval of 60-80 days. It gives 100 tonnes/year/ha green fodder yield.

Gliricidia (Glyricidia sepium): Gliricidia sepium is one of the major tropical forage trees due to its protein rich foliage (19%) and high nutritive value. It produces fresh growth after every cutting. It can be propagated through seeds or stem cuttings. The cuttings should be taken from plants over 6 months old and about 1.5 m long and 3-5 cm in diameter. It tolerates a wide range of climatic conditions. It yields 9-16 tonnes/ha of dry matter in fodder lot. It can be lopped around 7 months after establishments on plants grown from cutting and 14 months after seedling. Lopping can be done every 2-3 months during the rainy seasons and every 3-4 months during dry season provided regrowth reaches 1-2 m high before harvest.

Neem (Azadirachta indica): Neem is a large evergreen tree with edible fruits and aromatic leaves. It can be grown all over the country. This remains green throughout the year and is drought resistant. A mature tree can give 350 kg of leaves in a year. Crude protein concentrations may range from 17.5 percent to 18.7 percent. In arid regions like Virudhunagar district, goats are solely depend on neem leaves for their green fodder requirement in peak summer months.

Goats feed on Neem leaves

Manila tamarind (Pithecellobium dulce): Manila tamarind is one of the most important browse species and is primarily used as a fodder for goats during the dry season. Leaves can withstand heavy browsing. Oil meal, pods and leaves are useful livestock feeds. Pods are relished by goats. Leaves contain more than 22% of protein.

Albizia lebbeck: Fodder of this tree can be fed to animals in large quantities as it has no toxic compounds and animals will readily eat this. This tree grows in the form of shrub with many branches in dry areas with little rainfall (600 mm/year) and as a tree in wet areas (2500 mm/year). It can be propagated from seeds in acid, alkaline or saline soils directly in the field or first in a nursery and then transfer to the field after about 4 months. Leaves contain more than16% of protein.

Mango (Mangifera indica): Mango tree foliage is available year round. It can be used as fodder, either cut and carry or browsed.

Goats feed on Mango leaves

Mulberry (Morus alba): Mulberry is primarily grown for sericulture. The excess leaves and leftovers can be fed to goats. Animals consume the leaves avidly. Leaves are highly palatable and the digestible crude protein is 7.8 percent and total digestible nutrients are 48.4 percent. On dry matter basis, leaves contain an average of 20-23 percent crude protein, 8-10 percent total sugar and 12-18 percent minerals. Under irrigation, mulberry yields nearly 35-45 tonnes of fresh leaf/ha/year.

Prosopis (Prosopis cineraria): It is a deep rooted, perennial and multipurpose tree that provides useful fodder for livestock in the drier areas of India. It is a slow growing tree and it can reach upto 3-5 m in high in 5-6 years. It is browsed or lopped several times per year to feed goats. A moderate sized tree may yield 45 kg of dry leaf fodder per year.

Ber (Zizyphus jujube): In arid zones, it is an important fodder for sheep and goats. Leaves are palatable. It contains 18.6 percent crude protein but the total digestible nutrient is only 36 percent.

Drumstick (Moringa oleifera): Moringa oleifera is one of the fastest growing trees with high biomass yield, high crude protein of more than 25 percent and contains negligible amounts of anti nutritive compounds. Moringa leaves are a valuable source of protein for goats but they have a moderate palatability.

Babul (Acacia nilotica): It is a useful fodder source especially very important in dry areas. The foliage and the pods can be a fundamental source of nutrients in fodder scarcity periods. Leaves and pods are palatable. Pods contain up to 15% protein.

Points to be considered while feeding tree fodder to goats

- Goats refuse to take soiled fodder. So it is advisable to hang the fodder as bundle in a suitable height. Portable feeding racks may solve the purpose.
- Fodder should not be offered in large quantities at a time to prevent wastage by trampling. Instead small quantities of fodder at frequent intervals can be offered.
- Goats prefer to consume variety of fodder. So mixing 3- 4 types of tree leaves will increase the feed intake.
- Leguminous tree leaves should not be fed alone in large quantities as it may cause bloat. It should be combined with non-leguminous fodder crops.
- Wilting of Gliricidia leaves 12 hours before feeding will reduce the offensive smell and thereby it will increase the feed intake.

7. SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Impact of Long-Term Inorganic Nutrient Management on Soil Organic Carbon

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Introduction

Soil organic carbon – A key to the soil health

Soil health, according to the Intergovernmental Technical Panel on Soils[1] is "*the ability of the soil to sustain the productivity, diversity, and environmental services of terrestrial ecosystems*". Soil organic matter (SOM) and soil organic carbon (SOC) are crucial for soil quality, as they are the significant determinants of soil health, influencing soil physical, chemical, and biological properties that govern soil fertility and productivity. The term SOM usually refers to the total organic material in the soil, consisting of both living and dead materials, whereas SOC specifically refers to the carbon content within that organic material. Since carbon is a fundamental component of SOM, these two terms are closely related, however the SOC is a more focused metric often used in studies of soil health and climate change. The SOC is one part of the much larger global carbon cycle, and to one-meter soil depth, the SOC pool stores 1500 Petagram carbon[2], that is 3.4 times the size of the atmospheric pool and 4 times the biotic pool.

Green revolution & organic farming: Impacts on SOM / SOC

The green revolution, which began in the mid-20th century, marked a significant transformation in global agriculture[3]. The introduction of high-yielding crop varieties, extensive irrigation, chemical fertilizers, and pesticides, significantly increased food production. Worldwide, fertilizer consumption increased dramatically as countries sought to improve agricultural productivity to feed growing populations. However, concerns have emerged about its long-term sustainability, especially its impact on soil health. Intensive farming practices are often linked to SOM & SOC depletion and are a subject of significant interest and debate. Critics of synthetic fertilizers, particularly proponents of organic farming, argue that chemical fertilizers negatively impact soil quality[4,5]. Potentially, fertilizer application can affect SOM & SOC dynamics via two mechanisms[6], (i) it may increase the SOC by promoting plant & root biomass, and (ii) it may accelerate the SOC loss via increasing microbial activities. In context to the first mechanism, the purpose of the seminar is to discuss the research findings of several long-term fertilizer experiments in India and worldwide.

Long-Term Fertilizer Experiments and Research Findings

Long-term fertilizer experiments (LTFEs) are research studies conducted over extended periods, often decades, to assess the sustained impact of fertilizer and nutrient management practices on soil health, crop productivity, and environmental quality. Such experiments were initiated in various parts of the world, including India, which provided critical insights into sustainable agricultural management. The LTFEs have been instrumental in understanding the effects of nutrient management practices on SOC dynamics.

Research findings of LTFEs in India

Just after the beginning of the green revolution, the Indian Council of Agricultural Research initiated the All India Coordinated Research Project on LTFE in 1970. These experiments spread across 11 agroclimatic zones of India, covering 7 major cropping systems under 4 dominant soil types. It has been well established that a balanced nutrient supply is vital for proper maintenance and improvement of SOC. **Thakur *et al.* (2011)[7]**

