Watersheds and Agriculture Development

N. Andotra, B. Sambyal
Shakuli Saxena

Watersheds and Agriculture Development

N. Andotra
B. Sambyal
Shakuli Saxena

Watersheds and Agriculture Development

N. Andotra
B. Sambyal
Shakuli Saxena

Dominant
Publishers & Distributors Pvt Ltd
New Delhi, INDIA

Knowledge is Our Business

WATERSHEDS AND AGRICULTURE DEVELOPMENT
By N. Andotra, B. Sambyal, Shakuli Saxena

This edition published by Dominant Publishers And Distributors (P) Ltd
4378/4-B, Murarilal Street, Ansari Road, Daryaganj,
New Delhi-110002.

ISBN: 978-81-78885-72-8

Edition: 2022 (Revised)

Dominant
Publishers & Distributors Pvt Ltd

Registered Office: 4378/4-B, Murari Lal Street, Ansari Road,
Daryaganj, New Delhi - 110002.
Ph. +91-11-23281685, 41043100, Fax: +91-11-23270680

Production Office: "Dominant House", G - 316, Sector - 63, Noida,
National Capital Region - 201301.
Ph. 0120-4270027, 4273334

e-mail: dominantbooks@gmail.com
info@dominantbooks.com

www.dominantbooks.com

CONTENTS

Chapter 1. Wetlands as Environmental Guardians: Mitigating Agricultural Runoff Pollution for Sustainable Water Resources 1
— Shakuli Saxena

Chapter 2. Integrated Water Management: Addressing Poverty, Agricultural Sustainability, and Resource Governance in Arid Regions 10
— Praveen Kumar Singh

Chapter 3. Sustaining Livelihoods in India's Dryland Agro-Ecological Zones: Challenges and Strategies in Groundwater-Based Agriculture 17
— Sunil Kumar

Chapter 4. Economic Valuation and Policy Imperatives for Watershed Management: Bridging the Gap between Environmental Assets and Sustainable Resource Use 24
— Devendra Pal Singh

Chapter 5. Sustainable Watershed Management: Bridging Environmental and Socioeconomic Sustainability 33
— Upasana

Chapter 6. Strategic Mapping and Prioritization Techniques for Watershed Management 42
— Ashutosh Awasthi

Chapter 7. A Comprehensive Analysis and Management Strategies for Torrent and Stream Bank Control in Watershed Management 48
— Anil Kumar

Chapter 8. Integrated Watershed Management: Enhancing Sustainability through Advanced Planning and Vegetative Resource Conservation 56
— Kusum Farswan

Chapter 9. Enhancing Soil Conservation Through Innovative Farming Practices and Crop Management 63
— Kuldeep Mishra

Chapter 10. Reviving Agriculture for Sustainable Development: Challenges and Opportunities for Emerging Nations 70
— Heejeebu Shanmukha Viswanath

Chapter 11. Sustainable Agriculture: Principles of Farm Business Management 79
— Devendra Pal Singh

Chapter 12. Evolving Dynamics of Indian Agriculture: Past Challenges and Future Prospects 87
— Ashutosh Awasthi

Chapter 13. Enhancing the Agricultural Productivity: Challenges and Strategies 95
— Kusum Farswans

CHAPTER 1

WETLANDS AS ENVIRONMENTAL GUARDIANS: MITIGATING AGRICULTURAL RUNOFF POLLUTION FOR SUSTAINABLE WATER RESOURCES

Shakuli Saxena, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-shakuli2803@gmail.com

ABSTRACT:

This paper explores the crucial function of wetlands in reducing agricultural runoff-related nonpoint source pollution (NPSP), which presents serious risks to water quality, aquatic ecosystems, and the many beneficial uses of water resources. A wide range of water-quality pollutants, such as fertilizers, pesticides, pathogens, silt, salts, trace metals, and compounds that increase biological oxygen demand, are carried by agricultural runoff. Regulations governing water quality and the use of management techniques to reduce NPSP are becoming more and more obligatory for growers. One of the best management strategies (BMPs) for resolving this problem is constructed and restored wetlands. This thorough investigation focuses on how well built and restored wetlands may protect against a variety of water-quality pollutants that are often present in agricultural environments. We find that well planned and maintained wetlands may efficiently remove or hold onto many of these toxins, with removal efficiency for important pollutants often surpassing 50% when located in suitable settings. However, the establishment of wetlands has the potential to have negative effects, such as the buildup of mercury and selenium, increased salinity, the creation of mosquito habitats, and greenhouse gas emissions. Wetland management strategies that reduce these negative consequences while maximizing pollution removal are investigated.

KEYWORDS:

Agriculture, Fertilizer, Pollution, Water Resources, Wetlands.

INTRODUCTION

According to predictions from the Food and Agriculture Organization (FAO), the world's population is expected to grow by 70% by 2050, which would require an astounding 40% increase in food production by 2030. In use there are over 1.4 billion hectares of agriculture globally. However, due to continued loss of prime farmland to urbanization and other land-use changes, satisfying this projected global need would require more than doubling the amount of cropland now in use. This loss puts additional strain on soil and water resources by forcing agriculture into marginal regions that are more prone to erosion and need greater input levels[1], [2].

Nonpoint source pollution (NPSP), which is mostly caused by agricultural runoff, is a worldwide threat that puts the security of drinking water and aquatic ecosystems at jeopardy. According to the 2000 National Water Quality Inventory, NPSP from agriculture is the main factor contributing to the United States' declining surface water quality. Sediment, nutrients (nitrogen and phosphorus), pesticides, pathogens, salts, trace elements, dissolved organic carbon, and chemicals that increase biological oxygen demand are all pollutants found in agricultural runoff. Significant ecological imbalances, including the creation of hypoxic and anoxic "dead zones" in more than 400 areas throughout the globe, have been caused by these pollutants. Therefore, in order to minimize its influence on the sustainability of water resources, agriculture must develop, test, and monitor novel and effective management strategies. Wetlands have received a lot of praise for being vital parts of the planet's ecosystems because they provide a wide range of benefits, including the removal of pollutants, the preservation of biodiversity, the provision of habitat for threatened and endangered species, groundwater replenishment zones, localized flood protection, carbon sequestration, and aesthetic value. Sadly, over 53% of the country's wetlands were lost after the United States was settled due to a lack of knowledge about the value of wetlands and the push for agricultural growth. More than 5 million hectares of wetlands were lost by California and Texas, two of the top agricultural states in the United States, as a result of initiatives like Swamp Buster, which promoted the conversion of marginal lands, including wetlands, into agricultural producing zones. The use of agricultural pesticides increased concurrently with this landscape change, separating the filtering function of wetlands from riparian ecosystems and drastically harming the country's and the world's water supplies[3], [4].

Wetlands' ability to reduce NPSP has just recently begun to get attention. Historically, man-made and restored wetlands have been created in agricultural areas primarily to improve animal habitats, most notably via programs like the Wetlands Reserve Program (WRP) and the U.S. Conservation Reserve Program. The WRP provides landowners with financial and technical help to restore, improve, and protect wetlands and the nearby surface waterways. It is managed by the Natural Resource Conservation Service (NRCS) and its partners. A total of 785,000 hectares of marginal agriculture had signed up for the WRP by 1999. Across the country, the practice of turning floodplain agroecosystems into wetlands is expanding. However, there is no evidence to support how these wetlands efficiently filter agricultural field pollutants that affect water quality.

This research mainly examines how built and restored wetlands (herein referred to as CWs) may be used to enhance water quality in agricultural environments. Construction wetlands are built in places where there were no natural wetlands before, whereas restored wetlands are built in places where there were formerly wetlands but were drained or otherwise damaged. Our attention is mostly on surface flow CWs, which collect agricultural runoff (subsurface and/or surface) and eventually discharge it into nearby surface water bodies including rivers, streams, lakes, and estuaries. We discuss the use of CWs in agricultural contexts to reduce NPSP, notably from field runoff and subsurface drainage.

Although many studies have examined treatment wetlands, which are primarily used to filter and treat municipal wastewater, there is still a paucity of published data on the effectiveness of CWs in controlling NPSP. This is especially true when you take into account the significant distinctions between treatment wetlands and CWs in agricultural contexts. The goal of this study is to provide the most recent information on the application of CWs in agricultural settings to improve water quality. We look at the benefits of using CWs, study the main wetland processes, evaluate the effectiveness of removing contaminants, look at wetland management techniques, and investigate design and location issues. Evaporation ponds, vertical seepage wetlands, treatment wetlands, and natural wetlands are not included in our analysis since they are not surface flow-through wetlands. We also discuss the possibility for certain elements to accumulate and have negative effects given the wide range of water-quality pollutants that CWs encounter in agricultural contexts[5], [6].

Agricultural runoff poses a danger to drinking water quality, aquatic ecosystems, and a number of other beneficial uses of water resources due to nonpoint source pollution (NPSP). Numerous water-quality pollutants, including fertilizers, pesticides, pathogens, silt, salts, trace metals, and compounds that increase biological oxygen demand, are often found in agricultural runoff. Growers who discharge agricultural runoff are increasingly required to adhere to water-quality rules and employ management techniques to lessen NPSP. One of the numerous effective management strategies that farmers may use to solve this issue is the construction and restoration of wetlands. The main topic of this study is how created and restored wetlands may reduce a number of water-quality pollutants that are present in the majority of agricultural landscapes. We discovered that, if thoughtfully planned and maintained, created and restored wetlands eliminate or retain numerous water-quality pollutants in agricultural runoff. When wetlands were put up under the right conditions, the removal efficiency of contaminants for sediment, nitrate, microbial pathogens, particle phosphorus, hydrophobic insecticides, and certain trace elements often approached 50%. Construction and restoration of wetlands may have certain unfavourable impacts that need to be taken into account, such as mercury and selenium buildup, increased salinity, habitat for mosquitoes, and greenhouse gas emissions. Wetland design elements and proper management practices are highlighted in order to minimize these negative consequences and maximize pollution removal.

Wetlands as Pollution Reduction Tools

Feeding the globe without harming the environment is a new challenge for agriculture. An alarming pace of growth is being seen in the world's appetite. In order to support the planet's population growth, food production must rise by 40% by 2030 and 71% by 2050, according to FAO forecasts. Approximately 1.4 billion hectares of farmland are now used for agriculture worldwide, but to meet the growing demand, agricultural area would need to more than quadruple. At the same time, urbanization and other land uses are displacing valuable agriculture. Due to the loss of this profitable farmland, farming now takes place on marginal areas, which are more erosive and need more inputs than prime farmland does. As a result, soil and water resources will face increased strain in the future, necessitating best management techniques (BMPs) that are affordable and assure environmental protection. Globally, nonpoint source pollution (NPSP) poses a threat to the quality of our water supply and aquatic environments. Agriculturally produced NPSP is the main factor causing water quality deterioration in surface waterways, according to the 2000 National Water Quality Inventory (US EPA, 2002). Sediment, nutrients (N and P), pesticides, pathogens, salts, trace elements, dissolved organic carbon (DOC), and chemicals that increase biological oxygen demand (BOD) are among the pollutants that come from agricultural runoff. In more than 400 areas throughout the globe, for instance, fertilizer input into aquatic ecosystems has caused major changes in trophic interactions, including hypoxia/anoxia-induced "dead zones."

In order to lessen the effects of agriculture on the sustainability of water resources, innovative and efficient management strategies for agriculture must be found, tested, and monitored. Wetlands are widely promoted as essential elements of our planet that provide a wide range of ecosystem services, including habitats for rare and endangered species, biodiversity hotspots, ground water recharge zones, localized areas for flood protection, carbon sinks, and aesthetic value. Over 53% of the country's wetlands were lost during colonization due to a lack of knowledge about the function of wetlands and a focus on agricultural development. More than 5 million hectares of wetlands have been destroyed in California and Texas, the two states with the highest agricultural output in the country. Programs in the United States, like Swamp Buster, which promoted the conversion of marginal land (like wetlands) into agricultural production, were responsible for a large portion of this loss. The increase in the usage of agricultural chemicals happened at the same time as this landscape change. The nation's (and the planet's) water supplies have been severely degraded as a consequence of the filtering effect of wetlands being decoupled from riparian ecosystems. Wetlands have just recently begun to be recognized for their ability to reduce NPSP. In agricultural contexts traditionally, especially in the U.S., artificial and restored wetlands have been created to enhance animal habitat. The Wetlands Reserve Program (WRP) and the Conservation Reserve Program. The Natural Resource Conservation Service (NRCS) and its partners are in charge of the WRP, which is an outreach program. It is intended to provide landowners financial and technical support so they may restore, improve, and preserve wetlands and the nearby surface waterways. A total of 785,000 hectares of marginal agriculture have been included in the WRP as of 1999. While turning floodplain agroecosystems into wetlands is a common land-use strategy nationally, little is known about how these wetlands filter toxins that affect water quality in runoff from agricultural fields.

DISCUSSION

The capacity of two forms of wetlands, built and restored wetlands (referred to as CW here), to enhance water quality in agricultural landscapes will be discussed in this study. Built wetlands, also known as constructed wetlands, are made where there were no natural wetlands prior. In regions where wetlands were drained or otherwise damaged, restored wetlands are upgraded and/or created wetlands. Surface flow and subsurface flow (vertical and horizontal) are the two primary categories of CWs. A lack of subsurface flow wetlands in agricultural settings is a result of the high maintenance expenses brought on by the obstruction of porous medium. Since agricultural runoff (surface and/or subsurface) is transported to and travels through a wetland system on its way to nearby surface water bodies including rivers, streams, lakes, and estuaries, this research has mostly focused on surface flow CWs. The use of CWs to reduce NPSP in agricultural contexts, especially from field runoff and subsurface drainage, is covered in this paper. CWs are one of the BMPs for NPSP mitigation. Treatment wetlands, which we define as wetlands created to filter and treat municipal waste water (as well as storm runoff, mining waste, and animal waste), are the subject of a vast body of literature[7]. There is a dearth of published data addressing the effectiveness of CWs for treating NPSP despite the enormous amount of knowledge on treatment wetlands (e.g., Kadlec and Knight, 1996). Furthermore, treatment wetlands and CWs in agricultural contexts have quite different functions, making it difficult to directly compare the two since treatment wetlands have generally steady input flows.

Most treatment wetlands that take in animal or municipal waste have consistent input amounts of waste and continuous water flow. For instance, standard deviations of mean values for nutrients were roughly 10% in a study of the water quality in 244 sewage treatment facilities throughout the country. In contrast, for a number of water quality measures, the relative standard deviation for irrigation tailwaters in the San Joaquin Valley of California often approached 50%. Prior to the early 1990s, runoff from confined livestock activities was the main focus of most waterquality studies on wetlands in agricultural contexts. A difference in nitrogen (N) and phosphorus (P) content exists between agricultural field runoff and waste water effluent. Agricultural runoff typically tends to be P restricted with a mean N:P ratio of 31:1, while wastewater is N limited with a mean N:P ratio of 2.4:1. The process of plant absorption is especially pertinent since nutrients in treatment wetlands are often trapped in organic/particulate forms, while in agriculture, these elements are typically inorganic/dissolved. This review's objective is to provide an overview of the present body of information about the use of CWs to agricultural settings in order to enhance water quality.

In this attempt, we looked at the advantages of using CWs and spoke about common wetland processes, the effectiveness of removing contaminants, wetland management techniques, and design and location concerns. Evaporation ponds, vertical seepage wetlands, treatment wetlands, and natural wetlands are not specifically included in this analysis since it concentrates on surface flow-through wetlands. Since CWs in agricultural contexts are exposed to a wide range of water-quality pollutants, it is also important to consider the possibility that particular elements may be amplified and have negative consequences [8].

A crucial element in the removal of contaminants is the synchronization of agricultural runoff with seasonal temperatures since temperature controls the rates of biogeochemical response. The best-case scenario is irrigated agriculture, when CWs get inflows from tailwaters at the hottest periods of the year. However, a lot of CWs are positioned in farmscapes to stop runoff from storm drains. These systems often see their maximum inflows during the wettest parts of the year, such as winter rains or spring snowmelt. The energy balance of a wetland is driven by solar radiation, which also controls all other wetland activities. Primary productivity, temperature, and evapotranspiration are all directly impacted by solar radiation. Additionally, it aids in the photodegradation of organic substances. Evapotranspiration and water loss are governed by solar radiation and wind, which have an impact on removal efficiency determined on a concentration basis.

CWs that receive agricultural runoff observe event-based fluxes of water and materials that match hydrological patterns, irrigation and farming techniques, and biogeochemical cycles—all of which are largely controlled by climate. As a result, CWs in these environments encounter a significant level of fluctuation. The architecture of the wetland and the source of the water (such as irrigation runoff, tile drainage, surface runoff, stream flow diversion, or in-stream flow) both affect the variability of the hydrologic loading. As a consequence of land use, storm events or snow melt, discharge from tile drainage, and/or irrigation runoff, seasonal trends in pollutant flux and dilution take place. The timing of fertilization, the mineralization of soil organic matter, the application of soil amendments, and/or runoff events may all be reflected in concentration pulses. The date of treatment, crop rotation, crop mix, and drift patterns all affect pesticide concentrations. It is crucial to take into account the characteristics of source waters and the time of their delivery when assessing the effectiveness of CWs for improving water quality or when comparing CWs across areas. The duration of the growing season and farming practices influence the seasonal fluctuation experienced by CWs receiving irrigation runoff. Wetland input water concentrations of nutrients, silt, and salinity from tailwaters were found to be very variable and to have no connection with flow in California's Central Valley when the contributing area was small (1500 Ha). However, in significant contributing regions that provided consistently high input loads, the concentrations of water-quality contaminants were less varied. Because pulses are related to the timing of biogeochemical processes, irrigation, fertilization, and agriculture, contaminant concentrations tend to be more variable when the size of the contributing region is less. A more consistent pollutant content in input waters is the outcome of the integration of all contributing components in large contributing regions.

Processes for removing contaminants

Wetlands act as filters, sinks, and converters of water-quality components in agricultural contexts. There are three main mechanisms that control the retention and/or removal of water-quality pollutants in CWs: additions, transformations, and translocations. The rate and route of elimination processes are impacted by input loads. While translocation mechanisms make pollutants passive and/or inert, often by burial, transformations cause a shift in the phase and reactivity of components. Translocations and transformations often operate together to cause a component loss. Some specialized processes, such as the conversion of nitrate to N_2O and N_2 gas and its diffusion into the environment, result in a permanent loss from the system. Others cause toxins to move from one area of the system—the water column—to another—the sediment—which makes the contamination less reactive in the environment. There are a number of processes that take place in CWs that help to remove contaminants, such as: (1) sedimentation and burial (for pathogens, pesticides, phosphorus, and particulate organic carbon); (2) biogeochemical transformations (for the production of dimethylselinide, methanogenesis, and denitrification); (3) biotic uptake of nutrients and salts; (4) microbial degradation of pesticides and organic matter; and (5) redox transformations Due to these processes, wetlands are often thought to have an overwhelmingly positive impact on the quality of the water. Rate of pollutant inflows, residence duration of water in the wetland, availability of organic matter and other substrates for microbial development, light intensity and penetration, temperature, and nutrient absorption by plants are important elements affecting wetlands' ability to purify water[9], [10].

The chemical phase aqueous, solid, or gas, the mobility of certain pollutants, and the reactivity of sorption sites are all governed by the redox state of wetland soils. As soils get saturated, reducing conditions develop. Due to the oxygen diffusion rate being orders of magnitude slower in wet soil compared to well-drained soils, oxygen quickly becomes scarce in submerged soils. In the absence of oxygen, anaerobic conditions arise, requiring the use of alternative electron acceptors for microbial respiration. Redox potentials in the presence of oxygen are typically 400–600 mV in range. Nitrate is converted to N2O and N2 gas at a threshold redox potential of around 250 mV after oxygen deprivation. At redox thresholds of 225 and 100 mV, respectively, components that impact P cycling, such as manganese and iron (hydr)oxides, are decreased after nitrate (NO3) has been consumed. Sulphate is reduced to sulphide at low redox potentials (=100 mV), while CO2 is converted to methane at low redox potentials (=200 mV). There is still some reduction in wetland soils. The soil surface has a thin oxidative layer that is between a few millimetres and several centimetres thick. As the soil, water column, and atmosphere combine, this layer is created. Temperature, diffusion rate, plant and microbe respiration rates, oxygen generation through photosynthesis by aquatic vegetation, and mixing in the water column all influence how thick it is. This thin oxidized layer may serve as a barrier for translocations from sediment pore water to the water column because certain water-quality components (Mn and Fe) become less mobile under oxidizing circumstances. Additionally, it is a significant location for aerobic metabolic processes like mineralization and methane oxidation to take place.

Sedimentation

Solid particles physically sinking in water is known as sedimentation. Particle size, density, water velocity, turbulence, salinity, temperature, and depth of the water column all affect how quickly sediment accumulates. Sedimentation has several positive environmental effects in wetlands. The most notable result is an improvement in water purity, which is crucial to the habitat of fish downstream and the aesthetic appeal of related water bodies. Through the settling of reactive particles that function as sorption sites for other pollutants such pesticides, trace metals, phosphate, ammonium, and pathogens, sedimentation also helps to enhance the quality of the water. Sedimentation helps to some extent with carbon sequestration by burying and preserving settled organic carbon and carbon linked with sediment in anaerobic soil settings where breakdown is extremely slow. The BOD is decreased by the removal of particulate organic matter, which also lowers the risk of hypoxia in aquatic habitats.

Sorption

Sorption is the process by which pollutants in the water column are drawn out of solution and held on the surfaces of solid particles. By making the pollutant less reactive or by expelling it from the system via sedimentation and burial, sorption results in contaminant elimination.

The quantity of sorptive surfaces, as well as the chemical and mineralogical makeup of the particles, determine the extent of sorption. It's crucial to take into account the types of pollutants that affect water quality. Cation exchange interactions, for instance, cause cations to be drawn to negatively charged clay or organic matter colloids. Pathogens and pesticides may be removed by sorption to particles, together with sedimentation and burial. Through sorption through inner- and outer-sphere complexes to crystalline and weakly crystalline oxides or clay crystal edges, followed by sedimentation, an essential step that promotes phosphorus elimination takes place.

Technique of Photochemistry

Contaminants that affect water quality might change directly or indirectly as a result of photochemical reactions. In wetlands, photodegradation may be used to remediate organic compounds and components such pesticides, herbicides, medicines, pathogens, and DOC. While UV light may directly kill the majority of microorganisms, indirect photolysis is responsible for the decomposition of many pesticides. For instance, humic compounds may produce reactive oxygen species when exposed to photons, and the photochemically excited states of dissolved organic matter (DOM) can facilitate the photolysis of organic pollutants. In wetlands, nitrate has also been shown to be a significant photosensitizer that, when photolyzed, produces hydroxyl radicals (OH).

Sediment in Suspension

The majority of the contaminants from irrigated farmland that are removed by CWs are suspended sediments. In addition to reducing water clarity and destroying benthic organisms and breeding grounds in rivers and streams, sediment has a negative impact on surface water bodies. Since contaminants including metals, herbicides, viruses, and nutrients often bind to particles in sediment, it may also be regarded as indirectly dangerous. Mineral and organic silt are both types of suspended sediment. Microaggregates, sand, silt, or clay are examples of possible mineral fractions. Sedimentation is the primary method used to remove suspended particles. The velocity decreases when high energy input flows are spread across the CW environment, which causes the suspended load to settle. The increase in cross-sectional area and some of the energy required to sustain suspended particles are absorbed by vegetation, which slows down the flow of water and lessens turbulence. The assertion that vegetation has a direct impact on sedimentation, however, has been refuted by a number of studies. It is believed that vegetation instead decreases resuspension, increasing net sediment retention. The degree of particle flocculation, particle diameter, particle density, water temperature, turbulence, and residence duration are other elements in the CW environment that impact sedimentation.

CWs sometimes need time to develop before reaching their maximal removal efficiency. Depending on the pace of vegetative and microbiological establishment, the required period might take anywhere between 1 and 3 years. A defined lifetime is based on sedimentation rates for the majority of CWs. Therefore, while building sediment traps, the height of water control structures, and dikes, design parameters should take sedimentation rates into account. There are two main ways to minimize NPSP from agriculture: (1) on-site management techniques that restrict application and losses from farmlands, and (2) off-site techniques that stop NPSP before it enters significant water sources. In order to minimize NPSP at watershed scales, CWs may be utilized inside a farmscape as an on-site farm practice or as an off-site strategy when downstream flood plains are converted to wetlands. Placement of a CW is ultimately a site-specific decision that takes into account the kind of input flows, pollutants of concern, and intended community objectives. With the objective of having a low watershed to wetland area ratio, the size of the contributing area and its location within a watershed should be taken into account. This is crucial for CWs that receive stream flow or agricultural runoff. Intact aggregates, which have faster settling speeds than smaller particles, are more likely to reach the CW and reduce transit distance as a result. This investigation was carried out at wetland areas that experienced significant particle loads, despite the fact that a CW area of at least 0.1% of the watershed area was required for optimal sediment trapping. The watershed to wetland area ratio should be about 15-20:1, which equates to 3-6% of the watershed area, according to research conducted in the Midwestern United States to achieve efficient N and P removal. In irrigated agriculture, the size of the contributing area is only incidentally significant; instead, it is more crucial to take into account where the CW is placed in relation to the amount of input and its fluctuation.

CONCLUSION

A vital weapon in the fight against agricultural runoff-related nonpoint source pollution (NPSP) is constructed and restored wetlands. This review's in-depth study highlights the amazing capacity of thoughtfully created and maintained wetlands to filter out or hold onto a wide range of water-quality pollutants common in agricultural settings. Wetlands have proven their ability to preserve water quality and safeguard aquatic ecosystems, with removal efficiencies exceeding 50% for key pollutants like sediment, nitrate, microbial pathogens, particulate phosphorus, hydrophobic pesticides, and selected trace elements when situated in appropriate settings. But it's important to recognize the possible drawbacks of created and restored wetlands, such as mercury and selenium buildup, increased salinity, the development of mosquito habitats, and greenhouse gas emissions. Prudent wetland management and smart design elements are essential for maximizing the benefits of wetlands while reducing these negative effects.Wetlands act as environmental guardians, screening and purifying agricultural runoff as part of the continual goal of sustainable agriculture and the protection of water resources. They serve as a pillar of best management practices for dealing with NPSP and are essential for maintaining the quality of our waterways, guaranteeing access to clean drinking water, and sustaining the vitality of aquatic ecosystems. The integration of manmade environments with agriculture is becoming more important as it struggles to feed an expanding global population while reducing its environmental impact.

REFERENCES:

[1] I. U. Ahmed, W. Shou, and D. D. Gang, “Nonpoint Source Pollution,” *Water Environ. Res.*, 2014, doi: 10.2175/106143014x14031280668335.

[2] P. Vadas and J. T. Sims, “Soil Fertility: Phosphorus in Soils,” in *Reference Module in Earth Systems and Environmental Sciences*, 2014. doi: 10.1016/b978-0-12-409548-9.09116-8.

[3] D. Tan *et al.*, “An in situ study of inorganic nitrogen flow under different fertilization treatments on a wheat-maize rotation system surrounding Nansi Lake, China,” *Agric. Water Manag.*, 2013, doi: 10.1016/j.agwat.2013.03.011.

[4] W. P. Pandit, T. V Arjun, and N. Jaydeep, “Go green using selective bioculture containing mixture of mesophilic and thermophilic bacteria for composting of solid waste.,” *J. Environ. Res. Dev.*, 2013.

[5] A. T. Messina, “Terrestrial Sediment and Nutrient Fluxes to the Faga’alu Reefs in American Samoa,” *AGU Fall Meet. Abstr.*, 2013.

[6] K. A. Rolf, J. S. Strock, D. J. Mulla, And And P. H. Gowda, “Implications Of Conventional And Organic Farming Practices On Nonpoint Source Pollution And Tmdls,” 2013. Doi: 10.13031/2013.15600.

[7] M. Piniewski, P. Marcinkowski, I. Kardel, M. Giełczewski, K. Izydorczyk, And W. Fratczak, “Spatial Quantification Of Non-Point Source Pollution In A Meso-Scale Catchment For An Assessment Of Buffer Zones Efficiency,” *Water (Switzerland)*, 2015, Doi: 10.3390/W7051889.

[8] L. M. W. Yasarer *Et Al.*, “Climate Change Impacts On Runoff, Sediment, And Nutrient loads in an agricultural watershed in the lower Mississippi river basin,” *Appl. Eng. Agric.*, 2017, doi: 10.13031/aea.12047.

[9] W. Yue, Y. Cai, L. Xu, Q. Tan, and X. Yin, “Adaptation strategies for mitigating agricultural GHG emissions under dual-level uncertainties with the consideration of global warming impacts,” *Stoch. Environ. Res. Risk Assess.*, 2017, doi: 10.1007/s00477-016-1244-4.

[10] K. Lee, H. Gao, M. Huang, J. Sheffield, and X. Shi, “Development and Application of Improved Long-Term Datasets of Surface Hydrology for Texas,” *Adv. Meteorol.*, 2017, doi: 10.1155/2017/8485130.

CHAPTER 2

INTEGRATED WATER MANAGEMENT: ADDRESSING POVERTY, AGRICULTURAL SUSTAINABILITY, AND RESOURCE GOVERNANCE IN ARID REGIONS

Praveen Kumar Singh, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-dr.pksnd@gmail.com

ABSTRACT:

The problems of pervasive poverty, damaged agroecosystems, and falling agricultural sustainability loom large in arid and semi-arid parts of the globe. Water shortages, frequent droughts, degraded soil, and other factors are prevalent in these areas, which lower agricultural output and jeopardize the viability of nearby towns. For instance, Sub-Saharan Africa struggles with these problems, with rural regions housing a significant share of the poor and food insecure populace. IWM, or integrated water management, is becoming more widely acknowledged as a potential strategy for boosting sustainability and production in outlying, low-lying regions. IWM includes market-driven technologies that reduce risks associated with market and climatic swings in addition to international initiatives to maintain soil and water. It is crucial to understand how the hydrological units that determine the resilience and sustainability of ecosystem services relate to the physical properties of water. While community-based amplification promotes economic growth and sustainability on the downstream side, hydrological amplification helps with agricultural and technical changes on the supply side. However, a thorough comprehension of the unique features of each watershed is necessary for the successful implementation of an IWM program, taking into account both ecological and socioeconomic issues. Watersheds often include a variety of communities with differing rights to utilize natural resources. They are complicated ecologically and socially. Owners of property rights and effective institutional procedures that promote collaboration and group action are necessary for managing externalities, whether they are negative or positive, resulting from choices about the use of resources.

KEYWORDS:

Agroecosystems, Ecosystem, Natural Resources, Watersheds.

INTRODUCTION

People living in widespread poverty, the degradation of agroecosystems, and declining sustainability are major issues for agricultural development in many parts of the world where the overexploitation of natural resources has resulted in livable climates. This is particularly true in arid and semi-arid regions where water scarcity, frequent droughts, soil degradation, and other biotic and abiotic constraints reduce agricultural productivity and compromise the resilience of the system. In sub-Saharan Africa (SSA), rural regions make up over 90% of the cultivated land and are home to a significant portion of the impoverished, food-insecure, and vulnerable population. It is now accepted that integrated water management (I W M) is an effective method for promoting productivity and sustaining agriculture in remote, low-lying areas [1], [2].Arid and semi-arid environments provide complex obstacles to agricultural production that go beyond standard farming methods. The lives and resilience of populations in these places are threatened by pervasive poverty, the degradation of agroecosystems, and declining agricultural sustainability. Water shortages, ongoing droughts, deteriorating soil, and numerous biotic and abiotic restrictions all work together to lower agricultural production and increase population vulnerability. This conflict is nowhere more evident than in sub-Saharan Africa, where rural areas account for over 90% of the region's arable land and house a sizeable amount of the region's poor, food-insecure, and vulnerable people. The idea of "Integrated Water Management" (IWM) has arisen as a ray of hope among these difficulties. IWM adopts a comprehensive strategy that goes beyond simple conservation efforts and integrates cutting-edge market-driven tactics to reduce risks related to market volatility and weather unpredictability. Understanding the complex interrelationship between the physical properties of water and the hydrological units that support the persistence of ecosystem services is crucial [3], [4].

IWM has the indisputable potential to revive agriculture in dry places, but its effective application requires a thorough understanding of the distinctive features of watersheds. Watersheds are by their very nature complex structures that include a variety of natural resources and are populated by people from a wide range of socioeconomic backgrounds. The possibility of resource usage disputes is always present, especially between the high, middle, and lower sections of the watershed. As a result, it becomes crucial to manage the consequences of resource usage decisions. The connection between the biophysical description of water and the hydrological unit that governs the durability and sustainability of ecosystem services. The hydrological amplification procedure aids in the development of the agricultural and technological in-transitions on the supply side, while the community-based amplification procedure allows for the creation of institutions for the development of the country's economy and sustainability on the downstream side.

However, a constructive imitation of a man is an effect. IWM Program necessitates careful consideration of the unique features of watersheds. Both ecological and socioeconomic factors, as well as the arrangements for political parties and institutional structures, are taken into consideration. A watershed is a geographically defined unit that contains a variety of natural resources. that are only distributed within a certain geographic area location where there are water drains leading to a point. Watersheds include a variety of natural resources water, trees, soil, biodiversity, etc. that are used by various groups of people with appropriate use rights and entitlements. Watersheds are also inhabited by socially diverse populations that are dispersed along the river's course, potentially leading to conflicts over the use of the resource between the upper, middle, and lower reaches of the catchment. Watersheds are undoubtedly biologically and socially complex geographical units that are distinguished by the spatial and temporal interdependence between resources and resource consumers. This statement emphasizes that the efficacy of watershed protection measures should be taken into consideration in order to treat the natural landscape rather than just a particular aspect of it.

More generally, due to the lateral and downward movement of soil and water resources, the actions taken by one resource user may have an impact (externalities) on other resource users. The ability to exclude or prevent negative externalities is defined by the holders of property rights to the resource. Negative externalities may come under the control of other agents when they are designed to be prevented at low cost. Some resource usage choices for conservation purposes may also fall under the control of other agents. When environmental conditions are poor, resource utilization levels may be inappropriate for the time and may even be detrimental to societal well-being. The opposite is true when it comes to favourable externalities for which individual resource consumers are not fully compensated. The ability to internalize these types of mutual spillover effects from spatial and temporal perspectives necessitates institutional measures that promote cooperation and cooperative action. Augmented landowners' and shareholders' conflicting and divergent interests are produced by the usage of exclusive access and use rights for certain types of property. This lessens the incentives for cooperation and raises the transaction costs associated with gathering resource users for collective action. This article discusses the political system and the institutional needed for it based on the lessons learned from events in South Asia and other places [5], [6].

Institutional and policy problems

Numerous factors that affect the management of natural resources have been discussed. Three major actors have pledged to define the incentives for individual participation in watershed management programs. These include territorial size, geographical scale, and property rights. The purpose of these factors is to improve individual incentives for cooperative action in water management.On the other hand, investments in a number of other fields have been made. Authentic Resource Management (N R M) technologies are necessary for water-shed management, but they don't pay off right away. Terraces for soil and water conservation, as well as planting, construction of check dams, and other examples are typical examples. In the same way as seed-based production methods N R M technologies sometimes have a lengthier gestation period than those that provide results in a single season. Costs are incurred immediately, whereas expenses are postponed and build slowly over time. Some of the social advantages derived from watershed management include non-transferable public goods. environmental services, such as improvements in ecological fields, are also included. sustainability and system health are improved by doing so. Such advantages are not well appreciated by individual resource consumers. This implies that similar to other agricultural innovations (such as new varieties), the requirements for IWM services need a considerably longer planning period.

The property rights legislation that regulates the use of land, water, forests, and other resources is another important factor in the history of the United States. Costs and benefits associated with watershed development projects are determined by the stock of resource use rights. a and entitlements of individual holders, as well as the capability to include more individuals when engaging in such transactions. Excludability is reliant on biophysical constraints (such as those related to physics), property rights, and the applicable law. include judicial legislation, as well as other institutional frameworks. Many times, property is privately owned by its owners or leased from them by the government in order to protect their rights. This is because of specific contracts. In the latter scenario, land cannot be sold and may not be used as collateral to secure institutional loans. Surface (rivers, lakes, and groundwater) and freshwater resources are mostly subject to inconsistent political regimes. This indicates that users of the resource who are a part of the corporate group will have unrestricted access to utilize these resources exclusively without payment. There are no incentives or institutional mechanisms to control usage of these resources since they are not valued, and because there is no collective action. This may result in significant management issues in water-related environments. In watersheds, for instance, the groundwater level starts to decline as soon as regulation and storage systems are put in place, and this is accompanied by an increase in the individual cost of drilling new wells. A study in one and a half semi-arid villages in Andhra Pradesh has shown that more than 65% of the open wells and between 28% and 45% of the underground wells had dried up. More than 90% of the inhabitants in a few of the villages have completely grown up.

A well-defined and protected property right must have all of the following: accessibility, durability, robustness, and assurance. Duration measures the extensibility of the rights; robustness assesses the extent to which the rights are held; assurance measures the ability to enforce the agreed-upon 3 9 rights. There is lateral movement of soil and water resources within watersheds. Any one resource user's actions might have detrimental effects (externalities) on other resource users. This is known as unintended collateral damage. Some instances of environmental externalities go in the opposite direction of intended consequences (i.e., unintended consequences), but in other instances, the opposite is true. They could move in mutually beneficial connections (reciprocal exchanging of goods and services) [7], [8].

Lack of inclusion of unavoidable effects implies that people's decisions over how to utilize resources and what to do with their leftovers have an impact on all of the other people in their communities. In the presence of negative externalities, the degree of private resource consumption exceeds what is socially desirable, whereas the converse is true in situations where the effect is positive. The spillover effects of the kind that affect people differently require adjusted policies, as well as financial incentives that promote cooperation and collective action. The social dimension is also important for IWM; it includes a variety of social groupings with different rights to exploit natural resources in hot climates. Ethnic and transnational organizations will always have the freedom to weigh the costs and advantages of their activities, as well as their impact on the environment. unequally distributed for om water heaters are used as inserts. Inconsistent and conflicting interests are produced when generalized land ownership and use rights are combined with contractually granted access and use rights.

As a result, there are less incentives for cooperation and higher transaction costs associated with grouping resource users for cooperative action. The traditional division between a village or a city and the boundaries of the watershed is what is known as "all-knowing." Rivers and other natural boundaries often define settlements or local administrative units when the majority of them fall within of watersheds. A wise course of action to resolve this issue is to choose a village that is next to a major watershed, as this will enable the formation of a major watershed when many villages are close to one another. The need to harmonize social, political, and economic facets of society is necessary for sustainable development. NRMWL will need appropriate political authority and institutional arrangements that promote cooperation between individuals and collective efforts.

Issues relating to organizations

Collective act ion in a water-shed management mechanism is really similar to that of a magnificently crafted object. This is mostly due to the fact that many business owners and resource consumers are unstructured, disorganized, and scattered, and therefore must pay high transaction costs in mobile communities. Building structures for control of aquatic activities in watershed management necessitates the formulation of rules, regulations, and guidelines. that enable effective implementation of corporate program. There is a clear set of guidelines and rules for the state's development project that provide a legal framework for community organizations' existence. These guidelines and rules apply to users of the development project's resources, including corporations and nonprofits. Additionally, there are a number of state-specific mechanisms for promoting public policy that aid in establishing community and local public goods and that act as building blocks for more successful and effective political action. However, the amount of support required by these communities may be more extroverted establishing legal checks and balances and putting in place a system of checks and balances. Additionally, it is crucial to prevent the manifestation of mental illnesses and engage in healthy interpersonal behaviour.

DISCUSSION

This illustrates the obvious responsibility that the government must have in establishing favourable conditions. It is obvious that managing privately owned resources as well as those of other people will be the responsibility of those involved in the project. It will eventually become the primary responsibility of the nation to invest in and manage common property resources. The national government's research and development institutions will play a significant role in assisting manufacturers, corporations, and the federal government in providing crucial resources, cutting-edge technologies, and best practices for improving productivity and expanding the national resource base. It is very important that all of the participants collaborate closely toward a common objective and vision. A consensus about the terms of the agreement should be reached based on the merits of each party, as well as their relative advantage over other parties in terms of citizenship and competitiveness.

However, it will be the responsibility of all participants to contribute toward the development of effective and durable institutions. As local institutions develop, it becomes necessary to use an effective strategy for managing the transfer of all local public goods to the community. This does not imply that the NGO's and government entities should not be strengthened. Instead, it indicates that the current situation must be improved. Success will depend on the ability of the organization to adapt to the shifting conditions, as well as on its leadership and governance. For a more accurate assessment of resource utilization and a more effective solution.

Factors influencing community initiatives

Incentives for cooperative action (CA) differ depending on the types of CA problems that communities and resource users encounter. The emergence of CA in a particular context emphasizes the knowledge of inward-directedness and recognition of potential rewards from coordinating the activity of individual actors. Individual decisions about participating in activities in California are consequences of other people's behaviour. Even while the potential rewards are great, cooperative behaviour could not transfer into actual practice until individuals extend their support to other potential beneficiaries, like Weise. the existence of confidence and trust facilitates the potential for interpersonal cooperation and cooperative behaviour. In addition, individual participation in politics may take into account household-specific (idiosyncratic) characteristics that influence the costs and advantages of participation in politics.

Physical and financial assets, as well as human and social capital, may all play a big part in determining the proportional advantages from participation. The success of CA in a specific situation after it develops depends on a number of variables. The two defining characteristics of CA are quantity and quality, according to Olden. Many success stories of cooperative action by people who saw a need have been described in Nostrum’s synthesis of case studies. These incidents show how people may come together and solve problems that might otherwise be intractable. Allow them to organize themselves effectively for their collective gain. A number of characteristics, including the geographic location of the company and its subsidiaries and their geographic proximity to one another, were identified as important determinants for the effectiveness of the 42 collective efforts in managing customers. Included in them are clearly defined borders, monitoring, mitigation measures for conflict resolution, recognition of the right to organize, and the provision of appropriate punishments to punish offenders.

A significant number of empirical research have been conducted in relation to water stress management at both household and group levels. What followed looks into the contributing aspects. It revealed the essence and resolution of the issue at hand. C a method to control soil erosion utilizing information from micrometer-scale measurements made in Haiti. The study emphasizes how awareness of individual differences, assurance about others' behaviours, and a collective mass of people working toward common goals are necessary for successful cooperation in watershed management. Similar to the changes observed in the study of Indian watersheds. this study also identifies the crucial role that quality in the distribution of benefits can play in maintaining conservation efforts [9], [10].