observed that the SOC content of Vertisols with an initial value of 5.7 g/kg had increased significantly after 36 years of continuous application of 100-150% NPK under intensive soybean-wheat cropping systems and attained a value of 7.1-8.5 g/kg. For the same LTFE, after 44 years, Tiwari *et al.* (2024)[8] also reported increased SOC and soil microbial biomass carbon (SMBC) for plots receiving 100-150% NPK fertilizer. Also, Bahera *et al.* (2007)[9] observed no significant decline in SOC of plots receiving NPK fertilizers under a wheat-soybean cropping system for 5 years compared to unfertilized plots. For the same cropping system in the sub-temperate agro-ecosystem of the Indian Himalayas, Bhattacharyya *et al.* (2008)[10] revealed that 30 years of the sole application of NPK led to a significant increase in both SOC and SMBC contents. After 32 years of LTFE under a maize-wheat cropping system, Rasool *et al.* (2008)[11] reported 21% higher SOC in 0-60 cm profile of sandy loam soil of NPK treated plots than of control plots. However, Chakraborty *et al.* (2011)[12] reported that mineral fertilizers resulted in statistically comparable SOC levels in the jute-rice-wheat system, although higher fertilizer dose was associated with increased SOC value. In contrast, the authors observed significant variations in MBC content attributable to mineral fertilizer application. Tripathi *et al.* (2014)[13] emphasized that the total organic carbon (TOC) content of plots after 42 years of application of NPK fertilizers in a tropical rice-rice system was statistically equivalent to FYM-treated plots. In the maize-wheat system, Brar *et al.* (2015)[14] reported that continuous use of inorganic fertilizers for 36 years increased the SOC to 3.34-3.71 g/kg compared to the unfertilized control (3.08 g/kg). The carbon sequestration rate also increased under inorganic fertilization for 36 years[14]. For the groundnut-wheat cropping system in calcareous loam soil, Deshraj *et al.* (2015)[15] observed ~35% increase in the SOC with the use of inorganic fertilizers for 12 years compared to their initial SOC values. Chaudhary *et al.* (2017)[16] demonstrated that the continuous application of NPK fertilizers alone to rice-wheat cropping system for 15 years improved the SOC (i.e., 4.19 g/kg from its initial value of 2.42 g/kg) and its labile fractions in soils under intensive rice-wheat system. The authors also found a better carbon management index, CMI (59%) for the surface soil under NPK treatment, implying that the SOC status has improved. After 44 years of wheat based cropping in Inceptisol, Ghosh *et al.* (2018)[17] reported nearly two-fold increase in SOC and SOC stock with 100% and 150% NPK treatments than control plots. The authors also noticed a considerable rise in the SOC fractions, MBC, CMI, OC accumulation, and CS rate after 44 years of mineral fertilization[17]. Das *et al.* (2019)[18] reported 12% increase in the TOC in colloidal organo-mineral fraction extracted from different soils after 31 years of fertilization. Srinivasarao *et al.* (2020)[19] examined a 16-years LTFE with mono-cropping rainfed groundnut to quantify the influence of fertilization on SOC in rainfed Vertisols, and authors noticed no significant decline in SOC owing to 100% NPK compared to the initial status. Singh *et al.* (2021)[20] reviewed the effect of various LTFEs on depletion/sequestration of carbon and concluded that the increase in amount of applied nutrients (NPK) from 50% to 150% resulted in an increase in carbon sequestration, which is ascribed to increase in total biomass or primary productivity of crops. Rathod *et al.* (2024)[21] demonstrated that the NPK fertilization for 32 years in Vertisol under a sorghum-wheat cropping sequence increased SOC, TOC, and carbon sequestration parameters compared to unfertilized control plots.

Research findings of LTFEs worldwide

Singh (2018)[6] reviewed the findings of various LTFEs from all over the world and stated that adequate and balanced use of mineral fertilizers increased SOC as compared to plots receiving no fertilizers. The Broadbalk experiment at Rothamsted[22] is one of the longest-running agricultural experiments in the world, initiated in 1843 in UK. The results of this experiment on changes in the SOC status after 175 years reveal that the plots receiving only inorganic fertilizers have exhibited relatively stable SOC levels[22]. Gao *et al.* (2015)[23] assessed the 33-years LTFE on the fluvo-aquic soil of North China in a wheat-maize rotation and found that application of inorganic fertilizer enhanced the SOC content by 28-47% over its initial SOC value. Likely, Zhao *et al.* (2015)[24] assessed a 12-years experiment under a rice-wheat system to study the changes in the SOC and soil microbes due to long-term fertilization and concluded that the long-term fertilization increased the SOC by 13-23% in plough soil layer. Results further showed that fertilizers stimulated the population of soil microbes[23]. Ashraf *et al.* (2020)[25] similarly observed no decline in the SOC content due to application of inorganic fertilizers in rice-wheat system for 37 years.