Environmental advantages

There are environmental advantages. We weren't valued, but rather measured using certain biological indicators throughout time, such as changes in ruin, soil loss, groundwater levels, and groundcover. The soil and water management measures include plugging in and checking dams at regular intervals along the river that runs through the village and the surrounding area. In order to maintain the accessibility of the land, uncultivated areas were created with practices that were inconsistent with those of farmers, without the use of any technological advancements.

These areas served as catalysts for the implementation of soil and water conservation measures. The evidence was gathered over a period of two years. There is a large difference in the amount of soil loss from the drained portion of the river and the drained portion of the province.

The rate of evaporation has increased by around 2% to 60%, the maximum rate being from years with heavy rainfall. Since high soil erosion levels weren't maintained across all years, the findings from 2010–2011 show an increase in erosion levels of almost 60%.

Economic advantages

the average amount derived from each of the three major sources crops, animals, and farms, as well as their proportional shares in the years 2010 and 2011. The income from crops is calculated as a return to family labour and land, i.e., net of any variable expenses that are paid to third parties in addition to family labour and land using the 2010–2011 constant prices. This seems to have a large impact on the effect of IWM. In order to separate the effect of other connected effects, a mathematical formula was employed to calculate the relative impact of IWM and relevant external elements, as well as to total the number of households affected by the other factors. The findings have shown a considerable effect of IWM on current conditions, as well as total home heating costs even in years when draught occurs.

CONCLUSION

Property rights are crucial in this situation because they influence how resources are managed. The rights and entitlements that people and groups have are crucial for encouraging cooperation and internalizing externalities. Additionally, establishing strong institutional policies is essential for fostering group action and protecting natural resources. This essay explores the complex political and institutional aspects of IWM, learning from examples outside of South Asia. It emphasizes how important it is to coordinate social, political, and economic factors in order to promote sustainable development. It also deals with the complexity of property rights and how they affect the management of forests, lands, and other resources. In conclusion, coordination across a broad range of stakeholders, ranging from local communities to governmental institutions and non-governmental groups, is necessary for effective watershed management initiatives. These programs have challenging questions to answer about governance systems, resource access, and property rights. Understanding that the advantages of IWM may not be immediately apparent but are essential for the long-term sustainability of agriculture and resource management in dry places may be necessary for realizing the environmental and economic benefits.

REFERENCES:

[1] S. Saravia-Matus and S. G. Y. Paloma, "Challenges in implementing the National Sustainable Agriculture Development Plan (NSADP) for subsistence and semisubsistence farmers in Sierra Leone," *Cah. Agric.*, 2015, doi: 10.1684/agr.2015.0757.

[2] P. Bhalekar, S. Ingle, And K. Pathak, "The Study Of Some Ict Projects In Agriculture For Rural Development Of India," *Asian J. Comput. Sci. Inf. Technol. J. Homepage*, 2015.

[3] G. G. Shailendra Singh, "Plant Growth Promoting Rhizobacteria (PGPR): Current and Future Prospects for Development of Sustainable Agriculture," *J. Microb. Biochem. Technol.*, 2015, doi: 10.4172/1948-5948.1000188.

[4] R. S. Shepitko, T. A. Dugina, A. V. Nemchenko, and Y. A. Likholetov, "Multifactorial vector of regional agriculture development," *Econ. Reg.*, 2015, doi: 10.17059/2015-4-22.

[5] A. Dorward and E. Chirwa, "Strategic Options for Agriculture and Development in Malawi," *Ifpri*, 2015.

[6] L. I. Astuti, Hermawan, and M. Rozikin, "Pemberdayaan Masyarakat Dalam Pembangunan Pertanian Berkelanjutan (studi kasus Desa Asmorobangun, Kecamatan Puncu, Kabupaten Kediri)," *J. Adm. Publik Mhs. Univ. Brawijaya*, 2015.

[7] S. S. Uplaonkar and S. S. Biradar, "Development of agriculture in India through agripreneurs," *Int. J. Appl. Res.*, 2015.

[8] A. Azam, F. Nazir, M. Rafiq, S. Nazir, S. Nazir, and S. Tasleem, "Role of Agriculture in Economic Development of Pakistan," *Int. J. Business, Econ. Manag. Work. (ISSN 2410-3500)*, 2015.

[9] SoumyaKM, "Organic Farming: An Effective Way to Promote Sustainable Agriculture Development in India," *IOSR J. Humanit. Soc. Sci. Ver. IV*, 2015.

[10] A. van Arendonk, "The development of the share of agriculture in GDP and employment," *A case study China, Indones. Netherlands …*, 2015.

CHAPTER 3

SUSTAINING LIVELIHOODS IN INDIA'S DRYLAND AGRO-ECOLOGICAL ZONES: CHALLENGES AND STRATEGIES IN GROUNDWATER-BASED AGRICULTURE

Sunil Kumar, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-sunilagro.chaudhary@gmail.com

ABSTRACT:

The complexity of maintaining livelihoods in India's dryland agro-ecological zones, where agriculture mostly depends on rainfall, is examined in this research. Two-thirds of India's arable land is located in these areas, which are urgently challenged by climatic unpredictability, frequent droughts, and erroneous rainfall. The Indian government launched the Watershed Development Programme (WDP) in the early 1990s to address these issues and improve rural lives. WDP focuses on replenishing groundwater levels in order to increase irrigation coverage via soil and water conservation methods. Groundwater is a common-pool resource, but its complexity creates special governance problems. In order to promote sustainable groundwater usage in micro-watershed communities, this study investigates the function of institutions, notably agricultural extension organizations. The micro-watershed development initiative in India encourages groundwater recharge to enable irrigation in agricultural areas that would otherwise be reliant on rainfall. The results support the idea that spreading information about groundwater usage and its effects motivates group action and that extension agencies have a significant impact on farmers' crop choices. Finally, farmers with greater irrigation needs serve as a bridge between the community and the extension agency, demonstrating their capacity for managing programs.

KEYWORDS:

Agriculture, Ecological System, Irrigation, Management, Watershed.

INTRODUCTION

In India, two-thirds of the farmed land area is located in arid agro-ecological zones. Two-thirds of the food produced in this area, which accounts for 40% of global food output, is fully dependent on rainfall. Agriculture-related livelihoods have also been disrupted by rising climatic variability, such as dry spells, ongoing drought, and irregular seasonal rainfall. In the lack of irrigation, farmers suffer with poorer production or even total crop failure. These rainfed agricultural areas will now be covered by irrigation thanks to the Watershed Development Programme. The program's guiding principle is to apply scientifically prepared methods to reduce soil erosion and save water in order to revitalize all natural resources land, forests, and water within the treatment area [1], [2].

Increases in the area under irrigated cultivation, crop intensity, productivity, agricultural revenue, and farm employment are the direct benefits of the WDP. A benefit-to-cost ratio of 2:1 was discovered by impact assessment studies using data from 311 locations and another 636 sites. The adoption of a comprehensive strategy to soil and water conservation, as well as guaranteeing community engagement during the program's execution and in the post-programme phase, are necessary for maintaining the program's advantages over the long term. While a comprehensive approach may be planned for and affected by legislation, maintaining community involvement in resource management remains difficult. The primary resource on which the program focuses is groundwater, therefore actions to save soil and water are intended to guarantee that groundwater tables are recharged. Farmers then invest in wells to acquire access to irrigation.

Since groundwater is a shared resource, a farmer's use of it affects the amount of groundwater that is available to other farmers in the watershed. It is particularly challenging to keep track of how much water is being used on other farmers' property since land use rights cannot be separated from water usage rights. The fact that groundwater has a concealed network below the surface, making it almost difficult to detect subterranean water flows, further hinders the capacity to monitor. Resource monitoring is very costly because of hazy borders and scattered consumers. Finally, cheap access to motorized pumps and subsidized power have fueled groundwater exploitation. Farmers that have a lot of land and easy access to capital stand to benefit more. Overall, while the demand for irrigation from the watershed is increased by agricultural expansion, the uneven distribution of program benefits and the CPR nature of groundwater make managing the watershed a challenging challenge for both the community and local government institutions.

Depletion of the groundwater table is a common consequence of poor groundwater administration; semi-arid countries' micro-watersheds are particularly susceptible to this phenomenon, which puts the sustainability of the improvements in livelihood brought about by WDP in jeopardy. This is because of their sensitive ecology, which supports a delicate balance of extraction, replenishment of groundwater levels, and rainfall received. Unchecked over-extraction may cause watersheds to close in the worst-case scenario of bad resource management, severely harming the lives in the lower catchments. Micro-watersheds are part of socio-ecological systems, which are complex systems in which interactions between people and nature result in feedback loops that repeat a series of actions and interactions.

Dissemination of information about the resource system among resource users is a characteristic that helps them to self-organize and take collective activities for improved resource management, according to Ostrom's basic framework for studying sustainability of SES. The provision of assistance for the social learning process that enables communities to create local resource-use norms is made possible by the information dissemination. This causal relationship is supported by the complicated CPR of groundwater. Additionally, the community's resource management has improved as a consequence of knowledge sharing through field games or community champions training [3], [4].

The goal of this study is to better understand the role that institutions may play in informing the public and inspiring group action for micro-watershed communities' sustainable groundwater usage. The community is better prepared for groundwater governance with institutional assistance in the form of updated or new knowledge on resource system interaction. The organizations that are capable of giving information on system interactions and feedback include agricultural extension agencies and other institutions like the WDP project implementation agency. Additionally, they are acquainted with the area and skilled at creating specialized information distribution plans. Increased knowledge of groundwater extraction levels and their effects on the system among resource users, particularly for micro-watershed management, is likely to deter them from over-extracting it.

DISCUSSION

They were covered under the Indo-German Watershed Development Programme, a WDP that used a participatory approach to project development and execution. In the post-project phase, resource management falls within the purview of the village community. The time between project completion and data collecting is fifteen years. The lapse in time offers a chance to comprehend the current state of a developed community governance system and its consequences for agricultural livelihoods. Additionally, it makes sure that sustained and long-term benefits of the program, rather than immediate and short-term effects, are recorded in the data. In order to identify the variables that affected irrigation usage, an ordered logistic regression model is used. Enumerated household surveys were used to gather the data for the study. Both towns' entire housing stock was covered. To learn more about their backgrounds in local governance, interviews were held with three local government officials and a senior official from the agricultural extension office. The remainder of the essay is structured as follows: a quick overview of WDP in India, then an explanation of the research area, the methodology, findings, and conclusions.

In India, WDP

A watershed or catchment is an area where all of the water that falls on it drains to a single location, according to the definition provided by the Soil and Land Use Survey of India, Ministry of Agriculture and Farmer Welfare, Government of India. The river basin serves as the primary point of reference for WDP planning, and micro-scale soil and water conservation measures are implemented in each micro-watershed. The smallest, most accurate illustration of how people and environment interact is a micro-watershed, which is fed by the hydrological cycle of precipitation, runoff from rain, groundwater recharge, and evapotranspiration. Land treatments, drainage line treatments, and the creation of percolation tanks are the methods employed for resource rejuvenation. Percolation tanks are built in the valley of the micro-watershed to collect and store rainfall runoff, and land treatments are done along the ridgelines to decrease the speed at which the rainfall-runoff moves. Water that has been collected seeps down to replenish the groundwater table. In a nutshell, a ridge-to-valley strategy is used for micro-scale resource rejuvenation initiatives. The first WDP to advocate for this strategy for enhancing agricultural livelihoods was the IGWDP. Priority areas for restoration include the arid, hilly areas where poverty is prevalent and resource degradation is a problem [5], [6].

A micro-watershed often lies within the confines of one or two villages and covers an area of between 500 and 1000 hectares. The program considers community involvement as a key element in affecting program performance and the scale is suited to community-based natural resource management. Participation fosters a feeling of ownership that is essential for managing SES. As a result, the initiative devotes a lot of effort to cultivating positive relationships with the locals. Five to eight years were invested in community rapport-building activities in the micro-watershed villages that were the subject of the study. The technical committee formed to assess the effectiveness of WDP in India acknowledged IGWDP techniques of interacting with the community. During the project's conception phase, a Village Watershed Development Committee is established to improve communication between the village and the development agency. Members and office holders are chosen by the community via nomination or election. All segments of the community are represented on the committee, especially women, landless people, small-scale farmers, and people from other castes. The project agreement's rules guarantee an inclusive representation. The VWDC is provided with maintenance money and is in charge of maintaining the watershed.

Additionally, the communities are obliged to contribute 16–18% of the project's overall cost. The donation may take the form of Shramdhan, or equal monetary donation, which is voluntarily free work. The reason why the extension agencies like Shramdhan is because volunteering promotes "learning by doing," which helps develop skills for maintaining watershed infrastructure. To sum up, the empirical findings show that, while having access to irrigated land is a determining factor, institutional assistance in the form of agricultural financing and advisory services affects farmers' decisions about the crops they grow. High-value crops that use a lot of water are grown by farmers in an effort to increase their revenue. Growing horticulture crops is a sign of more advanced agricultural aspirations and social standing. As a result, they make increasing investments in wells to extract groundwater for irrigation. The WDP initiative advocated treating groundwater as a reliable supply of irrigation, but the increase in wells also created rivalry for groundwater utilization. In order to balance these conflicting demands for water, irrigation management in a micro-watershed is essential for maintaining agricultural livelihood advantages from the watershed. Good crop choice management in the community may lead to irrigation management that protects the sustainable use of groundwater. Agencies that provide agricultural extension services have a significant influence in influencing farmers' crop decisions.

Despite the fact that WDP programs created local institutions and gave them the funding to assist resource management, these institutions are unable to manage the micro-watershed in the post-project phase successfully. As one would anticipate, the villages' growth trajectories after getting access to irrigation can never be completely predicted. The VWDC was unable to control irrigation usage patterns since there was no instruction on how to manage resources. Findings from the study villages imply that a second crisis may drive communities to reevaluate how they utilize their resources. Although groundwater is a renewable resource, its ability to be replenished depends on how much of it has already been used up. The extension office must continue to communicate with the project communities throughout the post-project period in order to prevent similar catastrophes. The need for information sharing closely resembles Ostrom's classification of SES knowledge. According to Ostrom (Citation 2009), the cost of organizing is reduced when SES users exchange information and explicitly consider how their activities influence others. As it becomes clear that the connection between the extension office and the village community is highly important in the demand and supply of agricultural extension information, this aspect emerges as a major pillar of how the function of VWDC should be reinterpreted.

Results and policy repercussions

In the semi-arid dryland areas of India, where agriculture is mostly rainfed, the WDP seeks to increase irrigation coverage using groundwater-based irrigation. The intervention's conservation measures for soil and water enable the collection of yearly seasonal rainfall and groundwater table replenishment. Private wells provide farmers with irrigation access. Access to irrigation promotes agricultural intensification, which leads to a rise in well construction and an excessive amount of groundwater extraction in the micro-watershed. It is essential to monitor groundwater usage effectively to guarantee that the WDP's positive effects last for a long time [7], [8].The variables that affect farmers' demand for irrigation have been examined in this research, as well as the potential of information institutions like agricultural extension offices to help communities properly manage groundwater's CPR. The findings show that agricultural extensions have a significant impact on farmers' crop selection choices. The amount of groundwater extracted in a watershed is closely related to the crops they grow. The part that agricultural extension played in shaping this choice shows how valuable it can be in managing groundwater's CPR.

Extension offices are in a good position to create site-specific groundwater management tools because they have the necessary scientific expertise and information. The agricultural extension agency helped the community in the study villages manage groundwater effectively and sustainably by providing a water budgeting tool and training community champions for monitoring groundwater recharge and withdrawals.

The findings also show that farmers who grow crops with higher economic value but greater water use interact with the agricultural extension service. This is beneficial in two ways: first, since they use the most water, their crop selection choices directly influence sustainability; and second, because they establish a trustworthy connection between the agency and other farmers, they have the potential to be the agents of change in the neighbourhood. Additionally, the extension services' knowledge will provide farmers in groups 1 and 2 a way to enhance their agricultural livelihoods while guaranteeing resource sustainability in spite of the unavoidable rise in water extraction.

Only with more focus on information gathering, management, and dissemination in watershed communities is it possible to manage CPRs in SES situations efficiently. In order to achieve sustainable and fair economic advantages, the IWRM paradigm for managing water resources emphasizes the need of allocating water resources for both promoting commercial activity and resource rejuvenation.

This is important given India's present environmental regulations, which do not currently include natural resource management as a core component of agricultural programs. Recognizing the importance of knowledge institutions in fostering social learning toward sustainable resource usage is essential for bringing about these changes in resource allocation patterns.

While it is necessary to enhance local government institutions, new options for generating income must be paired with them. For instance, shifting market pricing for certain crops may alter how agricultural land is used. Farmers may alter their crop selections in this situation, which may affect the certainty of pricing for such crops. An institutional tradition of providing a floor of a minimum price, known as the minimum support price, for certain crops has existed in the instance of India. A notable example is the decision to set a minimum support price for millets in the Indian states of Andhra Pradesh, Odisha, and Telangana in order to discourage farmers from growing rice. A successful farm with supporting businesses deters farmers from growing high-value, water-intensive crops. The tried-and-true approach of supporting activities related to agriculture is pertinent in this situation; by enabling simple access to the market and reasonable pricing, an eco-system draws a lot more adopters [9], [10].

CONCLUSION

The management of water resources is a challenging issue. This complexity is a result of a number of factors, including the selection of an appropriate scale for planning and management, the particular approach to resource management, the division of scarce resources among different sectors, the lack of a legal framework to establish clear property rights, the absence of a rights-based approach to the market allocation of water, and evidence of climate change. A platform for two-way learning is provided by finding a solution that strikes a balance between the needs of the community and the resources of a local institution, even if this article was unable to address all of the concerns. In an Ostrom-type framework, the devolution of resource management that resulted from the failure of resource management designed at the larger scale has shown to be a more effective way to lower information costs. This is encouraging for future research on managing natural resources to support sustainable rural living. Future research that looks more closely at the technologies that might support regional organizations and achieve efficient resource management may open up new avenues for resource management to become more sustainable in SES situations. The Watershed Development Programme (WDP) has emerged as a major tactic to improve lives in India's dryland agro-ecological zones, where agriculture is often rainfall-dependent. This research has shown the complex issues and solutions related to maintaining agriculture in these areas.The crucial role that agricultural extension organizations play in influencing farmers' crop decisions, which in turn affect groundwater extraction patterns, is one important discovery. In addition to being essential for economic reasons, farmers who grow high-value, water-intensive crops also act as information brokers in their local communities. This demonstrates the role that academic institutions may play in efficient groundwater management. The study also highlights the value of community involvement and information sharing throughout the WDP post-project phase. Due to its vulnerability and need for constant monitoring, groundwater has to be extracted with care.

To promote sustainable resource usage, extension offices and local communities must maintain open lines of communication. The report also urges a comprehensive strategy for resource management that takes into account shifting market dynamics and the need for livelihood diversification. Fair pricing and supportive policies may deter farmers from high-water-use crops and help build a more resilient and well-balanced agricultural environment. In conclusion, managing water resources in dryland agro-ecological zones is a complex challenge, but this research shows that informed, community-based approaches, supported by knowledge institutions, offer promising ways to preserve vital groundwater resources while sustaining livelihoods. India may go a step closer to attaining sustainable rural livelihoods within the framework of socio-ecological systems by fostering social learning and bolstering local institutions.

REFERENCES:

[1] F. Lescourret *et al.*, “A social-ecological approach to managing multiple agro-ecosystem services,” *Current Opinion in Environmental Sustainability*. 2015. doi: 10.1016/j.cosust.2015.04.001.

[2] J. Papaïx, J. J. Burdon, J. Zhan, and P. H. Thrall, “Crop pathogen emergence and evolution in agro-ecological landscapes,” *Evol. Appl.*, 2015, doi: 10.1111/eva.12251.

[3] I. Nakalembe, J. D. Kabasa, and D. Olila, “Comparative nutrient composition of selected wild edible mushrooms from two agro-ecological zones, Uganda,” *Springerplus*, 2015, doi: 10.1186/s40064-015-1188-z.

[4] T. B. Katwal *et al.*, “Community Perspectives on the On-Farm Diversity of Six Major Cereals and Climate Change in Bhutan,” *Agric.*, 2015, doi: 10.3390/agriculture5010002.

[5] N. M. Motsa, A. T. Modi, and T. Mabhaudhi, “Influence of agro-ecological production areas on antioxidant activity, reducing sugar content, and selected phytonutrients of orange-fleshed sweet potato cultivars,” *Food Sci. Technol.*, 2015, doi: 10.1590/1678-457X.6443.

[6] H. Hao, J. Zhang, X. Li, H. Zhang, and Q. Zhang, “Impact of livelihood diversification of rural households on their ecological footprint in agro-pastoral areas of northern China,” *J. Arid Land*, 2015, doi: 10.1007/s40333-015-0049-5.

[7] M. T. Niles, M. Lubell, and M. Brown, “How limiting factors drive agricultural adaptation to climate change,” *Agric. Ecosyst. Environ.*, 2015, doi: 10.1016/j.agee.2014.11.010.

[8] A. Kamala *et al.*, “Multiple mycotoxin co-occurrence in maize grown in three agro-ecological zones of Tanzania,” *Food Control*, 2015, doi: 10.1016/j.foodcont.2015.02.002.

[9] Z. Kołoszko-Chomentowska, J. Wiater, and J. Zukovskis, “Environmental sustainability of family-owned agricultural holdings in the podlaskie voivodeship,” *J. Ecol. Eng.*, 2015, doi: 10.12911/22998993/59357.

[10] J. Pascual-Aguilar, V. Andreu, E. Gimeno-García, and Y. Picó, “Current anthropogenic pressures on agro-ecological protected coastal wetlands,” *Sci. Total Environ.*, 2015, doi: 10.1016/j.scitotenv.2014.07.007.

CHAPTER 4

ECONOMIC VALUATION AND POLICY IMPERATIVES FOR WATERSHED MANAGEMENT: BRIDGING THE GAP BETWEEN ENVIRONMENTAL ASSETS AND SUSTAINABLE RESOURCE USE

Devendra Pal Singh, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-dpsinghevs@gmail.com

ABSTRACT:

This study explores the crucial nexus between the demands of policy and economic value in the context of watershed management. Although watersheds provide a wide range of products and services to civilization, their worth is sometimes undervalued economically. The study examines the difficulties and possibilities involved in estimating the financial costs and gains of watershed management techniques. It emphasizes the significance of taking into account watersheds market and non-market values and provides insights into a number of economic valuation methodologies. It also studies the significance of environmental accounting in giving decision-makers a standard framework to evaluate the efficiency of current policies and investment rates. The importance of Payment for Environmental Services (PES) programs is emphasized in the paper's conclusion as a way to internalize advantageous environmental externalities and guarantee the long-term viability of watershed resources.

KEYWORDS:

Economic Valuation, Management, Organic Farming, Policymakers, Watersheds.

INTRODUCTION

Watersheds benefit society economically by offering a wide range of products and services. These include both marketable goods and services, like drinking water, as well as non-marketable ones, like the functions of mangroves or wetlands for storm protection or water filtration. Despite the fact that numerous studies, including one by the United Nations Economic Commission for the European Union, have noted that degradation of watershed services represents a loss of capital assets, there are still significant gaps at the policy and methodological levels. Simply put, there is presently no single framework through which decision-makers may effectively access knowledge and best practices created by academics in the area of environmental economics with relation to the value of water resources [1], [2].

Thus, as part of the process of creating policy alternatives, this background paper analyzes some of the potential and constraints related to doing an economic cost-benefit analysis of water management approaches. As the agenda for the upcoming Inter-American meeting on water is discussed, it is hoped that this will spark discussion on the subject and that economic valuation and cost-benefit analysis will be more frequently used as policy-makers try to improve on current methods of managing water resources. The fundamental obstacle to quantifying "non-market" services still exists, much like in other areas of environmental value and associated environmental accounting methods. The economic value that individuals obtain from the watersheds in which they reside, for instance, is influenced by natural hydrological processes, sustainable upstream farming practices like soil conservation, and related protection of downstream regions from floods and sedimentation. The lack of pricing or inadequate pricing of watershed ecosystem services perpetuates a vicious cycle in which environmental degradation is never fully taken into account as a component of market prices. This is because these ecosystem functions are not measured and exchanged within economic markets. Effectively, when watershed management programs are developed and put into action at the policy level, current investment flows are prioritized for other efforts and many of the most important commodities and services produced by water systems are not given fair attention.

In order to advance policy, it is suggested that a Stern-like study on the financial costs and advantages of watershed management for the Americas be created in the next months. In light of this, this paper emphasizes the advantages of using economic valuation techniques as tools that can efficiently interact with and aid in the formulation of more effective water management policies that more fully account for the total economic value of the goods and services produced by watersheds. This paper emphasizes that watershed valuation techniques are a crucial first step through which policymakers can monetarily convey the need for increased investment in the protection of natural water resources, and can justify the enactment of policies like Payment for Ecological Services to more optimally manage watersheds' goods and services to the benefit of both civil society and the environment. The paper begins with a brief overview of economic valuation as a foundation for analysis [3], [4].

Overview of economic valuation

Projects on watershed valuation initially have two goals in mind. First, valuation methodologies assist policymakers in quantifying the relative value of natural water systems in terms of economics. Furthermore, these methods provide policymakers a foundation on which to balance the preservation of such systems with boosting economic returns on the environmental benefits and services they offer. As previously said, failing to take into account the whole economic value of watersheds leads to a significant policy conundrum since management initiatives cannot maintain the integrity of entire water systems when investment rates do not account for all of the inherent values connected to such systems. The goal of traditional water management has been to invest in downstream purification technology in order to satisfy human demand for drinkable water. However, this strategy hasn't managed to prompt the necessary reflection on the close relationship between safe drinking water and the organic ecological and hydrological functioning of watersheds. The quantity and quality of marketed drinking water is entirely dependent on upstream factors, such as current agricultural practices, soil conservation efforts, and levels of forestation. These factors all have a significant impact on the overall functionality of natural ecological and hydrological watershed processes, which in turn affects the drinking water used by communities downstream. Traditional downstream purification technologies may prove more expensive than beneficial if upstream management practices like organic farming, sustainable livestock management, soil conservation, and reforestation are neglected. This is because it may become necessary to make retrofit capital investments to account for increased degradation of upstream water sources, which directly affects the quality and quantity of downstream water.

However, taking into account the entire economic value of watersheds and incorporating upstream factors into current management practices gives policymakers leverage for an alternative management option that allows them to manage water resources more holistically while simultaneously improving the livelihoods of upstream communities (for example, a farmer's increased long-term return via soil conservation). Thus, better socially and economically effective utilization of water systems will arise from internalizing the non-market values (externalities) linked to watersheds.

Policies must take into account the value of all potential marginal benefits and costs associated with water management projects in order to achieve an appropriate degree of management that will both conserve environmental integrity and improve returns on watersheds. According to neoclassical economic theory, in order to create and implement policies, communities often strike a balance between marginal gains and marginal costs. Communities won't be motivated to spend more in the current system of watershed management if marginal costs outweigh marginal gains. Project managers may determine the entire economic worth of the benefits and costs produced by such systems by analyzing the aggregate benefits and costs associated with a specific watershed. As a result, they can create and implement management policies within the relevant watershed more successfully [5], [6].

DISCUSSION

The entire economic worth now given to watersheds, however, often is wildly off. The values that are directly quantified by economic markets are often the sole values taken into consideration by watershed management programs. Current legislation often undervalues the overall economic benefits of such systems since the most recent watershed evaluations do not take non-market values into consideration. By ignoring the diverse interests that benefit from many of the non-market oriented characteristics of such systems, policy and managerial decisions may be skewed in favour of environmentally degrading practices without attempts to quantify the non-market benefits associated with the goods and services generated by watersheds.8 To reduce the impact of such negative externalities and correct the total economic value of environmental assets, economists and other experts have developed a number of methods.

It is helpful to think about the many sorts of values contained into watershed systems and how such values effect the evaluation of economic gains and costs before diving into the study of such methodologies. The 'direct-use' and 'non-use' components of the watershed systems' overall economic value are both present. The benefits that individuals obtain by directly using an associated item or service, such a watershed's irrigation capacity or drinking water, make up the direct use values of watersheds. Even though they are most closely related to human welfare, such values only make up a small fraction of the overall economic worth of watersheds. Resource managers and politicians should be aware that 'nonuse' values, or the current or potential value that individuals may obtain from products and services independent of any direct use, also make up a significant amount of a watershed system's economic worth.

Existence values, pure non-use values, bequest values, and option values are examples of non-use values. The non-use values that have the most impact on the financial worth of natural watersheds are bequest and option values. Bequest values result from people's desire to protect watersheds for future generations to utilize. On the other hand, option values result from uncertainty over the future supply or demand for watershed products and services. Neglecting the significance of such non-use values has the potential to lead to the long-term over-exploitation, degradation, and depletion of watershed resources, which would result in a general decline in societal welfare. Therefore, the advancement of better upstream management techniques including organic farming, sustainable livestock management, soil protection, and reforestation is justified by such ideals. The present need for the aforementioned practices of sustainable watershed management cannot be quantified or fully understood because the temporal scope of these non-use values is grounded in the preservation of future goods and services provided by watersheds. As a result, markets for such amenities simply do not exist. The value of non-market environmental goods and services is therefore measured by economists and policy-oriented social scientists using a variety of valuation techniques with the goal of demonstrating the total economic value of assets being assessed, ensuring that resources are being allocated optimally, and ensuring that requests for additional investments can be justified if they are required. At the policy level, valuation approaches have sometimes been used to date, although they have mostly been used in academic settings. However, unless they are used at the policy level, such strategies are of little practical utility. As a result, the section that follows discusses various environmental valuation methodologies as they apply to the products and services produced by watersheds and emphasizes how these techniques may be useful to decision-makers in charge of resolving important environmental challenges [7], [8].

Assessment of Watershed Systems

Environmental economists have created a variety of economic valuation methods over the last three decades that have been effective in determining the worth of non-market benefits related to the environment and natural resources. As previously said, it is crucial that policymakers be aware of the value and practical implementation of such strategies in order for them to directly contribute to the preservation of natural resources and the improvement of social welfare. There are already a wide range of alternative methods for valuing the economic advantages of watersheds. Both revealed preference techniques and expressed preference approaches may be used to classify them.

Methods for Revealing Preferences

Revealed preference approaches use data on human preferences for environmental and natural resources via direct or fictitious market comparisons to assign a monetary value to an environmental asset. Simply put, revealed preference methodologies extrapolate and create correlations from relevant market data to assign value to non-market items and services. Hedonic pricing and the production function or averting behaviour methods are two revealed preference techniques that are especially helpful for watershed valuation.

Hedonic Pricing

The hedonic pricing technique calculates a statistical link between the characteristics of particular surface freshwater systems and the cost of an item for which a market already exists in that same system in order to assign prices to watershed goods and services. To put it another way, the hedonic model presupposes that the valuations of market items, such as homes, are determined in part by their qualities. It is crucial to highlight that a thorough technical study of these procedures is beyond the scope of this work; hence, the explanations that follow are only intended to provide an overview of current valuation methodologies in order to make these themes politically appealing.

Method for the production function

The production function technique creates a connection between an environmental input and an output, uses current market pricing of the output to value the environmental input, and uses these values to monetize the value of watershed products and services. The production function technique calculates the difference between the profit before and after the change by taking into account all productive adjustments in situations where a change in the environmental input affects the production of products connected to the final output. For instance, the economic value of the loss is measured in terms of the change in agricultural profit taking into account all productive adjustments if deterioration in irrigation water quality changes the entire production function (i.e., altering the amount of fertilizers, pesticides, etc.). By taking into account all changes made at the productive level as a result of environmental inputs, such as chemical control and modified farming methods, the production function technique internalizes non-market watershed values.

In the case of the stated preference method, the contingent valuation (CV) method is the best strategy for determining the total economic value of watershed benefits.15 The CV method directly requests willingness to pay (WTP) estimates from a random sample of the population residing in the region of interest in order to put monetary values on the non-market goods and services produced by watersheds. The CV valuation technique employs sample surveys that ask a series of questions about fictitious projects and policy initiatives in order to arrive at these estimations. Such CV surveys typically consist of three main parts: (1) the scenario or description of the policy or program by which the good or service will be provided; (2) a value elicitation mechanism; and (3) questions pertaining to the socio-economic, demographic, and environmental factors that could potentially influence the value individuals attribute to the environmental good or service at hand.

To put it another way, a typical CV survey presents a scenario of a policy or program that will provide the good or service. Although no one methodology is more reliable than another, it is still a significant methodological problem to estimate meaningful economic benefits for all persons who can possibly benefit from changes in water quality. As previously mentioned, both use and nonuse values must be assessed in order to determine the "total economic value" of a specific improvement in a watershed system. In terms of data needs and underlying assumptions regarding connections between economic and environmental factors, the methodologies described above diverge significantly. Each valuation technique focuses on a different component of overall economic value, hence they all have various assessment potentials for the complete environmental service packages connected to watershed systems. Policymakers would thus be best advised to make use of a few of the aforementioned valuation techniques within the particular area or watershed of interest in order to correctly calculate the entire economic worth of any given watershed. Of course, it shouldn't be expected of federal agencies that have never before employed such valuation studies to use such methods in a blind manner. In order to assist the preservation of non-market watershed benefits, the following section gives a description of a case study in which different valuation methodologies were effectively used to create an estimate for a water-user charge.

The aforementioned valuation methodologies have been effectively used by several local and federal authorities to date to spark changes in the ways that water is currently managed in a variety of contexts throughout the world. The Nature Conservancy has led various valuation campaigns throughout Latin America and the Caribbean in recent years to build support for more funding for the protection of watersheds and the products and services they supply. Although there are numerous examples of successful case studies, this section will focus on one in order to keep it concise. The Sierra de las Minas Biosphere Reserve in Guatemala was the subject of a partnership between the Nature Conservancy, USAID, and local agencies. This section begins with a brief description of the Biosphere Reserve and shows how the valuation studies carried out by these organizations served as a catalyst for the creation and implementation of a water user fee as well as for new regulations that reflected a more comprehensive approach to watershed management within the Reserve.

A small NGO by the name of Fundacion Defensores de la Naturaleza (Defensores) collaborated with The Nature Conservancy and USAID to conduct several watershed valuation studies to demonstrate the value of integrating upstream forest conservation into current practices of watershed management in the Sierra de las Minas Biosphere Reserve in Guatemala. Defensores effectively produced baseline estimates for the overall economic value inherent within the hemisphere's watersheds using the valuation procedures mentioned above. To measure the total economic value of the Biosphere's watersheds, Defensores specifically used contingent valuation studies, production expenditure evaluations, and analysis of subsidiary markets. They also made the assumption that current water management practices would result in a 20–30% decrease in the current levels of forestation and stream flow [9], [10].

The results of the valuation research triggered rapid action at the community and policy levels, increasing awareness of the importance of water in rural communities throughout the Biosphere and Defensores' political clout. Such efforts have been quite successful, and since the establishment of these groups, governmental spending on watershed-related services has significantly grown. For instance, during the 2004 dry season, 14 local governments in and around the Reserve contributed funds to hire a total of 15 municipal park guards to collaborate with Defensores staff and Guatemala Protected Areas Council (CONAP) park guards to address upstream threats to downstream water quality, such as forest fires. Initiatives for watershed management have seen a rise in investment rates over time. The total number of municipal parks was

It is clear that the field of environmental economics is making progress in developing methods for communicating to project managers, policy makers, and potential investors the true value of environmental and natural services in order to spark a coordinated movement toward a more integrated approach to watershed management. In fact, the case study of Sierra de las Minas shows how watershed valuation has the potential to accomplish this goal. It is crucial to remember, nevertheless, that the degree of technical skill necessary for the effective use of such valuation approaches is sometimes lacking in many localized contexts. The Nature Conservancy and USAID arranged watershed valuation assessments in the aforementioned case studies and sent the results to the relevant local entities. This kind of direct multilateral aid, nevertheless, cannot be used consistently across all nations and in all required contexts. As a result, in 1992, the Rio Summit on Sustainable Development published an important resolution recommending that governments of participating nations use environmental accounting to coordinate current economic policies with those relating to the management of natural resources and the environment.

Environmental accounting may be used in a variety of contexts, from small and big businesses to federal organizations responsible for developing governmental policy. This article concentrates on environmental accounting at the national level since its goal is to demonstrate the benefits of using valuation methods as a crucial part of federal planning. By combining data from both fields into a single framework, environmental accounting systems in this context quantify both the influence of the economy on the environment and the contribution of the environment to the national economy. In other words, environmental accounting tracks and values national resource use, measures the costs and benefits of current and potential policies on the economy and the environment, and provides policy-makers with indicators and descriptive statistics to track interactions between economic activity and environmental assets. By leading initiatives to make the discipline of environmental accounting more comprehensible and available to all of its member nations, the United Nations Statistics Division (UNSD) propelled environmental accounting into the worldwide spotlight in 2003.

SEEA 2003, also known as National Accounting: Integrated Environmental and Economic Accounting, is a document that describes how any country can gather data on the environment and gauge the actual or potential effects of federal policies on the economy and the environment of such natural resources. SEEA 2003 created a database for strategic planning and policy analysis to find more sustainable avenues for growth in addition to unifying statistics frameworks. The information required to conduct environmental goods and services valuation is now more easily accessible to policymakers and other relevant stakeholders thanks to these unified frameworks, and as a result, the total economic value of environmental assets like watersheds can be compared to the current investment rates made in such resources.

Indeed, since the publication of SEEA 2003, environmental accounting systems have proliferated in nations all over the world, and data from these systems has been successfully used to support the adoption of regulations that take into account the full value of environmental assets (the internalization of the environmental externality). The United Nations Statistics Division, for instance, conducted a global assessment of environmental statistics and environmental-economic accounting in 2006 and found that these systems are now well-established and growing parts of national accounting programs all over the world. According to the survey, 50% of responding countries had environmental accounting programs, and 70% of respondents said they intended to expand current programs by expanding regional assessments and the informational scope of current systems.26 The study also revealed that 22% of LAC countries had environmental accounting systems at the time the survey was conducted.

Environmental accounting systems have the ability to communicate valuation study findings to policymakers, such as the cost-effectiveness of integrating upstream and downstream management methods, in the context of water management in particular. Since they offer a common informational baseline through which stakeholders and decision-makers may assess the cost-effectiveness of current policies and investment rates and enact changes accordingly, environmental accounting systems actually play an invaluable role in evaluating the economic and environmental efficiency of current water management practices. It's interesting to note that water accounts are among the modules that are most consistently collected within the current environmental accounting programs in the UNSD's worldwide evaluation of environmental accounting systems. A Regional Workshop on Water Accounting for LAC nations was recently held in Santo Domingo, Dominican Republic, in collaboration with the UNSD, the Central Bank, and the Ministry of Environment. The workshop's objectives were to: (a) provide an introduction to environmental accounting; and (b) outline the structure and applications of the System of Environmental-Economic. In light of this, a regional framework is emerging through which environmental accounting systems are being formally acknowledged and promoted as instruments that can be used to close the information gap created by valuation studies and the gap between the development and implementation of policies that reflect the overall value identified by such evaluations. The relationship between valuation studies, environmental accounting systems, and payment for ecological service programs is examined in the next section in this context.

For Environmental Services, Compensation

Direct payments for ecological services (PES) may be justified by policymakers and stakeholders as a portion of the expenditures required to manage watershed systems more cost-effectively in circumstances where valuation studies and/or environmental accounting systems assess present management techniques to be inadequate. PES systems, which include and sell environmental services in established economic marketplaces, attempt to change the incentives of service managers and/or create funds to support conservation activities. The Nature Conservancy and USAID claim that through compensation for environmentally sound land use practices, PES schemes in the water sector promote the conservation of upstream areas and, ultimately, entire watersheds30. Such compensations can be made through taxation incentives, trust-fund disbursement, or direct remuneration between bilateral or multilateral parties. For instance, in the Sierra de las Minas case study, a water user charge was established and implemented using valuation methodologies. As previously mentioned, the money obtained from this water levy was used to pay Park Rangers for their work in monitoring and safeguarding the environmental integrity of upstream land use and improving the quality and quantity of drinking water downstream. As a result, the associated governmental organizations were able to amass the money necessary to pay the park rangers so that they could control the non-market advantages found by the valuation projects in a way that was more socially and ecologically beneficial by charging all public water users.

Clearly, the concept of internalizing positive environmental externalities through a payment mechanism is one that makes sense and has been quite successful in a variety of circumstances. However, it is still unclear what kind of payment system will most effectively provide long-term financial resources to support the implementation of regulations that reflect the full value of the products and services produced by watersheds over the long run. There is currently no research that provide conclusive answers on which PES mechanism preserves watershed products and services the best effectively. This, of course, is primarily because watersheds are located in a variety of political, social, economic, and environmental contexts. In fact, the majority of PES programs that are now in place across the world have been created using locally appropriate guidelines. Nevertheless, in the context of watershed management, the expanding use of PES schemes to water-related initiatives is suggestive of a growing awareness among governmental actors, project managers, and local stakeholders with regard to the overall economic value of watershed management.

As of September 2004, over 300 different PES schemes had been inventoried throughout the world, each with unique objectives and technical payment mechanisms set up with deference to local specificities. For instance, contemporary water user rates throughout the hemisphere increasingly include the value of advantages not often evaluated by market, while in the past water values were only monetized by virtue of direct use values, such as demand for drinking and agricultural uses. However, it is essential that site-specific PES programs continue to be put into place within localities to provide the money required to internalize non-market benefits like natural hydrological functions, upstream forest conservation, and sustainable agriculture. This will help manage watersheds more efficiently throughout the hemisphere and around the world. To achieve this, project managers, political actors, and downstream water consumers must first be informed of the overall economic worth of the products and services produced by watersheds. In order to effectively communicate the value associated with upstream water conservation to all relevant stakeholders and to give leverage for using PES mechanisms as a means of accruing funds to be used toward the internalization of positive upstream externalities, it is crucial that current policies and projects related to watershed management place due emphasis on valuation studies and/or environmental accounting.