Conclusion

Soil organic carbon (SOC) is a key determinant of soil health, influencing soil fertility, productivity, and ecosystem services. Long-term fertilizer experiments (LTFEs) conducted both in India and globally have demonstrated that balanced and adequate application of inorganic fertilizers can significantly enhance SOC levels, total organic carbon (TOC), and related carbon management parameters across various agroecosystems. Indian studies reveal that the application of 100-150% NPK fertilizers in diverse cropping systems over decades consistently increased SOC content, microbial biomass carbon (MBC), and carbon sequestration rates. Similarly, global research confirms the positive effects of mineral fertilizers on SOC stabilization and enhancement. Notable findings include the All India Coordinated Research Project on LTFE in India, Broadbalk experiment in the UK and trials in China, which show sustained or improved SOC levels with long-term fertilization. These improvements are attributed to enhanced plant biomass production, soil microbial activity, and carbon sequestration. However, some studies indicate limited SOC gains in specific conditions, emphasizing the need for customised nutrient management strategies. Overall, the evidence underscores that balanced inorganic fertilization is crucial for maintaining and improving SOC stocks, thereby promoting sustainable soil health and long-term agricultural productivity.

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8. HORTICULTURE

Future Smart Farming with IoT: An Overview

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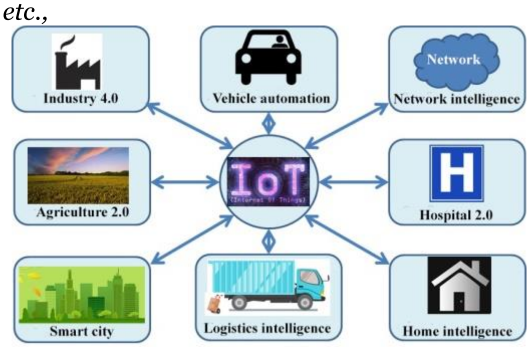
Introduction

According to the recent report by FAO, the world's population will surpass 9.0 billion people by year 2050. Significant challenges will have to be overcome to achieve the level of agricultural productivity necessary to meet the predicted world demand for food, feed, fibre and fuel in 2050. Although agriculture has met significant challenges in the past, targeted increases in productivity will have to be made by 2050, in the face of stringent constraints including limited resources, less skilled labour, limited amount of arable land and changing climate, among others. However these problems can be addressed through upgrading the farming tools and techniques by smart technological application in agriculture.

One of the recent advances in technology is Internet of Things (IoT). The term was coined in 1999 by Kevin Ashton and represents a domain of technology in which it is possible to imagine a global network that makes connected, enabling their cooperation, millions of objects (wearable gadgets, logistics and transport systems, everyday used devices, sensors, *etc*.). The most significant example in this sense is the "Precision Farming" a smart agriculture vision to integrate crop requirement and Internet of Things (IoT) technologies in a secure fashion to manage a production system.

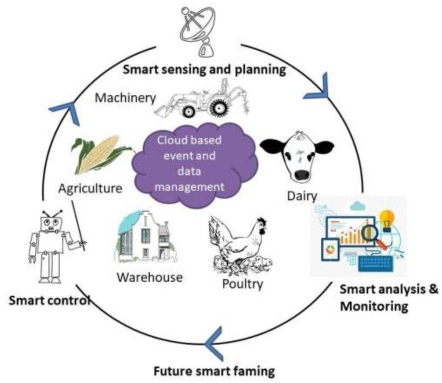
Applications of IoT

Smart home, wearable's, smart city, smart grids, industrial internet, connected health, smart retail, smart supply chain, smart farming *etc.*,



IoT in Farming

The farming has to become SMART to overtake the today's challenges, and the IoT model (that is now evolving toward Internet of Everything ((IoE)) may represent the right architecture to reorganize farming and all the disciplines and technologies involved in the smart way.



IoT for Agri and Horticulture

Crop Water Management

Usually the farmer pumps the water more or less to cultivate. This may result in wastage of water or insufficiency to the crops. By using soil moisture sensor, farmer gets an alerting message when the moisture level increases or decreases.