CONCLUSION

The article highlights the need to close the gap between the value of natural assets and sustainable resource use, shedding attention on the critical link between economic valuation and policy imperatives in watershed management. Watersheds are often devalued despite their many benefits to society, which results in insufficient funding for their management and protection. This topic is addressed by the study, which provides an overview of several economic valuation methods and emphasizes the significance of taking into account both market and non-market values related to watersheds. By offering a uniform framework for evaluating the effectiveness of present water management systems, environmental accounting emerges as a potent instrument for balancing economic policy with the management of natural resources. It provides a method for calculating the entire economic worth of watershed resources and assists in making policy choices that more properly reflect this value. The report also emphasizes the usefulness of Payment for Environmental Services (PES) programs as a means of internalizing advantageous environmental externalities. PES schemes create sustainable financial resources to support policies that take into account the whole value of watershed goods and services by paying people who contribute to watershed conservation. This study concludes with a call to action for policymakers, stakeholders, and environmental economists to acknowledge the economic importance of watersheds and incorporate this knowledge into policies that guarantee the sustainable management of these essential natural resources. This will ensure a better future for our watersheds and the people who depend on them by bridging the gap between environmental assets and sustainable resource use.

REFERENCES:

[1] K. D. Farnsworth, A. H. Adenuga, and R. S. de Groot, “The complexity of biodiversity: A biological perspective on economic valuation,” *Ecol. Econ.*, 2015, doi: 10.1016/j.ecolecon.2015.10.003.

[2] B. Bartkowski, N. Lienhoop, and B. Hansjürgens, “Capturing the complexity of biodiversity: A critical review of economic valuation studies of biological diversity,” *Ecol. Econ.*, 2015, doi: 10.1016/j.ecolecon.2015.02.023.

[3] M. Huxham *et al.*, “Applying Climate Compatible Development and economic valuation to coastal management: A case study of Kenya’s mangrove forests,” *J. Environ. Manage.*, 2015, doi: 10.1016/j.jenvman.2015.04.018.

[4] E. Varela and M. Soliño, “Incorporating economic valuation into fire prevention planning and management in Southern European countries,” *For. Syst.*, 2015, doi: 10.5424/fs/2015242-06449.

[5] M. M. Carballo, J. E. Araña, C. J. León, and S. Moreno-Gil, “Economic valuation of tourism destination image,” *Tourism Economics*. 2015. doi: 10.5367/te.2014.0381.

[6] J. Lee, “Economic valuation of marine litter and microplastic pollution in the marine environment: An initial assessment of the case of the United Kingdom,” *SOAS-CeFiMS London, UK*, 2015.

[7] M. Hema and P. I. Devi, “Economic Valuation of Mangrove Ecosystems of Kerala, India,” *J. Environ. Prof. Sri Lanka*, 2015, doi: 10.4038/jepsl.v4i1.7850.

[8] N. Lienhoop, B. Bartkowski, and B. Hansjürgens, “Informing biodiversity policy: The role of economic valuation, deliberative institutions and deliberative monetary valuation,” *Environ. Sci. Policy*, 2015, doi: 10.1016/j.envsci.2015.01.007.

[9] Y. A. Tegenie, “Economic valuation and sustainable natural resources management: review paper,” *J. Econ. Sustain. Dev.*, 2015.

[10] S. Nocera, S. Tonin, and F. Cavallaro, “The economic impact of greenhouse gas abatement through a meta-analysis: Valuation, consequences and implications in terms of transport policy,” *Transp. Policy*, 2015, doi: 10.1016/j.tranpol.2014.10.004.

CHAPTER 5

SUSTAINABLE WATERSHED MANAGEMENT: BRIDGING ENVIRONMENTAL AND SOCIOECONOMIC SUSTAINABILITY

Upasana, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-upasana35954@gmail.com

ABSTRACT:

By effectively managing natural resources while addressing issues of economic viability, social acceptability, and environmental security, watershed management plays a crucial role in assuring the long-term agricultural sustainability of areas. Watershed Development Programs (WDPs), which were first designed as a means of reducing poverty, have won praise from governments throughout the world for their success in reducing the effects of climate change. The ministries of agriculture, rural development, and environment and forests in India have all made contributions to WDPs using different strategies. The major goal of WDPs is to improve water management, irrigation systems, and land use practices, which will raise agricultural output, particularly in desert and drought-prone regions. In turn, this promotes sustainable development by reducing poverty, enhancing livelihoods, and improving the biophysical and socioeconomic environment. This study compares a watershed's drainage system to the human body's circulatory system in order to highlight how crucial it is. It emphasizes how crucial it is to comprehend the foundational ideas and practical implementations of participatory watershed management in order to guarantee resource preservation and sustainable production. The justification for watershed management is obvious: extensive soil erosion and loss of vegetative cover have left areas lacking in soil nutrients and water, essentially forcing them to depend on livestock-based agricultural methods. Since piecemeal strategies have failed, comprehensive watershed-based development is now necessary.

KEYWORDS:

Biophysical, Environment, Socioeconomic, Watershed Management.

INTRODUCTION

Through effective resource management, the economic and social viability of production systems, and environmental security, watershed management has become a widely recognized instrument and viable approach for long-term agricultural sustainability. The Watershed Development Program (WDP), which was originally intended as a means of reducing poverty and improving lives, has now taken on even more significance as the success of its approach in halting climate change has come to be recognized on a global scale. With significantly different methods, many Ministries in India, including the Ministries of Agriculture, Rural Development, and Environment and Forests, have been active in watershed development programs. Under the umbrella of the Watershed Development Programs, the Ministry of Rural Development has been coordinating sector-specific flagship programs such the IWDP, DPAP, and DDP.

The fundamental goal of the WDP was to raise agricultural output in desert and drought-prone regions by improving water conservation, irrigation infrastructure, and land use patterns. Sustainable development would result from reduced poverty, enhanced livelihoods, and an improved biophysical, socioeconomic, and environmental environment [1], [2]. Similar to veins and arteries in the human body, drainage lines are crucial in a watershed because water may be stored or drained via them as required. The correct development, conservation, management, and use of water resources at the watershed level including the local people are crucial for sustainable agriculture. Therefore, for resource conservation and sustainable production, a thorough grasp of the fundamental ideas, methods, and applications of participatory watershed management is necessary.

Watershed Management's Purpose

Lands that are starving for soil nutrients and thirsty for water are the results of the loss of vegetation cover followed by soil deterioration from different types of erosion. A lack of biomass for animals not only lowers animal production but also worsens the ecological balance by causing uncontrolled grazing pressure on already damaged areas. All of these locations have agricultural systems that are primarily centered on raising livestock. Increased population pressure, increased food and fodder needs, and the effects of quickly transforming socio-economic circumstances have all fueled the fire. Individual holdings or a group of farms who use piecemeal strategies like contour bunding or terracing get only modest benefits since they ignore what occurs in other places that affect the hydrological features. Farmers are often turned off by such occasional acts since the returns on the investments and efforts invested are usually insufficient to entice them. Therefore, all developmental operations should be carried out in a thorough manner on a watershed basis in order to maximize the benefits.

With an emphasis on social and institutional components in addition to bio-physical features and a participatory "bottom-up" methodology, watershed management (WSM) has therefore developed as a new paradigm for planning, development, and management of land, water, and biomass resources. The watershed technique is being used to undertake several initiatives for improving productivity. The management of watersheds is becoming more and more significant as a means of enhancing human well-being and preserving and replenishing natural resources. It is now commonly acknowledged that community involvement is essential to the effectiveness and sustainability of watershed management [3], [4].

Watershed Concept/Attack

Growth and sustainable development are fundamentally dependent on the efficient use of land and water. In order to guarantee the efficient use of both natural and social resources, the idea of watershed management has emerged. Thus, land, water, and people resources are crucial elements of the watershed development projects. The major goal of the watershed program is to raise agricultural output via greater in situ moisture conservation and protective irrigation for the socioeconomic development of rural people. It is largely a land-based program that is increasingly focusing on water.

DISCUSSION

Watersheds are considered the optimal units for planning and developing land, water, and vegetation resources since they are hydrological units comprising an area draining to a single outlet point. Due to the significance of water balances in the study of ecosystems, the watershed idea has been employed widely. The hydrologic cycle, sediment, energy, heat, carbon, and nutrient balances in an ecosystem may all be accurately measured and monitored thanks to watersheds. In order to track the status of pollutants at various places, this may create a network of monitoring stations on sites within a basin that are nested or otherwise organized. The analysis of the effects of present and upcoming actions will be aided by the monitoring at the level of watersheds or sub-watersheds in a basin, which will then assist develop area-specific management choices or alternatives based on the priorities as per the planned project goals. The idea of a watershed is not very novel. The multitude of institutes and programs dedicated to the study and management of watersheds attest to their seriousness. However, the conventional top-down strategy to managing watersheds has not been successful, in part because it has placed too much emphasis on biophysical factors without giving appropriate consideration to socio-economic factors requiring community involvement. Therefore, watershed management programs should be closely associated with the individuals whose socioeconomic and cultural backgrounds are crucial to the effective development, implementation, and administration of watershed programs. Therefore, integrated watershed management is the process of formulating, putting into practice, and overseeing a course of action involving natural and human resources in a watershed while taking into account all the factors operating within the watershed. This process covers the area from the highest point (ridge line) to the outlet [5], [6].

Watershed Programs: Development & Growth

Though initially less targeted, watershed management in India has a history dating back around 50 years. Over the years, a number of organizations have contributed to the expansion and development of watershed initiatives. For the purpose of observing changes in surface water hydrology, natural plant successions as a result of closure, and watershed interventions in 1956, these Research Centres created 42 tiny experimental watersheds. The Union Agriculture Ministry's Soil and Water Conservation Division introduced the centrally funded "Soil Conservation in the Catchments of River Valley Projects" program in 1961–1962, with the goal of protecting 27 catchments' watersheds.

Principles of Watershed Management

Size and Watershed Selection

Typically, a watershed with a working size of 500 hectares or less is recommended. Depending on the method of categorization, there are many categories into which watersheds may be divided. The size, drainage, form, and pattern of land use are the most typical classification criteria. The stream or river's width, site of intersection, drainage density, and dispersion might all be used as additional criteria for categorization. Using terms like water resource region, basin, catchment, and watershed, the All-India Soil and Land Use Surveys (AIS&LUS) of the Ministry of Agriculture, Government of India, have devised a framework for delineating watersheds. Based on the geographical region of the watershed, the following five stages of watershed delineation are generally accepted:

1. (More than 50,000 hectares) macro watershed
2. (10,000–50,000 hectares) Sub-watershed
3. (1000–10,000 acres) Milli-watershed
4. (100 to 1000 hectares) Micro watershed
5. A small watershed (1 to 100 hectares)

The size of watersheds with an extent of 3000-5000 ha are being examined for development after the impact assessment and analysis of the meta-data of the watersheds in order to suit a realistic output in comparison to bigger watersheds. Because watershed management programs are really the people's programs and because the government agency should act as a facilitator, the participatory method is more applicable in their design and implementation. This is true because it calls for not only good resource development or management, but also equitable distribution among all interested parties or beneficiaries. It also calls for the effective development, management, and maintenance of the Common Property Resources (CPR), in addition to the Private Property Resources (PPR). This requires that all watershed stakeholders adopt and execute the suggested management plan and actively participate in the processes of designing, implementing, and maintaining the plan.

In this bottom-up participatory communication method, two fundamental elements should be taken into account. The first is that the suggested development plan has to take into account what the populace requires. The suggested aims must be connected to the needs and interests of the neighbourhood community in order to be desired. The second is that it ought to be doable. Since 2008, the Government of India has adopted common criteria for watershed development projects that place a higher focus on community organizing and invest 10% of the project's total budget for this crucial component within the watershed program's preparation phase. Prior to starting the program's development activities, enough emphasis should be given to spreading knowledge about the new strategy and the key components of the "Common Approach for Watershed Development" among the community members. Repeated gatherings in big or small groups might be planned for this purpose. When holding big group meetings, it would be beneficial if traditional street dramas, folk music, etc. were used to convey the spirit of the redesigned watershed program. If necessary, a summary version of the recommendations in the local tongue may also be disseminated to those who are interested [7], [8].

Watershed Development Plan/Detailed Project Report (DPR) preparation

A watershed treatment and development plan, comprising drainage line treatments and infrastructure development, is created for both arable and non-arable lands based on the current land use, the LCC map, issues, needs, and priorities identified by participatory rural appraisal (PRA). A typical plan could include the following components:

Measures for protection and conservation

The majority of completed projects indicate that a combination of structural and vegetative measures is the best course of action. Water harvesting structures like ponds, nalla bunds, small dams, percolation ponds, etc., drainage line treatments with engineering structures and vegetation for checking land degradation and conserving water; repair, restoration/strengthening of existing common structures for sustained benefits from previous improvements are all included in this.

Production Measures

Included in this category are the actions necessary to sustainably produce consumer goods like food, fodder, fuel, fruit, fibre, milk, etc. by making effective use of conserved soil and water resources. Improved crop cultivation and management techniques, afforestation, alternative land use models, the cultivation and raising of industrial, medicinal, and aromatic grasses and plants for the provision of alternative livelihood support systems, the development of livestock, dairying, poultry, sericulture, fisheries, and other crucial income-supporting activities are some examples of these.

Convergence Strategy

A single-window, integrated area development program is watershed management. It's possible that integrated watershed management cannot be done alone by resource integration employing a multidisciplinary approach with the money or assistance offered under any watershed program, such as NWDPRA, IWDP/DPAP, etc. This may also include the coordinated use of resources from other sectors and development plans for the area/district that are now being implemented or already exist. Such resources may be integrated with watershed projects, which will aid in both effective monitoring and the helpful convergence of multiple schemes and programs for the area's overall development. Education, health, sanitation, drinking water, roadways, and other industries may be included among them, and the majority of these may be integrated with the entrance point operations. The present Five-Year Plan provides a chance to combine and coordinate the resources of various programs and schemes, particularly those under Bharat Nirman and other Flagship Schemes, with watershed development initiatives.

Increasing Capacity

Both the field level project staff/officers and functionaries of people's institutions, i.e., the watershed community, which is often overlooked, need training and capacity development in this emerging idea of multi-disciplinary integrated participatory watershed management. Along with improving the technical abilities of the project team, this would also provide community members the chance to grow their ability to carry out DPR-required tasks and maintain the program after the project is through. According to the new standards, 5% of the overall budget allocation will be used to increase the capacity of the watershed community and its officials.

Evaluation and Monitoring

In the past, this has been among the projects' weaker points. Provisions should be created in the project for monitoring and creating data bases in both space and time, and an appropriate agency should be found to carry out this duty in order to implement any necessary mid-term changes. According to the common approach standards for watershed development, 2% of the overall budget for the watershed has been set aside for monitoring and effect assessment of the watershed initiatives. Repair and upkeep of watershed management and soil conservation projects have not received the attention they should have under the conventional top-down management style. A formal institution should be established and given this duty, ideally with the active participation of the local community. In this endeavour, participatory watershed resource management is a suitable illustration. Watershed Committees (WC) or Village Resource Management Societies (VRMS) may manage resources, create income, and take care of repairs and upkeep for these buildings. When necessary, the government authorities should provide the appropriate technical direction or monitoring. In accordance with the new guidelines for watershed development projects, 5% of the total budget has been set aside for the program's consolidation and final phase in order to ensure its sustainability in addition to building a corpus fund through project and community contributions under the name of the Watershed Development Fund (WDF).

Natural resource management and social resource management are combined. For benefits to be sustained, social resource management (SRM) and natural resource management (NRM) must be integrated. If action plans for each component are created independently within each SHG/UG, if the aforementioned plans are carried out by the appropriate groups, and if sufficient emphasis is placed on production enhancement and livelihood support activities in addition to protection and conservation activities by combining short-, medium-, and long-term gains for the watershed community, then such integration would be made easier. In the modern context of participatory watershed management for comprehensive development of rainfed regions, this is becoming more and more significant [8], [9].

Development of Water Resources

Both nationally and internationally, the development and effective management of water resources are of vital significance. Water collection using Tanka, Ponds, Bawories, Khadins, and other methods has a long history in our nation. The watershed program's technique for building small embankment/dug-out type ponds offers a workable substitute for the large river valley projects, for which environmental requirements are becoming more strict. While the cost of small irrigation projects was projected to be approximately Rs. 45,000 per ha (1995 pricing level), the cost of producing micro-irrigation using tiny harvesting structures ranged from Rs. 9000 to 20,000 per ha. The community used communal fence to save several catchments so that water collecting systems could be preserved and used economically for irrigation. Everywhere any irrigation could be given by building modest buildings in a watershed program, it was discovered that creating local institutions was considerably simpler and that success rates were greater. Depending on the crop and soil, supplemental irrigations enhanced output by 119 to 485 percent. Outstanding conservation choices for basin, sub-basin, or watershed level planning include multiple or cascading uses of water, recycling of waste waters, and value addition. The growth of aquaculture via the use of water collecting structures has a significant impact on the livelihood security of rural populations.

Control of Mass Erosion

Landslides, mining waste, and rivers all contribute to widespread soil erosion and degradation issues in the nation's hilly terrain. For the bioengineering technology-based restoration of such severely damaged areas, CSWCRTI, Dehradun, has launched pilot projects. The successful applications of this method include the Bainkhala stream control project, the Sahastradhara mining spoil rehabilitation project, and the Nalota nala landslide project on the Dehradun-Mussoorie route. Highly damaged mine waste and landslide slopes were rehabilitated with modest engineered structures like Watling, geojute, loose stone/gabion check dams, contour trenches, etc. and planted with appropriate plant species. One of the crucial initiatives was the treatment of drainage lines using gabion constructions. The adoption of the bioengineering technique not only led to the area's rehabilitation but also to a sustained improvement in the area's water and vegetation resources for the benefit of the local populace. Due to frequent changes in their route, the hill torrents and rivers have been severely damaging the nearby agricultural and forest regions as well as the people via bank cutting and floods. The institution has developed strategies for training torrents and using the recovered areas that line their banks. The hydraulic flume laboratory experiments aided in the safe and cost-effective construction of spurs for training torrents.

Applications of New Scientific Methods for the Development of Watersheds

Geographical Information Systems (GIS) and Remote Sensing (RS): Remote Sensing (RS) data from both aerial and space platforms provides a better method for more rapid, effective, and trustworthy data collecting. RS data are distinctive and provide a comprehensive image of the terrain with all of its aspects expressed at once. Information produced from remote sensing will need to be combined or integrated with the traditional database using the appropriate software. A geographic data base may be created using information gathered from a variety of sources, including topographical maps, thematic maps created using ground surveys or remote sensing data, cadastral maps, census records, etc. These many data sources may be used as inputs and transformed into a standardized map format. These data may be specifically integrated and analyzed using the right tools to provide results that are valuable, such as maps or statistical statistics.

A geographic information system (GIS) is a useful tool for compiling, organizing, storing, synthesizing/analyzing, and retrieving pertinent data of both geographical and non-spatial origin. An electronic tool called a GIS is used to analyze and manage both geographical and non-spatial data. Database management and digital mapping are two computer software technologies that are combined in GIS. A methodical approach to retrieving and arranging tabular data is database management. Map components are represented digitally as points, lines, polygons, or grid cells. In order for both sets of data to be updated and adjusted to the connection between them when either the map or the tabular data are modified, digital map components and tabular data must be connected. Recently, GIS has advanced quickly, making it feasible to produce, alter, store, retrieve, and utilise geographical data at a pace that is considerably quicker than with traditional techniques. GIS is the perfect solution to assist this process since management and topological overlays of significant amounts of spatial and non-spatial data are a need in watershed planning.

International Positioning System

A satellite-based navigation system called the Global Positioning System (GPS) can instantly provide location and time everywhere in the world. It is made up of a constellation of 24 orbiting satellites that go around the sun twice daily at a height of around 20,000 km. The specific position (Latitude, Longitude, and Altitude) and time are sent by each satellite. The location of a handheld GPS receiver is triangulated using broadcast signals from the GPS satellites. GPS may be used in a variety of ways to manage local resources and track activity over wide regions. More and more remote sensing data is being verified/ground truthed using GPS receivers to get comprehensive attribute information. Particularly when creating the thematic maps needed for watershed planning, GPS data may be a crucial input to the GIS. To effectively characterize and evaluate the functions and conditions of watersheds, data from GPS surveys and remote sensing may be used inside GIS. Differential Global Positioning Systems (DGPS) are used to improve the precision of the location information acquired by GPS receivers. Differential correction may be used while processing data in the office or in the field in real-time. Despite the fact that both approaches share the same fundamental ideas, they access various data sources and attain various degrees of accuracy. Combining the two approaches increases data integrity and offers flexibility during data collecting.

One of the main pieces of survey testing equipment is the total station, which is really an optical device with a variety of uses in surveying. A total station is a common electronic optical tool used in contemporary surveying. The electronic theodolite (transit), electronic distance meter (EDM), a measuring tool for reading distances, and software operating on an external computer are all components of the total station surveying apparatus. Robotic total stations, which are more recent iterations of survey total stations, allow the user to operate the instrument remotely. This surveying tool's primary duties are determining coordinates, measuring angles and distances, and processing data. This is widely utilized in fields including aerial photogrammetry, mining, road mapping, and land surveying [10].

Telemetry Inspection

Measurements and data collecting are done remotely and relayed for monitoring via telemetry, a highly automated communications approach. Although the initial systems employed cable communication, this technology often employs wireless transmission. The most significant applications of telemetry include gathering meteorological data, monitoring hydrological data, keeping an eye on power facilities, and tracking human and unmanned space missions. A transducer serves as the input device in a telemetering system, which also commonly includes a transmission channel in the form of wired lines or radio waves, signal processing equipment, and devices for storing or displaying data. A physical quantity, such as temperature, pressure, or vibration, is transformed by the transducer into an electrical signal that is then delivered across a distance for measurement and recording. Google Maps are web-based maps that provide higher-resolution resource information on the surface of the world. This may be used to map resources (Land use, vegetation, water resources, etc.), define watershed borders, monitor and assess watershed initiatives, even at the micro-watershed level. This event logger connects to most common tipping-bucket rain gauges and records rainfall times, duration, as well as momentary contact events and temperature. Because event data is stored as it occurs, memory is efficiently used. The data logger has event/measurement memory of 32,000 events. Data can be viewed in inches or millimetres. Tips are logged with time-stamps.

The system is powered by two rechargeable sealed maintenance-free batteries with integral solar panel, which easily keeps the batteries charged all year long. the evaporation sensor can be attached with this data logger for the collection of data. the digital evaporation recorder comes with a weather proof enclosure which contains the data logger power supply, sensors, and comes complete with a solar panel & pan. Measurements can automatically store in the system's memory with a date and time stamp according to the user-selectable logging period. It also includes an integral solar panel, which will easily keep the batteries charged throughout the year. The digital water level recorder is made up of a weatherproof enclosure that houses the data logger and power supply, as well as a Shaft encoder type water level sensor.

CONCLUSION

A comprehensive paradigm for organizing, developing, and managing land, water, and biomass resources has evolved called watershed management (WSM). It adopts a participative "bottom-up" methodology and includes several initiatives aimed at increasing productivity. This study emphasizes the need of community involvement in watershed management, which is now a widely established practice. The study digs into the fundamentals of watershed management, with special emphasis on the choice and size of watersheds, carrying out fundamental resource assessments, writing in-depth project reports, and encouraging convergence with diverse development strategies. The importance of capacity development, monitoring, and evaluation as part of watershed management is also emphasized. It is emphasized that integrating social resource management with natural resource management is essential for obtaining long-term advantages. The research also examines the use of contemporary scientific technologies in watershed development, including remote sensing, geographic information systems (GIS), global positioning systems (GPS), telemetry monitoring, and digital recording equipment. By facilitating data gathering, monitoring, and evaluation at both temporal and geographical scales, these technologies help people make better decisions. In attaining agricultural and environmental sustainability, this study emphasizes the necessity and significance of sustainable watershed management. In order to secure the effective use of natural and social capital in the development of watersheds, it asks for the continuous use of integrated, community-driven initiatives. This will eventually result in the prosperity of rural communities and the protection of vital natural resources.

REFERENCES:

[1] P. Singh, A. Gupta, and M. Singh, “Hydrological inferences from watershed analysis for water resource management using remote sensing and GIS techniques,” *Egypt. J. Remote Sens. Sp. Sci.*, 2014, doi: 10.1016/j.ejrs.2014.09.003.

[2] B. Alemu and D. Kidane, “The Implication of Integrated Watershed Management for Rehabilitation of Degraded Lands : Case Study of Ethiopian Highlands,” *J Agric Biodivers Res*, 2014.

[3] Y. Kim and E. S. Chung, "An index-based robust decision making framework for watershed management in a changing climate," *Sci. Total Environ.*, 2014, doi: 10.1016/j.scitotenv.2013.12.002.

[4] M. J. Bunch *et al.*, "Watershed management and public health: An exploration of the intersection of two fields as reported in the literature from 2000 to 2010," *Environ. Manage.*, 2014, doi: 10.1007/s00267-014-0301-3.

[5] A. Amini, P. T. Ghazvinei, M. Javan, and B. Saghafian, "Evaluating the impacts of watershed management on runoff storage and peak flow in Gav-Darreh watershed, Kurdistan, Iran," *Arab. J. Geosci.*, 2014, doi: 10.1007/s12517-013-0950-1.

[6] L. S. Prokopy, N. Mullendore, K. Brasier, and K. Floress, "A Typology of Catalyst Events for Collaborative Watershed Management in the United States," *Soc. Nat. Resour.*, 2014, doi: 10.1080/08941920.2014.918230.

[7] A. G. Samaras and C. G. Koutitas, "The impact of watershed management on coastal morphology: A case study using an integrated approach and numerical modeling," *Geomorphology*, 2014, doi: 10.1016/j.geomorph.2013.12.029.

[8] G. L. Bagdi and R. S. Kurothe, "People's participation in watershed management programmes: Evaluation study of Vidarbha region of Maharashtra in India," *Int. Soil Water Conserv. Res.*, 2014, doi: 10.1016/S2095-6339(15)30023-X.

[9] M. A. Sloan and B. T. Bidolli, "Watershed management through transportation funding," *WIT Trans. Ecol. Environ.*, 2014, doi: 10.2495/EID140511.

[10] Mingxin Guo, "Effective Watershed Management: Planning, Implementation, and Evaluation," *J. Waste Water Treat. Anal.*, 2014, doi: 10.4172/2157-7587.1000e119.

CHAPTER 6

STRATEGIC MAPPING AND PRIORITIZATION TECHNIQUES FOR WATERSHED MANAGEMENT

Ashutosh Awasthi, Associate Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-ashuaw@yahoo.in

ABSTRACT:

In order to preserve environmental integrity, guarantee sustainable resource use, and increase agricultural output, watershed management is essential. It is essential to use strategic mapping and prioritizing approaches to solve the various difficulties inside a watershed. These methods are useful for describing the landscape, identifying regions that are susceptible to soil erosion, and figuring out where conservation activities would have the most impact. For the protection of the ecosystem and the sustainable use of resources, effective watershed management is crucial. The importance of strategic mapping and prioritizing methods in watershed management is examined in this research. It explores the techniques for classifying watersheds and determining the places that need soil conservation the most. The research places a strong emphasis on the use of morphological, hydrological, and sediment yield variables to identify priority watersheds. By using these measures, stakeholders may effectively allocate resources and adopt focused initiatives to reduce erosion and sedimentation, thereby improving the health and resilience of the watershed.

KEYWORDS:

Hydrological, Management, Morphological, Sedimentation, Watershed.

INTRODUCTION

Various methods in watershed management are planned using maps and plans at various sizes of various areas/locations. A plan is described as a visual depiction of characteristics on the earth's surface projected at a certain scale onto a horizontal plane, which is represented by the sheet of paper on which the plan is created. The depictions are known as maps when the scale is small. If the scope is broad, it is referred to as a plan. Typically, the topo sheets provided by Survey of India are utilized for watershed planning. There are several scales of these topo sheets. To develop integrated watershed management methods, additional maps, such as topo sheets, land capability categorization maps, current land use maps, soil maps, drainage maps, slope maps, etc., are needed. The fundamental knowledge regarding the watershed's geographic situation is provided by topographical maps. The selection, delineation, and characterization of the watershed all depend on these maps. The methods of map analysis and interpretation with regard to watershed planning are described in this subject [1], [2].

Reading a map

Reading maps is a crucial first step in gathering data for watershed planning and management. Reading a map involves the following stages.

1. The map's orientation
2. Symbols and legend
3. The map's scale
4. Dimensions and angles in the horizontal and vertical
5. Recognition of both natural and artificial ground characteristics
6. Drawing the borders of the watershed.

If the map is being utilized in a field environment, alignment of the map entails lining up its north with the true north. If not, locate north on the map as the first step, then fix the other direction after that. The size of the map is another crucial aspect of interpreting a map. The set ratio that every distance on a map or picture bears to the equivalent distance on the ground is known as the scale. The scale of the map is 10 m to 1 centimetre, which is often stated as 1 cm = 10 m or 1: 1000, if 1 cm on the map corresponds to 10 m on the ground. The term "Representative Fraction" (R.F.) refers to the proportion between a given distance on a map and its comparable distance on the ground. It is independent of unit of measurement. You may recall that regardless of height, the distance between any two locations on a map or plan is always their horizontal separation.

Watershed management is a multifaceted, complicated profession that deals with pressing problems in agriculture, ecology, sustainability, and water resources. Strategic mapping and prioritizing approaches must be used to manage and protect watersheds successfully. These methods are essential for comprehending the terrain, spotting problematic regions, and effectively allocating funds for soil conservation efforts. This in-depth explanation looks at the importance, procedures, and uses of strategic mapping and prioritizing tools in watershed management [3], [4].

The Importance of Prioritization and Strategic Mapping Techniques

Watersheds are dynamic landscapes with a wide variety of terrain, soil types, land uses, and climatic variables. Techniques for strategic mapping make it possible to characterize these environments in great detail. Topographic maps, land capacity classifications, land use maps, soil maps, drainage maps, and slope maps are all examples of this. Each of these maps offers useful details on the physical characteristics and environmental conditions of the watershed.

Resource Allocation

To effectively manage watersheds, it is necessary to allocate scarce resources to tackle certain problems. Participants may decide where to allocate their resources by using mapping and prioritizing tools. These methods enable targeted interventions to reduce soil erosion and sedimentation by identifying regions with the greatest potential for erosion. Watershed health is seriously threatened by soil erosion and sedimentation, which must be mitigated. By identifying crucial erosion-prone regions via strategic mapping, proactive solutions such contour bunding, terracing, and trenching are made possible. Techniques for prioritization aid in assessing the severity of erosion in various landscape units, enabling more targeted conservation actions [5], [6].

Techniques for Prioritization and Strategic Mapping

Morphological Characterization

A watershed's morphological attributes provide information about its hydrological features. Catchment size, perimeter, stream order, length, bifurcation ratio, drainage density, compactness coefficient, elongation ratio, circulation ratio, relief ratio, relative relief, and average slope are some of these metrics. Understanding the whole landscape and its possible susceptibility to soil erosion is made easier with the use of these measures.

Hydrological Characterization

Hydrological factors that affect runoff and sediment output in a watershed include rainfall patterns, evaporation rates, infiltration capacity, and soil moisture storage. Assessing the influence of these elements on erosion and sedimentation involves mapping hydrological data, such as isohyetal maps, soil maps, and plant cover maps. Sediment Yield Indices: When prioritizing watershed management initiatives, sediment yield is a crucial factor. Based on the features of the terrain, other indices may be computed, such as the sediment yield index (SYI). To estimate sediment production, SYI takes into consideration variables including slope, land use, soil type, and rainfall. Higher SYI values are associated with watersheds that are prioritized for erosion control efforts.

Applications of Prioritization and Strategic Mapping Techniques

The identification of priority watersheds within a larger catchment is one of the main uses of these approaches. Watersheds having the highest potential for erosion are identified using sediment yield indices and erosion intensity mapping units. Setting watersheds as a top priority enables effective resource management and focuses conservation efforts.

Work Scheduling

Once priority watersheds have been determined, thorough work schedules may be created. These plans include the precise conservation measures required, their expected costs, their reasons from an economic standpoint, and the roles and duties of the parties engaged in their implementation and upkeep.

DISCUSSION

On a map, the horizontal distance is measured along the paper's layout, but the height is often shown by contour lines that connect places of equal elevation. These lines assist in finding on the map characteristics including hills, ridges, valleys, depressions, and plains that are crucial for locating different land use management measures. Such a depiction that displays the range of land slope degrees is a slope map. If all other variables remain the same, increasing the land slope will cause the runoff to flow more quickly, increasing the severity of soil erosion. Maps of slope may thus be used as reference points to gauge the severity of soil erosion and possible soil loss. In addition, it may serve as a theoretical foundation for assessments of soil quality and the appropriateness of various land uses, including agriculture, forestry, grassland, agro-forestry, horticulture, and animal husbandry. It is vital to create a slope map because it may be used, together with information on soil type and rainfall, to determine if engineering constructions like contour bunding, graded bunding, terracing, and trenching are appropriate for particular fields located in watersheds.

Description of the Watershed

The hydrological features of a watershed are immediately reflected in its morphology. When there is a lack of hydrological data, morphological factors are crucial for anticipating the catchment's hydrological response. The following morphological characteristics are typically extracted from the map of each sub watershed after the catchment has been divided into sub watersheds.

(i) Catchment area and its perimeter.

(ii) Stream order, stream length, and bifurcation ratio: Horton's approach is often used to establish the stream order. Small, unbranched tributaries are given order 1, streams with just the first order are given order 2, streams with the second and lower orders are given order 3, etc. Rotameters are used to measure stream length. The number of streams in any given order to the number of streams in the next higher order is known as the bifurcation ratio.

(iii) It is described as the stream's length divided by the area. The number of hydrological features present in a watershed is reflected in this metric.

(iv) The compactness coefficient, which is defined as the ratio of the watershed's perimeter to its circumference, measures how compact a region is.

(v) This is the ratio of a basin's greatest length to a circle with a diameter equal to that of the basin. Values around unity for areas with modest relief, but values in the range of 0.6 to 0.8 are often related to stony terrain and steep slopes.

(vi) This ratio compares the area of a basin to the area of a circle with the same perimeter. For the first and second order basins in uniform shales and dolomites, the value of the circulatory ratios is uniformly between 0.6 and 0.7.

(vii) The longitudinal distance along the biggest dimension of the catchment parallel to the main drainage line divided by the maximum basin relief is known as the relief ratio. The difference between the highest and lowest main stream alleviation is the maximum basin relief. Thus, the relief ratio gauges the basin's entire incline. The ratio of the highest relief to the basin parameter is known as the relative relief.

(viii) Standard slope S=MN/100A, where M is the total length of contours within the watershed, N is the contour interval, and A is the area of the watershed, is used to calculate the average slope of a catchment. The contours shown on the map may be used to immediately calculate the slope at any location within the Watershed.

Biological Characterization of Water

It is necessary to have soil maps, plant cover maps, and drainage maps for watersheds overlaid with isohyetal maps for hydrological characterization. The quantity of runoff and sediment yield generated by a watershed is significantly influenced by the hydrological parameters of the watershed, such as rainfall, evaporation, infiltration, transpiration, soil moisture storage, and ground water storage. Runoff and sediment yield are the results of the interplay between rainfall and watershed features and these hydrological parameters. The curve number approach is the most used for runoff estimation. With the aid of the above-mentioned maps, the curve number of every land parcel may be determined using the curve number table, and runoff can be approximated using the isohyetal map. It is possible to estimate the watersheds' sediment production using the universal soil loss equation. Alternately, some of the hydrological properties of the watersheds may be determined using morphological criteria [7], [8].

Priority Watershed Selection

For the efficient application of soil conservation measures, a catchment's priority watershed selection is crucial. The following criteria may be used to demarcate such priority zones. The most popular set of criteria for watershed management is the sediment yield index or sediment production rate. The morphometric parameters may be used to estimate the sediment production of a watershed in an indirect manner, or the hydrological characteristics can be used to directly determine it. To estimate sediment yield using morphometric characteristics, however, relevant models must to be accessible for that area. Prioritizing watersheds is done by figuring out the likely sediment yield of various watersheds using the two approaches outlined below in the absence of models for calculating sediment yields: First Approach: By contrasting the severity of erosion and sediment yields, this technique prioritizes watersheds. The stages that make up the process are as follows.

To identify the wide range of geology and geomorphic landforms, a quick reconnaissance assessment of the whole region is conducted. The whole region is separated into large landscape sections based on the noticeable variances in these qualities. Broad geomorphic differences, such as mountainous landscape, alluvial landscape, intermontane valley, etc., may be used to build the landscape units. A mapping legend is then created for each mapping unit based on notable variations in slope, gradients, land use, cover conditions, current erosion, and management strategies. The accompanying parameters make up the mapping units known as EIMU. It divides the whole watershed into its constituent parts. As previously mentioned, physiography, slope gradient, soil properties including surface texture, depth, and colour, land-use, and surface conditions all play a role in determining erosion intensity mapping units. These units are given weighted values and serve as representations of sediment detachment. A number of 10 is seen as static, signifying that erosion and sedimentation are in balance; a value greater than 10 implies erosion, while a value less than 10 suggests deposition.

Values assigned to delivery ratios

Based on its intrinsic characteristics, a comparative maximum delivery ratio is established for each mapping unit. The delivery ratio for each mapping unit in various sub watersheds is determined by taking into account its size, form, drainage pattern, physiography, slope gradient, distance from the main stream/dam, etc. Each watershed is given a priority ranking after the SYI calculations. The watershed with the greatest sediment yield index receives the highest priority ranking. The classification of a watershed is done in 5 priority categories: very high, high, medium, low, and very low, based on the sediment yield indicators. The work plan for watershed treatment, which defines the watershed and its issues, is produced once the inter-se priorities of the watershed within the catchment have been determined. It outlines the general order in which the project's tasks are to be carried out, the projected expenses, the financial rationale, and the roles and duties of individuals involved in installing, running, and maintaining the measures required for the watershed's preservation and enhancement. The work plan will change from one watershed to the next because of the differences in difficulties [9], [10].

CONCLUSION

The interpretation and analysis of diverse geographic data, such as topographic sheets, land capability classifications, land use maps, soil maps, drainage maps, and slope maps, are necessary for the mapping and characterization of watersheds. These data sources provide insightful information on the watershed's natural characteristics and circumstances, which is crucial for developing integrated watershed management methods. effective prioritizing and mapping strategies are essential to watershed management. These methods help stakeholders make wise choices about resource allocation and conservation activities by accurately defining watersheds and identifying priority regions. The identification of watersheds with the greatest potential for erosion is made possible by the use of morphological factors, hydrological information, and sediment yield indicators. This enables targeted interventions to reduce soil erosion and sedimentation. Ultimately, strategic mapping and prioritizing strategies help watersheds be more resilient and healthier in general. It enables groups and communities to take proactive steps to protect the environment for future generations by preventing erosion, preserving natural resources, and more. The objectives of environmental preservation and long-term agricultural sustainability are aligned with these strategic methods, making watershed management a more effective and sustainable practice.

REFERENCES:

[1] G. L. Bagdi *et al.*, "Post-adoption behaviour of farmers towards soil and water conservation technologies of watershed management in India," *Int. Soil Water Conserv. Res.*, 2015, doi: 10.1016/j.iswcr.2015.08.003.

[2] M. G. Kang and S. W. Park, "An Adaptive Watershed Management Assessment Based on Watershed Investigation Data," *Environ. Manage.*, 2015, doi: 10.1007/s00267-014-0442-4.

[3] D. Zhang, X. Chen, and H. Yao, "Development of a prototype web-based decision support system for watershed management," *Water (Switzerland)*, 2015, doi: 10.3390/w7020780.

[4] K. Floress, K. Akamani, K. E. Halvorsen, A. T. Kozich, and M. Davenport, "The Role of Social Science in Successfully Implementing Watershed Management Strategies," *J. Contemp. Water Res. Educ.*, 2015, doi: 10.1111/j.1936-704x.2015.03189.x.

[5] A. K. Misra, A. Pachouri, and A. Kaur, "Watershed Management Structures and Decision Making Frameworks," *Water Resour. Manag.*, 2015, doi: 10.1007/s11269-015-1094-8.

[6] M. Hadush, "the Role of Community Based Watershed Management for Climate Change Adaptation in Adwa, Central Tigray Zone," *Clim. Chang. Conserv. Res.*, 2015.

[7] Z. F. Mohamad, A. Nasaruddin, S. N. Abd Kadir, M. N. Musa, B. Ong, and N. Sakai, "Community-based shared values as a 'Heart-ware' driver for integrated watershed management: Japan-Malaysia policy learning perspective," *J. Hydrol.*, 2015, doi: 10.1016/j.jhydrol.2015.09.043.

[8] A. M. Erickson, "Nested Localized Institutions for Adaptive Co-Management: A History of State Watershed Management in the Pacific Region of the United States," *Soc. Nat. Resour.*, 2015, doi: 10.1080/08941920.2014.933920.

[9] T. Gashaw, "The implications of watershed management for reversing land degradation in Ethiopia," *Res. J. Agric. Environ. Manag.*, 2015.

[10] G. Temesgen, "The implications of watershed management for reversing land degradation in Ethiopia," *Res. J. Agric. Environ. Manag.*, 2015.

CHAPTER 7

A COMPREHENSIVE ANALYSIS AND MANAGEMENT STRATEGIES FOR TORRENT AND STREAM BANK CONTROL IN WATERSHED MANAGEMENT

Anil Kumar, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-anilsingh2929@gmail.com

ABSTRACT:

Torrents, which are often described as watercourses with irregular flows, quick gradient changes, and high sediment dynamics, are essential to the dynamics of watersheds. Their efficient management is a high concern in watershed management strategies since they may seriously harm the surrounding landscapes via significant erosion, sedimentation, and destruction. This in-depth investigation examines the numerous aspects of torrents, their effects on watersheds, and methods for long-term management and conservation. In the context of watershed management, this publication gives an in-depth investigation of torrents and stream banks. Watershed health is severely hampered by torrents, which exhibit highly variable flows, steep slope gradients, sediment movement, and rapid changes in channel dimensions. In order to lessen the negative impacts of torrents on nearby lands and ecosystems, the research underlines the significance of strategic mapping, prioritizing methods, and other management strategies. It describes how to evaluate torrents, choose effective management tactics, and put into practice things like drainage line treatments, drop structures, revetments, and other things. The importance of land appraisal and capacity categorization in maximizing land use and resource conservation within watersheds is also covered in the publication.