Precision Farming

Precision farming is a management strategy that gathers, processes and analyses temporal, spatial and individual data and combines it with other information to guide site, plant or animal specific management decisions to improve resource efficiency, productivity, quality, profitability and sustainability of agricultural production. The farming involves major components such as GIS, GPS, Sensor's, Variable Rate Applicator *etc.,*

Pest and Disease Management

Often farmer's hard works are destroyed by predators (pests) that results in huge loss to farmers. To prevent such situation Agriculture IoT has a system that detects the motion of predators using PIR sensors. This information can be used by the farmers to reduce damage done by predators

Recent Achievements

- Climate smart Agriculture by ICRISAT
- Smart dairy management services
- Drone based soil moisture mapping through GPR (Ground penetrating radar)
- Smart supply chain
- eSAP (Electronic Solution against Agriculture Pest) *etc.*,

SWOT Analysis

- **Strength's:** Can be used in any field, can be accessed from anywhere, innovative farming technique and informative, more target groups and advanced technology
- **Weakness**: Too much technology, too complex system and requires a lot of marketing effort
- **Opportunity's:** Increased labour wages, more accurate, improving the efficiency, resource management and AI and block chain
- **Threat's:** Data privacy, per cent of accuracy, system failure, high initial investment and complex designing ability

Conclusion

Thus, the IoT agricultural applications are making it possible for researchers and farmers to collect meaningful data. Large landowners and small farmers must understand the potential of IoT market for agriculture by installing smart technologies to increase competitiveness and sustainability in their productions. With the population growing rapidly, the demand can be successfully met if the researchers, as well as small farmers, implement agricultural IoT solutions in a prosperous manner.

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9. AGRONOMY (BIODYNAMIC FARMING)

Biodynamic Farming

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'Biodynamic' originates from Greek words, ***bios*** meaning life, and ***dynamos*** meaning energy. The pioneer of biodynamic farming was Rudolf Steiner (1861-1925). The name "Biodynamic" refers to a 'working with the energies which create and maintain life. (Rudolf Steiner).

Biodynamic farming is ecologically oriented, but has a wider scope that includes cosmic influences, planetary positions against the fixed stars - the Zodiac, personal aspects of the farmer and his mental factor. (Swami Jai Chaitanya Das).

Biodynamic Principles:

Plant diversity, Crop rotation, Composting, Homeopathic preparation, To grow crop with suitable planet position, Animal health.

Importance of Biodynamic farming:

It is advanced form of organic agriculture. To emphasis the special preparationmade from fermented manure, minerals and herbals are used to enhance the soil health and microbial activity in the soil. It's help in restore the soil fertility and maintain the natural ecosystem.Crop rotation to enhance the soil fertility, soil structure, water-holding capacity and to control loss of topsoil. Natural pest and disease control.Animal wastes are recycled as compost to help nourish the plants that feed animals and humans.

Biodynamic farming practices:

Biological practices	Dynamic practices
Green manures	Special foliar sprays
Cover cropping	Special compost preparations
Composting	Planting by calendar
Companion cropping	Peppering for pest control
Integration of crops and livestock	Homeopathy
Tillage and cultivation	

Biodynamic compost:

Compost made of Cow horns,cow dung and herbals used to make the wonderful compost. To recycle animal manures and organic wastes, stabilize nitrogen, and build soil humus and enhance soil health. Biodynamic compost is unique because it is made with BD preparations from 500 to 508. It is not only food for crops but they facilities the effective functioning of etheric forces.It's not compost starter but can stimulatethe organisms activity in compost.It is harvest the potential of astral and ethic power for the benefits of soil and microorganism.

Type of Biodynamic preparation:

Foliar spray preparations :		**Uses**
BD500	Horn manure	Soil biological activity
BD501	Horn silica	Plant resilience
Compost preparations:		
BD502	Yarrow	K and S processes
BD503	Chamomile	Ca and K processes
BD504 nettle	Stinging	N management
BD505	Oak bark	Ca processes
BD506	Dandelion	Si management
BD507	Valerian	P and warm

		processes
BD508	Casurina Tea	To control fungus

Biodynamic certification:

In 1928, the first ecological label "*Demeter*" was used to certify the high quality nutritional food produced by organic and biodynamic agriculture. Most sustainable and successful forms of biodynamic farming practiced in forty countries across the world.The Biodynamic Association was founded in 1938.

Certification steps:

1. Submit completed certification pack
2. Farm visit
3. Follow up on summary report recommendations
4. Annual renewal of certification

Planting by calendar:

Rhythms of planting:

Biodynamic farming works from two poles the cosmic and earth. Understanding and using the rhythms of the cosmos for sowing, planting and harvesting.

The 6 Moon Rhythms are:

Full-New Moon	**29.5 days**
Moon opposite Saturn	27.3 days
Ascending-Descending Moon	27.3 days
Moon Nodes	27.2 days
Perigee-Apogee	27.5 days
Moon in Zodiac Constellations	27.3 days

Activities Connected with the Full Moon: Sow seeds at times of low humidity and warmth (48 hours before Full Moon). Apply liquid manures (48 hrs before Full Moon). Fungus control - Spray with BD 508. Insect control - use a garlic/ginger/chilli/pepper spray, Natural pyrethrum, Neem oil, Stinging Nettle with 5% Cow urine.

Activities Connected with the New Moon: Avoid sowing seeds.Cut the timber.Traditional Indian agriculture recognized the day before New Moon as No Moon day, a day on which no agricultural work is done.

Activities Connected with Moon Opposite Saturn: Seed sowing and Transplanting. Spray with BD 501 in the very early morning on the day of or the day before the opposition to strengthen plants against fungus.Spraying BD 501 at this time improves the keeping quality and the taste all fruits and vegetables.

Ascending Moon: Activities Connected with Ascending Moon are sow all seeds, Spray with BD 501 at early stages of growth, Harvest the crop. During an Ascending Moon Period (sunrise) at the beginning of the plant's growth and before harvest also on Moon opposite Saturn.

Descending Moon: Activities connected with descending moon are Spray BD 500 in the afternoon - the soil should be warm. Make and spread compost. Transplant seedlings. Make and plant cuttings, Tillage, Harvest root crops for storage. Prune all fruit trees in the appropriate season. Prune flowering trees and shrubs.

Conclusion

Biodynamic farming is not easily learned from a textbook, but better is "sensed" through "experiencing" it. Biodynamic farming is more than a body of information. In biodynamic farming, the farmer is considered a spiritual caretaker of the land. The farmer has direct experience of the rhythms of the seasons and intimate communication with the smallest of organisms unseen in the soil to the largest of organisms, such as the farm itself. Biodynamic farming helps in rejuvenating the soil and ensure sustainability of crop production and quality. Biodynamics is a scientifically sound approach to sustainable management of plant systems.

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10. REMOTE SENSING AND GIS

Drought Assessment Using Remote Sensing and GIS Techniques

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Introduction

A drought is a complex phenomenon that may be defined as "severe water shortage" prolonged period of dry weather that causes water scarcity. Drought means a *"sustained, extended deficiency in precipitation"* -WMO (1986), FAO (1983) defines drought hazard as *"the percentage of years whsen crops fail from the lack of moisture"*. Drought occurs due to various causes' usually lesser precipitation than normal. Drought may last from few months to several years.

Around 42% of India's land area is facing drought, with 6% exceptionally dry--four times the spatial extent of drought, according to data for the week ending March 26, 2019, from the ***Drought Early Warning System (DEWS)***, a real-time drought monitoring platform. When drought extends for longer period it may cause severe damage to plants and critically affects atmosphere. Impacts of drought include losses of lives, human suffering, damage to economy and devastation of crops. In Agriculture, drought which affects both surface water and ground-water which leads to demand in water supply for plants growth, reduced water quality, higher evapotranspiration rate, crop loss.

Types of Drought

- **Meteorological drought:** It is most commonly calculated using precipitation level. It is defined as lack of rainfall (precipitation) in a region over a period of time. Meteorological drought paves way for other types of drought.
- **Hydrological drought:** Hydrological drought related to period with inadequate water level in surface and sub-surface brought by insufficient water level in water reservoirs such as lakes, ponds, aquifers and reservoirs.
- **Agricultural drought:** It occurs due to lack of water available for crop growth, low soil moisture level which causes crop failure, declined moisture level in soil, affects plants metabolic functions & photosynthetic activities.
- **Socio-economic drought:** It is related to inadequate/failure of water resources to satisfy the water demands and drought associated with supply and demand for proper water.