KEYWORDS:

Environment, Management, Sedimentation, Watersheds.

INTRODUCTION

The main criterion for defining a torrent as a water course is the formation, transport, and deposition of sediment. Other characteristics of a torrent include highly variable discharges, high slope gradients of the bottom, high scouring activity, transport, and deposition of sediment, and frequent changes in channel dimensions. The ratio between the lowest and maximum discharges, or the fluctuation of discharges, may be as large as 1:5000 or even more. After a prolonged rainy season, when the soil in the watershed no longer has the ability to absorb the flood rain water, abrupt variations in torrent flows often occur. A defining property of torrents is that their discharge increases quickly to a maximum and then decreases just as quickly. Because of the ground's steep incline, surface runoff quickly collects in the channel and may eventually reach the lower reaches of the torrent when it rains. The primary indicator of the stream's "torrent" character is its scouring action, which releases and transports gravel debris downstream. The torrent channel itself, gravel deposits transported there from tributary ravines and steep valley slopes subject to erosion are some of the sources of sediment [1], [2].

The steep slope and unbalanced flow directions of the torrent channel cause scouring and movement of silt from it. The carrying capacity of the water stream, which moves gravel benches, releases more sediment, and deepens the bottom, increases with the gradient of the channel. Concave banks are exposed to a high pressure that promotes severe bank scouring and the loosening of significant quantities of gravel in torrent channels with unregulated flow direction. Water transports the increased silt from the channel of the torrent further downstream and dumps it once again where the torrent has a lower slope and, thus, less carrying capacity. This results in further harm since the gravel sludges up the farms around as well as the course of the torrent. If a torrent is not contained or stabilized, it might continue to grow and destroy nearby areas. Therefore, in order to decrease flow velocity, protect banks and side slopes from undercutting (or scouring), and safeguard neighboring fields and forest plantings, drainage line treatments (DLT) procedures are required.

Control methods for stream banks and torrents

To maintain the channel grade, prevent undercutting/scouring of the bank and, as a result, the recurrence of new slides/slips, proper disposal of runoff and sediment via discharge torrent and stream bank is essential. Due to the frequent changes in their paths and related flash floods during the monsoon, hill torrents and streams seriously harm nearby areas, people, and property. At such downstream portions, spurs, retards, retaining walls, etc. are utilized to train the torrent flow and lessen the severe gradient of the torrent. Reduced slopes result in decreased flow velocity and silt carrying capacity, which causes silt to settle in the bed of a stream.

Planning and Choice

To create a longitudinal section (L-Section), plan, and cross-section (at a few spots), a survey of drainage lines and torrents is conducted. This aids in the planning of various DLT initiatives. A reconnaissance survey of the affected area is conducted to determine the type and extent of problems and likely causes. Cadastral and/or contour maps of the catchment with details (like contours with interval of 5-10 meters, Land use maps with boundary and area of each land use, Soil texture, Soil infiltration, etc.) are some of the important data and information needed for planning and selecting of Drainage Line Treatment (DLT) measures [3], [4].

On the map, the impacted area and drainage line are shown so that the watershed area at a specific location may be identified and used to calculate peak discharge. In order to design a socially acceptable remediation plan, a transect walk of the drainage line(s) may be undertaken with local community members to gather their opinion of the reasons, as well as their needs and priorities. In order to determine the extent of the issue and whether the gully has been stabilized by natural vegetation or is still in an active stage of development, the depth, width, and side slopes of torrents, their condition in terms of erosion, the condition of natural vegetation growth, etc. are observed during field investigations and surveys. This will assist in determining the sorts of therapy needed, as well as their priority. To determine the highest discharge or flood peaks that may have occurred in the past, researchers looked at the area's rainfall intensities throughout a range of time periods and return intervals. To aid design the location, kind, and quantity of treatment measures, longitudinal sections will offer torrent gradient or bed slope and sites of precipitous drop or fall. In order to plan and design the construction, the cross-section will offer the width and depth at the necessary section.

DISCUSSION

A blanket of boulder/stone rip-rap or mat, known as revetment, is often applied to the steep and high vertical banks, away from the direct force of flood waters, to protect it from erosion. Revetments are advised on such steep, high banks where vegetation cannot provide protection and valuable properties reach all the way to the stream bank. In the lower part of the stream, moving toward the bed, it may also be utilized in conjunction with a retaining wall. Retaining walls are installed on the deteriorated slopes along gully or stream banks, next to road cuttings, or on steep, weak slopes close to the toe, or lower bank, to prevent earth or slope failures like landslides. Unlike revetments, these barriers may also be directly impacted by floodwaters. Retarders in the form of thick lines of live hedges in very low banks, jetted posts, or in the form of series of jacks can be used for erosion control along the eroding bank of a stream with stable gradient where the primary objective is not to change the alignment of the drainage line but to retard or dampen stream velocity to prevent erosion of the bank or scour of its toe. When protecting stream banks from direct stream flow at bends or in other straight stretches is not practicable using retards, spurs are required to divert the flow of water away from the bank and allow the land to be reclaimed [5], [6].

When the advantages of such structures outweigh the expense of building, permanent check dams are built. It is made of soil, metal, stone masonry, concrete blocks, reinforced concrete, or concrete blocks. The primary purpose of the construction is to securely transfer, from a higher elevation to a lower height, the peak rate of runoff for a certain periodicity. It should be equipped with mechanisms to disperse discharge kinetic energy inside the structure in a way and to an extent that will prevent damage to the structure and downstream channel. The following requirements should be met during construction.

Measures for Treating Drainage Lines in Torrent Control

When there is a high degree of safety against the loss of life and property and the volume and peak rate of runoff are both extremely significant and cannot be managed by other methods Because it is unavailable and unable to maintain regularly, the site has to be secured. In medium to big torrents, which transport greater runoff, permanent structures are employed, particularly in the lower portions. The heads of gullies are often steep and may sometimes drop practically vertically. It is advised to use a straight drop structure to regulate gully heads in these places if the fall or drop at the gully head is only 3 or 4 meters. Permanent drop structures (masonry, reinforced concrete, gabions, earthen gully plugs) are often employed as grade stabilization structures when there is an abrupt drop or fall in the gully. For drop structures, a sturdy narrow section with a gently upstream bed and a wider breadth is preferable. Permanent drop structures (masonry, reinforced concrete, gabions, earthen gully plugs) are often employed as grade stabilization structures when there is an abrupt drop or fall in the gully. For drops of up to three to four meters, drop structures are advised.

For drop structures, a sturdy narrow section with a gently upstream bed and a wider breadth is preferable. There shouldn't be any bends or curves upstream or downstream of the structure within at least 30 meters of the location. Because of its positioning, the spillway's centre line coincides with the direction in which water is flowing via the drainage line. If it is impractical to minimize curvature at a given location, excellent upstream alignment must be prioritized, and riprap is supplied at the bends. The approach channel shouldn't have any obstructions or channel limitations that might disrupt the design flow. In order to prevent flooding of nearby lands and homes, the site should have banks high enough to support the maximum depth of flow over the structure [7], [8].

The available standard type designs of check dams for a given size of catchment must be modified according to the unique site conditions, at the very least in terms of providing adequate head wall extension for proper abutment with the banks, side walls depending on bank conditions, including the provision of weep holes, and proper apron. It is important to take into account downstream scouring protection. Additionally, it must be assured that masonry breast walls, side walls, etc. are not built on recently filled, unstable ground. The purpose of watershed planning is to direct land use choices in a manner that uses environmental resources in the best way possible for people while also protecting them for the future. This planning has to take into account both the natural environment and the types of land use that are envisioned. There are several instances when natural resources have been harmed and land use projects have failed because the reciprocal links between land and the uses to which it is put were not taken into consideration.

The potential of a piece of land for a specific use may be determined via two different processes: land assessment and land capability categorization. Evaluation of the land is a necessary step in effective land management. The systematic appraisal of a piece of land's potential for alternative uses is known as a land evaluation. The appraisal of a piece of land's current performance is known as a land evaluation. This is important because it may have an impact on how the property is used in the future and, in certain situations, how its needs and characteristics evolve. The connection between a fundamental resource assessment and the decision-making process for land use planning and management is created by land evaluation. It makes available to customers the pertinent data on land resources required for planning, development, and management choices. There are several techniques for evaluating land. These techniques try to evaluate the characteristics of the land or its appropriateness for a particular land use as influenced by significant biophysical factors.

Land

Land is made up of the physical environment, which includes the capacity for land use as well as the climate, terrain, soils, hydrology, and vegetation. It covers both positive and negative effects of human activity, such as soil salinization and the reclaiming of land from the sea. However, the idea of land does not encompass purely economic and social features since they are a component of the economic and social environment. A mapped region of land with certain features is referred to as a land mapping unit. Natural resource surveys, such as soil surveys and forest inventories, identify and map the units of land. The size and scope of the research affect how homogeneous or variable they are internally. A river flood plain, which is mapped as a single unit but is known to include both well-drained alluvial sections and marshy depressions, is one example of a single land mapping unit that may encompass two or more distinct kinds of land with differing suitabilities. Additionally, they will be divided into two groups for the purpose of evaluating the land based on their traits and capacities. Soil and terrain are just a small part of the idea of land.

For this reason, soil surveys are sometimes the primary foundation for determination of land mapping units. Soil variation, or variation in soils and landforms, is often the primary source of variances between land mapping units within a local region. However, since it is impossible to evaluate soil suitability for land use in isolation from other environmental factors, land is used as the foundation for suitability assessments. When land features are used directly in assessment, issues occur because of how the characteristics interact. For instance, the risk of soil erosion depends on the interplay of many factors, including slope angle, slope length, permeability, soil structure, rainfall intensity, and other factors. It is advised that the comparison of land with land use be made in terms of the attributes of the land due to this interaction issue.

Suitability and competence of the land

In several land categorization systems, most notably the one used by the U.S. Soil Conservation Service, the phrase "land capability" is employed. Agency for Agriculture. According to the USDA method, soil mapping units are largely categorized according to their capacity to sustainably grow common cultivated crops, silvipasture, and pasture plants over an extended period of time. Others see capability as a classification of land primarily in relation to degradation hazards, while some see the terms "suitability" and "capability" as interchangeable. Some people see capability as the inherent capacity of land to perform at a given level for a general use, while others see suitability as a statement of the adaptability of a given area for a specific kind of land use.

Due to the wide range of meanings attached to "capability," as well as its historical connection to the USDA system, the word "land suitability" is used in this framework and "capability" is not mentioned again. Land suitability is the appropriateness of a particular kind of land for a certain purpose. The land may be taken into consideration in its current state or after upgrades. The evaluation and categorization of certain land parcels according to their appropriateness for predetermined applications is the land suitability classification process. The capability classification's structure is first explained. The breadth of accepted interpretive categories, including qualitative, quantitative, and appropriateness for present or future use, is then described. Separate classifications are produced with regard to each kind of land use that seems to be pertinent for the region in line with the generally accepted criteria. Therefore, a distinct capacity categorization is produced for each of these three types of use, for instance, in a location where arable usage, animal production, and forestry were all thought to be feasible on specific sections. Current land performance may be a factor in land appraisal. However, it often entails change and its results, including changes to how land is used and, in some situations, to the actual land itself. The following questions should thus be addressed by land evaluation:

1. How is the land now handled, and what will result from a continuation of existing procedures?
2. What modifications to current management techniques are possible?
3. What additional uses of the land are technically feasible and important from an economic and social standpoint?
4. Which of these applications has the potential for long-term production or other advantages?
5. What negative consequences—physical, financial, or social—accompanies each use?
6. What ongoing inputs are required to achieve the intended output and reduce the negative effects? What are the advantages of each use type?

Planning for land use and evaluating the land

Planning a watershed involves several different steps, including evaluating the land. In various situations, its exact function differs. It is adequate to summarize the land use planning process in the current setting using the following broad list of choices and actions:

1. Identifying and defining the many kinds of land that are found there.
2. Acceptance of the need for change.
3. Formulation of suggestions including various land-use types and identification of key prerequisites.
4. Comparing and evaluating each form of land according to its intended purpose.
5. Deciding on the best use for each kind of land.

Following the identification of this requirement, the goals of the proposed change are determined, and broad and detailed suggestions are then developed. A variety of possible uses are described throughout the evaluation process, and each one is evaluated and compared in relation to the various types of land found in the region. This results in suggestions that focus on one or a few recommended uses. The recommended types of land use for each unique region component may subsequently be determined using these guidelines. The desired applications will typically be given further in-depth examination in later phases, which will be followed, if it is decided to go forward, by the execution of the development project or other kind of modification and monitoring of the systems that result.

Parallel and two-stage methods for evaluating land

Which of the following techniques to land assessment is used will determine the connections between resource surveys, economic and social analyses, and how the many types of land use are developed. A method with two stages, the first of which is primarily concerned with qualitative land appraisal and the second of which consists of economic and social analysis afterwards (but not always). a strategy used in conjunction to economic and social study that examines the connections between land and land use. The two-stage technique is often used in studies for the evaluation of biological productive potential as well as resource inventories for general planning objectives. The classifications of the area's appropriateness for various land uses, such as arable cropping, dairy farming, maize production, and tomato production, are made during the fires stage of the survey. Economic and social analysis' only contribution to the fires stage is to evaluate the applicability of various land use types. These outcomes may then be submitted to the second et age, that of economic and social analysis, either right away or after a period of time, after the first et age has been finished and its conclusions have been presented in map and report form [9], [10].

In the parallel method, the survey and evaluation of physical characteristics happen concurrently with the economic and social study of the various land use types. The uses to which the assessment relates are often changed during the course of the investigation. For example, in the case of farming arable land, this adjustment can include crop and rotation selection, calculations of labour and capital inputs, and optimization of farm size. In forestry, it could also include things like choosing the right tree species, scheduling when to thin and cut down trees, and taking any necessary safety precautions. This method is most often used for detailed and semi-detailed degrees of intensity and specialized recommendations related to development initiatives.

The parallel technique is anticipated to provide more accurate findings faster. It provides a greater opportunity to focus survey and data-collection efforts on generating the information required for the assessment. The two-stage strategy has a distinct sequence of tasks, but it seems to be simpler. Economic and social analyses follow physical resource assessments without overlap, allowing for more flexible sequencing of operations and personnel hiring. Managers, engineers, and government officials may need to use the assessment tool known as land capability classification to help them evaluate alternative practices or general designs that will overcome unfavourable soil or terrain characteristics and minimize off-site effects like sedimentation and waterway pollution. The systematic division of land into different groups in accordance with its capacity to support a certain land use without causing land degradation is known as land capability classification. As the foundation for estimating the risk of erosion and other land use restrictions and hazards, the technique entails the identification and interpretation of distinctive land units with comparable climatic, geological, landform, and soil characteristics.

Indian classification practices

The many land capacity grades vary from the best and easiest to farm land to property that is not suitable for grazing, forestry, or agriculture but may be suitable for wildlife, recreation, etc. Thus, the capacity classes may be divided into two categories: those that are suitable for cultivation and those that are not. Based on the severity of the dangers involved and use restrictions, each group is further classified into four capability groups. As a result, capability classifications are established by the severity of land use restrictions that include dangers.

Sub-classes within the land capacity class are defined by the categories of constraints and dangers. The sub-classes are then separated into units based on a particular management practice, which it will react to 'unit' is the last and most essential sub-division in this classification system for practical planning purposes as it sets the management practice on each little piece of land.

Subclasses of land capabilities

The degree of restrictions or severity of the danger in land usage determines a land capability class. Planning cannot be done at this time since only the degree of difficulty is known. There are no land capability classifications that address the specific threat or issue. The subclasses describe the kind of restriction or risk. For instance, class III property has areas suitable for agriculture but exposed to severe water erosion risks owing to steep slopes, severe wind erosion risks on flat terrain, and severe water logging or overflow risks due to shallow bedrock depth. The following four types of constraints are recognized at the sub-class level:

1. This subclass is made up of soils whose vulnerability to erosion and historical erosion damage are its main determining elements. For instance, IIe will show mild erosion issues.
2. Comprises soils where the main risk associated with their usage is excess water. The factors that determine this sub-class include poor soil drainage, dampness, a high-water table, and overflow. For instance, Iiw will need to limit overflow or floods.
3. Soils with rooting zone constraints: This subclass contains soils with rooting zone limits including shallowness, stones, poor moisture holding capacity, low fertility, salinity, or alkalinity. For instance, IIs can indicate a mild drought issue, stones interfering with ploughing, or a less-than-ideal effective soil depth.
4. Comprises soils where warmth or a lack of moisture are the only significant hazards to utilizing the land as a result of climate.
5. The little letters denoting the danger that come after the Roman numeral for the land capacity class are used to represent (map) the land capability sub-classes, for example. e.g., IIe, IIIs, IIw.

When two different types of risks or restrictions exist, both suffixes may be used; however, the dominant suffix, like IIec, is shown first. When two types of constraints are equivalent, the sub-classes are prioritized in the following order: e, w, s, and c. Subclasses are thus a good indicator of the kind and degree of a constraint.

The soils in a capability unit are homogeneous enough to: (i) produce the same types of cultivated crops and pasture plants using the same management techniques; (ii) need comparable conservation management under the same kind and condition of vegetative cover; and (iii) generate equivalent conservation treatments. It has a similar potential for output. Information is provided by the capacity unit for planning specific land parcels. Due to individual variances, lands with the same capability class and subclass may not react to the same treatment. For instance, class IIIs would indicate land with significant soil limitations that might result from one of the following factors.

CONCLUSION

The necessity of comprehending and properly controlling torrents and stream banks within the framework of watershed management is highlighted in this document's conclusion. Due to the particular features of torrents, specific approaches and treatments are necessary to reduce their negative effects on soil derisiveness, sediment movement, and overall watershed health. In order to reduce the negative impacts of torrents and encourage sustainable land use within watersheds, stakeholders may take proactive measures by using techniques including drainage line treatments, drop structures, revetments, and land capability categorization. The protection of the environment and the people who rely on these essential water supplies depends on this all-encompassing strategy.The last stage in classifying a land capability is the land capability unit. It is the combining of one or more distinct soil mapping units with comparable potentials, enduring constraints, or dangers.

REFERENCES:

[1] P. Zhang, F. Yan, and C. Du, "A comprehensive analysis of energy management strategies for hybrid electric vehicles based on bibliometrics," *Renewable and Sustainable Energy Reviews*. 2015. doi: 10.1016/j.rser.2015.03.093.

[2] M. Aliakbari and B. Bozorgmanesh, "Assertive classroom management strategies and students' performance: the case of EFL classroom," *Cogent Educ.*, 2015, doi: 10.1080/2331186X.2015.1012899.

[3] S. Öztürk, "Determining management strategies for the Sarikum Nature Protection Area," *Environ. Monit. Assess.*, 2015, doi: 10.1007/s10661-015-4302-3.

[4] F. Nejabatkhah and Y. W. Li, "Overview of Power Management Strategies of Hybrid AC/DC Microgrid," *IEEE Transactions on Power Electronics*. 2015. doi: 10.1109/TPEL.2014.2384999.

[5] M. S. Behzadi and M. Niasati, "Comparative performance analysis of a hybrid PV/FC/battery stand-alone system using different power management strategies and sizing approaches," *Int. J. Hydrogen Energy*, 2015, doi: 10.1016/j.ijhydene.2014.10.097.

[6] O. Vors and N. Gal-Petitfaux, "Relation between students' involvement and teacher management strategies in French 'difficult'' classrooms,'" *Phys. Educ. Sport Pedagog.*, 2015, doi: 10.1080/17408989.2014.882889.

[7] B. Wang, J. Xu, B. Cao, and X. Zhou, "A novel multimode hybrid energy storage system and its energy management strategy for electric vehicles," *J. Power Sources*, 2015, doi: 10.1016/j.jpowsour.2015.02.012.

[8] I. van Deventer, P. C. van der Westhuizen, and F. J. Potgieter, "Social justice praxis in education: Towards sustainable management strategies," *South African J. Educ.*, 2015, doi: 10.15700/saje.v35n2a956.

[9] J. Wiedenmann, M. J. Wilberg, A. Sylvia, and T. J. Miller, "Autocorrelated error in stock assessment estimates: Implications for management strategy evaluation," *Fish. Res.*, 2015, doi: 10.1016/j.fishres.2015.07.037.

[10] R. M. Hughes, "Recreational fisheries in the USA: economics, management strategies, and ecological threats," *Fish. Sci.*, 2015, doi: 10.1007/s12562-014-0815-x.

CHAPTER 8

INTEGRATED WATERSHED MANAGEMENT: ENHANCING SUSTAINABILITY THROUGH ADVANCED PLANNING AND VEGETATIVE RESOURCE CONSERVATION

Kusum Farswan, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-kusumfarswan.14feb@gmail.com

ABSTRACT:

When managing land, water, and biomass resources, Integrated Watershed Management (IWM) takes a holistic strategy that emphasizes social and environmental considerations while encouraging community involvement. The importance of IWM is examined in this research, with a focus on cutting-edge planning strategies and the preservation of vegetative resources to improve sustainability in watershed development projects. The paradigm of detail project reports (DPRs) must be changed in order to advance holistic resource management, and this requires the use of contemporary technologies such as Geographic Information Systems (GIS), Remote Sensing (RS), and modelling. This research emphasizes the crucial significance of IWM in protecting and improving watershed resources by analyzing topography, soil erosion, land degradation, and other important elements. Additionally, it highlights the ecological and financial advantages of using vegetative approaches for soil and water conservation. The paper also examines the value of accurate rainfall analysis, return intervals, and weather patterns when designing engineering structures in a watershed environment. This study finally emphasizes the complexity of watershed management and the need for creative, scientific solutions to handle it. It is feasible to develop sustainable watershed management programs that provide environmental, social, and livelihood security by combining sophisticated planning techniques with vegetative conservation tactics.