Role of Remote Sensing and GIS in drought assessment and monitoring

Conventional methods of drought assessment mainly use rainfall data which has many limitations like inadequate climate data, requires more numbers of meteorological stations, time consuming, more labour requirement, etc. Since disasters require rapid and continuous monitoring, traditional methods are not possible of continuous monitoring and assessment of drought. To overcome such issues the remote sensing and GIS techniques are used. The remote sensing techniques are employed in assessing current situation - before, during and after disaster.

These steps can be used to analyse drought risk assessment:

- Assessing drought in relation to its frequency, area under risk and seriousness.
- Identifying and measuring vulnerability of drought.
- Calculating the drought risk pattern from hazard and vulnerability.

Most information required for drought assessment must have spatial part and it varies according to time. Therefore, the usage for

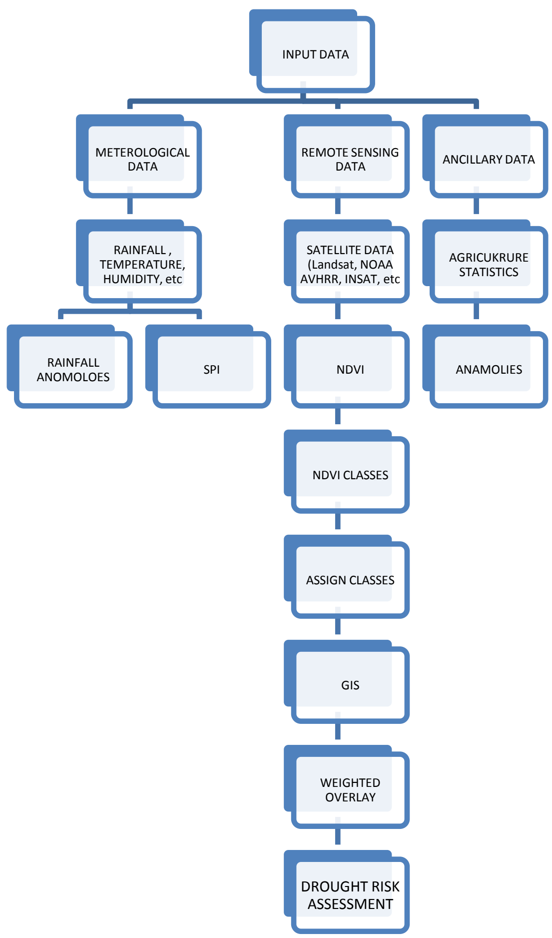
Remote sensing and GIS has become more essential. Thus, remote sensing plays a major role in drought risk assessment. The major advantage of using GIS is it create possibility to further analyses to calculate further damage assessment.

Commonly used indices for drought assessment

- Meteorology based indices for drought assessment and drought detection
  - Crop Moisture Index (CMI)
  - Standardized Precipitation Index (SPI)
  - Standardized Water Supply Index (SWSI)
  - Palmer Drought Severity Index (PDSI)
- Satellite based indices for drought assessment
  - Normalized Difference Vegetation Index (NDVI)
  - Normalized Difference Wetness Index (NDWI)
  - Vegetation Condition Index (VCI)
  - Soil-Adjusted Vegetation Index (SAVI)
  - Temperature Condition Index (TCI)
  - Perpendicular Drought Index (PCI)

Methodology for Drought Assessment

The following flow chart gives an idea about how the drought can be assessed using remote sensing and GIS technique.



Some important data sets used for drought assessment

Satellite	Sensors	Spatial resolution	Temporal resolution	Swath
Resource sat 1 & 2	AWiFS	56 m	5 days	750 km
	LISS III	23 m	26 days	140 km
	LISS IV	6 m	48 days	70 km
LANDSAT 8	OLI	30 m	16 days	185 km

Coarse resolution data

Satellite/ Sensor	Indices	Relevant Parameter
NOAA AVHRR (1km)	NDVI	Crop condition
Oceansat 2-OCM (360m)	NDVI, ARVI	Crop condition
Terra MODIS (500 m)	SASI, NDWI	Surface wetness/ sown area discrimination
Terra AMSRE (25 km)	Soil moisture	Surface wetness/ sown area discrimination
INSAT 3A CCD (1 km)	NDVI	Crop condition

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