KEYWORDS:

Environment, Ecological, Remote Sensing, Soil Erosion, Topography, Watershed Management.

INTRODUCTION

As a new paradigm for managing land, water, and biomass resources with an emphasis on social and environmental factors and a participatory approach, watershed management has arisen. Watershed management is more of a strategy for managing natural resources holistically and holistically. It attempts to combine the management of social and environmental resources. Preventive, progressive, corrective, and curative strategies are often used. Watershed management entails the wise use of natural resources with the active involvement of institutions and organizations while maintaining ecological balance. It is a complicated procedure with many different goals and multi-faceted roles. It produces several advantages that are combined to provide productive, protective/recoverable, environmental, social, and livelihood security. In order to create Action Plans and Detail Project Reports that will result in a watershed management program that is sustainable, planning is essential [1], [2].Watershed management has evolved as a groundbreaking paradigm for holistic resource management, focusing on the intricate interplay of land, water, and biomass resources within a geographical area. In recent years, Integrated Watershed Management (IWM) has gained prominence as an approach that prioritizes social and environmental factors, fosters community engagement, and relies on cutting-edge technology to revamp traditional practices. The essence of IWM lies in its commitment to combining the management of both natural and social resources, ensuring their prudent utilization while preserving ecological equilibrium.

This paper delves into the compelling realm of IWM, with a specific emphasis on its critical components: advanced planning techniques and the conservation of vegetative resources. It explores the pivotal role of modern technology, including Geographic Information System (GIS), Remote Sensing (RS), and modeling, in redefining the landscape of watershed development projects. By leveraging these technological advancements, the conventional approach to detail project reports (DPRs) is transformed, steering toward more holistic and effective resource management. The core elements of IWM extend beyond technological innovation. They include a comprehensive understanding of topography, soil erosion dynamics, land degradation patterns, and other critical variables that influence watershed sustainability. Within this context, the paper underscores the importance of strategic planning for watershed resources, ensuring their preservation and development in harmony with the natural environment.

Furthermore, this research investigates the manifold advantages of incorporating vegetative methods for soil and water conservation within the IWM framework. These methods are hailed for their cost-effectiveness, ecological benefits, and immediate impact on the well-being of local communities. By nurturing vegetative resources, IWM not only mitigates soil erosion and safeguards water resources but also offers essential provisions like fuel, feed, fiber, and thatching materials, thereby enhancing the livelihoods of those residing within the watershed. In addition to vegetation, this study delves into the intricate world of rainfall analysis, return periods, and weather patterns, recognizing their pivotal role in engineering structure design within a watershed context. Precise data on rainfall intensity, duration, and volume, combined with an understanding of return periods, is indispensable in developing infrastructure that can withstand the challenges posed by unpredictable weather events. this paper illuminates the multifaceted nature of watershed management and the imperative need for innovative, science-driven approaches to address its complexities. By integrating advanced planning techniques and vegetative conservation strategies, it is possible to formulate sustainable watershed management programs that not only ensure environmental protection but also enhance social well-being and livelihood security within these crucial landscapes [3], [4].

Common Guidelines for Watershed Development Projects-2008 place a strong emphasis on using new science and technology inputs, such as Remote Sensing (RS), Geographic Information System (GIS), and modelling, to shift the way detail project reports (DPRs) are created for the implementation of watershed development programs. Watershed planning is one of the crucial operational applications that may result from combining and integrating data from several sources, including conventional, remote sensing, and other sources. The complexity of the planning process, which includes watershed management, is presented in the study, along with the use of advanced scientific tools like GIS, RS, GPS, and modelling. Additionally, a framework for providing information to watershed planners and end users has been considered, along with a consolidated national watershed database system.

Watershed Management

A watershed plan prescribes planning at a micro level within the watershed and makes recommendations for how watershed resources should be safeguarded, maintained, and developed. Consequently, a vast range of information and data as well as a variety of techniques are needed for micro-level planning. The Multi-Tier Ridge to Valley Planning and Implementation, the Focus on Livelihoods through Integrated Farming Systems, and Scientific Planning Using New Science and Technology Inputs including RS, GPS, GIS, and Modelling to Bring a Paradigm Shift in Watershed Projects have all been highlighted in the Common Guidelines for Watershed Projects effective from April 2008 (Samra and Sharma, 2009). In order to solve this, planning has received more attention, with a 1% allotment in the Common Guidelines designated for DPR preparation.

Watershed Planning Modelling

Basic data layers like topography (i.e., slope), soils (i.e., texture, depth, hydrologic soil groups), soil erosion and land degradation, etc. are utilized to create derived data layers for themed maps. Higher resolution RS data, GPS, and GIS capabilities offer the ability to get around issues with traditional and time-consuming planning procedures. The use of modelling is now made possible by the multi-data method, which involves integrating and compiling data from traditional and/or RS and other sources using GIS. Using advanced modelling methods, critical regions are defined and intervention areas are prioritized.

Watershed modelling as a tool for planning

Lack of a trustworthy database and scientific planning often shows up in overly generic tactics or prescriptions in a DPR as well as inadequate intervention selection and placement, which results in unsuccessful plan execution. This is attributed to a number of factors, including (a) a lack of crucial baseline data at the watershed level, (b) challenges integrating multiple databases and manipulating their spatial relationships, (c) a lack of use of scientific tools, and (d) inadequate capacity building at the level of the field functionaries, the actual watershed managers. To address these issues, scientific planning using contemporary tools and approaches in conjunction with PRA has been highlighted. The ability to collect data, comprehend processes, and use modelling in watershed planning has significantly improved thanks to recent advancements in remote sensing, GIS-based modelling, and visualization capabilities, as well as the expansion of the Internet and the World Wide Web. The use of GIS in watershed management has shifted from operational assistance to prescriptive modelling and tactical or strategic decision support systems, including as inventory management and descriptive mapping [5], [6].

DISCUSSION

The idea of watershed management entails the holistic development of land, water, biomass, human, and animal resources for a sustainable production system and the enhancement of the living conditions of those who reside within the watershed. Therefore, the basis of watershed planning continues to be the development and management of the natural resource base, particularly soil and water. Understanding how soil and water relate to land use and transition within the confines of the watershed, or hydrological border, is essential for managing soil and water. Planning for watersheds must include runoff estimates, soil erosion, and land capability analysis.

By dividing a watershed into parcels of land use/cover or hydrologic response units (HRUs), one may estimate runoff by calculating land use/cover and CN for each cell or element. In order to predict runoff by entering rainfall data, each HRU or cell may be given a curve number. After that, an area-weighted CN is generated for the watershed. Planning for conservation measures requires the identification and allocation of watersheds into land capacity classes (LCCs). GIS may be used to split a watershed into LCC using data layers for drainage, slope, depth, and erosion risk. This may be done by successively overlaying several data layers in an interactive visual mode, or it can be done by building a GIS application or module to automate and modify the process. A sample field survey, which includes resource maps created from a PRA exercise, may be used to verify and enhance the LCC map as it has been generated.

Possibilities for Planning Watersheds Using Free Resources

As a time-bound activity of the watershed program, preparing a DPR in a short amount of time becomes challenging in the context of available resources at the watershed/local and national levels. The watershed must be thoroughly surveyed, which takes time, is challenging, is costly, and is extensive. It gets challenging to create contour maps at the watershed level. Surveying India's topographical maps at the prescribed contour interval may not be useful, particularly if the watershed is located in a plain. In other cases, there are no contour lines present inside the boundaries of the watershed of interest. Costly land use maps made with LISS-III data are another issue. Therefore, one option is to rapidly construct such baselines utilizing free resources like the Google Earth interface and GIS open source applications such as Map Window, GRASS, and many more [7], [8].

Designing and planning soil and water conservation techniques requires an analysis of the rainfall and runoff of a watershed. Derivation of parameters that describe the rainfall pattern in a watershed is implied by rainfall analysis. Runoff, floods, drought, and water yield estimates are all aided by hydrologic analysis of rainfall-driven characteristics. The safe and cost-effective design of small and medium-sized engineering constructions takes into account the maximum predicted rainfall of various return intervals for this reason. Rainfall drives the process of runoff, which is dependent on the bio-physical features of the catchment. Estimating runoff takes into account both its volume and peak rate of flow. Peak runoff rate is used for building streams, spillways, and other outlets, while runoff volume estimates are needed when evaluating the storage capacity of earthen dams, tanks, ponds, and other similar structures. The flow velocity needed to calculate the scour pattern in the riverbed and along the banks is another crucial quantity of relevance in drainage line treatment. So that soil and water conservation buildings may be designed, several characteristic characteristics of runoff are necessary. Surface runoff, which makes up the majority of a catchment's total water supply, is taken into consideration while treating drainage channels. The most popular runoff calculation techniques are covered in this chapter.

Weather Analysis

In order to determine such factors that may be employed in the construction of engineering structures, rainfall data from a particular location is evaluated. Rainfall intensity, which is often reported in millimetres per hour (mm/h), is one of the most significant parameters of importance. The intensity, length, and volume of the rainfall all affect how much runoff occurs. Even while they often produce flooding and erosive damage, very powerful storms are not always more common. Therefore, such seldom occurring, high intensity storms are taken into consideration in the design standards. The capacity of the runoff conveyance system is determined by the projected depth of rainfall during a certain time period. The statistical phrase "the return period," which estimates the likelihood of a high intensity storm occurring in a given place within a certain time, reflects the idea of time. The return period, also known as the recurrence interval, is the time frame during which it is anticipated that the depth of rainfall for a certain length will be matched or surpassed at least once.

Recent Developments in Vegetative Management of Natural Resources

About 80 million hectares (58%) of India's 140 million ha of agricultural land are severely eroded. On agricultural land, runoff water and the action of raindrops on soil particles are the main causes of erosion. The amount of vegetation on the land is crucial in reducing runoff and soil erosion. Since vegetative barrier technology is inexpensive to install, simple to maintain, and offers immediate advantages like fuel, feed, fibre, and thatching material, it may be nature's gift to marginal and small farmers in a significant portion of the nation. These farmers, who have a good point, think that these grasses fortify the bunds and keep them from collapsing during the monsoon, when overland floods are extremely significant. The provision of much-needed biomass for sustaining rural people' daily requirements across a range of sociocultural and ecological zones is another advantage of vegetative methods for soil and water conservation. In order to reduce erosion and preserve in-situ moisture on both arable and non-arable fields, the National Watershed Development Project for Rainfed Agriculture (NWDPRA), which is now in operation in 2500 small pilot watersheds, primarily uses low-cost vegetative methods.

the projects that get international funding, such the Himalayan Watershed Development project in Uttar Pradesh. The State of Karnataka, M.P., and Maharashtra's Pilot Watershed Development Project in rainfed regions has placed a lot of focus on vegetative measures. Despite being considerably less expensive, environmentally benign, and farmer-friendly, vegetative methods may only be used to reduce water erosion under particular circumstances. The stability of disturbed areas, such as roadside slips, canals, and dam walls, among others, as well as general improvements in cover and infiltration, safe transportation of sporadic large volumes of water through contour bunds, waterways chute and spilway, are among them. People have begun to recognize how vegetative strips on contours provide a powerful filtration mechanism, lower runoff, prevent soil erosion, and aid in the creation of natural terraces.Grass species have a lot of potential for conserving soil and water. the significance of choosing the right grass species to utilize as live hedges. There is a significant binding effect of grass roots on soil particles. Grasses enhance the biological activity, structure, and productivity of the soil. Grasses boosted the soil's effective organic matter mostly due to their quick root development, extensive fine root system, and fast root biomass turnover rate.

Plant-based barriers' characteristics

For creating vegetative barriers, grasses provide a number of benefits. They take root fast, expand swiftly, and create fibrous root systems to connect soil particles. A dense cluster of shoots may grow faster and the surface flow is moderated by frequent tillering. When creating vegetative barriers that are employed alone or in conjunction with mechanical methods on moderate slopes for erosion control, the selection of bushy shrubs and grasses in respect to habitat is crucial [9], [10].

Crop Mechanics

Crop geometry may also be designed such that rows of trees or crops that allow for erosion function as a barrier (bund) to stop soil erosion. discovered that decreasing the intra-raw spacing on the contour of corn plants, while maintaining the same plant density on a 4% slope, reduced erosion losses. Crop yields were about identical. The tighter planting in the row produced a more effective barrier to stop the silt from moving and to block runoff.

CONCLUSION

In order to manage land, water, and biomass resources in a specific geographic region sustainably, Integrated Watershed Management (IWM) emerges as a transformational strategy. It combines cutting-edge planning strategies, technological innovation, and the preservation of vegetative resources to completely address the complex issues of watershed development. It is impossible to overestimate how much current technology, such as Geographic Information Systems (GIS), Remote Sensing (RS), and modelling, has changed how watershed management is practised. With the use of these instruments, detail project reports (DPRs) may change paradigm, promoting ecologically and socially responsible resource management. Additionally, knowing important factors like topography, soil erosion, and land degradation is essential for protecting and enhancing watershed resources.The best ways to save soil and water are via vegetative approaches since they are economical, environmentally friendly, and they improve local communities right away. IWM improves the quality of life for individuals who live in the watershed by protecting and developing vegetative resources, which help reduce soil erosion and preserve water supplies. It is impossible to overstate the importance of rainfall analyses, return times, and weather patterns in the construction of engineering structures within a watershed setting. For building infrastructure that can survive the difficulties offered by erratic weather occurrences, accurate data on rainfall patterns is essential. This study emphasizes the complexity of watershed management and the necessity for creative, scientific solutions to handle its complexities. Sustainable watershed management plans may be developed to provide environmental preservation, improve social well-being, and safeguard livelihoods within these important landscapes by combining sophisticated planning approaches with vegetative resource conservation. IWM emerges as a ray of hope for the management of sustainable resources, offering a comprehensive and inclusive route to a better future.

REFERENCES:

[1] A. E. Punt, D. S. Butterworth, C. L. de Moor, J. A. A. De Oliveira, and M. Haddon, "Management strategy evaluation: Best practices," *Fish Fish.*, 2016, doi: 10.1111/faf.12104.

[2] H. Korpershoek, T. Harms, H. de Boer, M. van Kuijk, and S. Doolaard, "A Meta-Analysis of the Effects of Classroom Management Strategies and Classroom Management Programs on Students' Academic, Behavioral, Emotional, and Motivational Outcomes," *Rev. Educ. Res.*, 2016, doi: 10.3102/0034654315626799.

[3] M. F. M. Sabri, K. A. Danapalasingam, and M. F. Rahmat, "A review on hybrid electric vehicles architecture and energy management strategies," *Renewable and Sustainable Energy Reviews*. 2016. doi: 10.1016/j.rser.2015.09.036.

[4] T. Fletcher, R. Thring, and M. Watkinson, "An Energy Management Strategy to concurrently optimise fuel consumption & PEM fuel cell lifetime in a hybrid vehicle," *Int. J. Hydrogen Energy*, 2016, doi: 10.1016/j.ijhydene.2016.08.157.

[5] H. Altamony, A. Tarhini, Z. Al-Salti, A. H. Gharaibeh, and T. Elyas, "The Relationship between Change Management Strategy and Successful Enterprise Resource Planning (ERP) Implementations : A Theoretical Perspective," *Int. J. Bus. Manag. Econ. Res.*, 2016, doi: 10.3109/00016489.2011.603136.

[6] Z. Wang, N. Wang, J. Cao, and X. Ye, "The impact of intellectual capital – knowledge management strategy fit on firm performance," *Manag. Decis.*, 2016, doi: 10.1108/MD-06-2015-0231.

[7] A. M. Bassam, A. B. Phillips, S. R. Turnock, and P. A. Wilson, "An improved energy management strategy for a hybrid fuel cell/battery passenger vessel," *Int. J. Hydrogen Energy*, 2016, doi: 10.1016/j.ijhydene.2016.08.049.

[8] H. Yin, W. Zhou, M. Li, C. Ma, and C. Zhao, “An adaptive fuzzy logic-based energy management strategy on battery/ultracapacitor hybrid electric vehicles,” *IEEE Trans. Transp. Electrif.*, 2016, doi: 10.1109/TTE.2016.2552721.

[9] L. Olatomiwa, S. Mekhilef, M. S. Ismail, and M. Moghavvemi, “Energy management strategies in hybrid renewable energy systems: A review,” *Renewable and Sustainable Energy Reviews*. 2016. doi: 10.1016/j.rser.2016.05.040.

[10] S. Kermanshachi, B. Dao, J. Shane, and S. Anderson, “An Empirical Study into Identifying Project Complexity Management Strategies,” in *Procedia Engineering*, 2016. doi: 10.1016/j.proeng.2016.04.050.

CHAPTER 9

ENHANCING SOIL CONSERVATION THROUGH INNOVATIVE FARMING PRACTICES AND CROP MANAGEMENT

Kuldeep Mishra, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-mishraypikuldeep@gmail.com

ABSTRACT:

Due to continuous cultivation and exposure to erosive elements like rain and wind, soil, a vital natural resource, is continually under danger. This erosion eventually has an impact on crop yields and the long-term viability of agriculture by causing topsoil loss, decreased moisture retention, and nutrient depletion. Even in these protected regions, soil erosion persists despite the use of simple erosion control methods like contour bunds. Innovative agricultural techniques and crop management tactics are crucial to successfully combating this challenge. In order to reduce soil erosion and improve soil conservation, this study examines a number of techniques, such as contour cultivation, cover crops, strip crops, green manuring, mixed crops, crop rotations, and mulch farming. By reducing runoff, enhancing soil organic matter, and shielding soil from the effects of rains, these methods eventually support sustainable agriculture.

KEYWORDS:

Agricultural Techniques, Cultivation, Nutrient, Management, Sustainable Agriculture.

INTRODUCTION

The impact of raindrops and the forces of runoff result in a constant loss of the fertile top layer of soil, making soil erosion a continuous problem in agriculture. Over time, this erosion results in decreased soil moisture, decreased nutrient levels, and decreased crop output. Traditional erosion control techniques, like as contour bunds, have been used, however they often don't provide long-term answers. Innovative farming techniques and crop management methods must be investigated and applied in order to solve these problems and promote sustainable agriculture. In this study, we examine a number of strategies for improving soil conservation and reducing erosion. Contour cultivation, strip cropping, green manuring, mixed cropping, crop rotations, and mulch farming are some of these techniques. Each method has particular benefits for decreasing soil erosion, enhancing soil health, and preserving crop yields [1], [2].

We can learn more about how these techniques help to the larger objective of sustainable agriculture and environmental preservation by looking closer at them. Land is a valuable natural resource because it serves as a growing medium for plants and a reservoir for nutrients and water. Due to continuous cultivation for the development of numerous kinds of crops as well as frequent exposure to rain and wind, which accelerates erosion, this region experiences the greatest soil and water losses. The depth of the soil where erosion occurs decreases, which diminishes the area where crops can store moisture in the soil and feed from it. Additionally, a soil nutrient is concurrently depleted, limiting the types of crops that may be produced and shortening overall output. Even if simple erosion control techniques like contour bunds and graded bunds are used, soil erosion still occurs in the bunded region, causing soil and runoff to migrate from upstream to downstream even while soil and water conservation is accomplished per se. Adoption of conservation agronomy measures may significantly avoid this. By increasing soil organic matter content and soil structure, soil conservation agronomic practices help to catch raindrops and lessen the splash effects. They also aid in improving the rate at which water is absorbed by the soil. Finally, they aid in delaying and reducing overland flow of runoff through crop geometry, densely growing crops intercropping mixed cropping, strip cropping, etc.

Shape Cultivation

One of the factors promoting man-made erosion is the employment of the up-and-down style of farming in various regions of the nation. This method increases rainwater's velocity on steep slopes, making it easier for runoff water to erode soil. As a result, the rich soil's top layer gets washed away. Water loss and soil erosion are decreased by contour farming since all crop husbandry activities, such as preliminary tillage, sowing, inter-culture, etc., are carried out on the contour. The main goal of contour farming is to save rainwater as much as possible in low-rainfall areas, whereas in humid areas, the main goal is to decrease soil erosion caused by water, although water conservation is still very essential. Practically speaking, both situations aim to lessen soil erosion and keep moisture in the soil [3], [4].

The goal of contour farming is to position the rows and tillage lines at an angle from the surface's natural flow. Therefore, runoff velocity is decreased and more time is given for water to penetrate into the soil thanks to the resistance to water flow created by the crop rows and the furrows between the ridges. Thus, contour tillage operations capture some rainwater and retain it on-site, decreasing runoff and soil erosion and resulting in a more even distribution of rainwater. In addition to decreasing soil loss and raising yields, contour farming reduces wear and tear on equipment and fuel consumption in mechanized farming. On areas with an 8% slope, there is an estimated 10% reduction in fuel expenses. In the case of bullock cultivation, working along a contour as opposed to up and down soil slopes is more convenient and less taxing on the animals and ploughmen. According to a study conducted in Dehradun, contour cultivation of maize lowered the highest soil loss from up and down cultivation of 28.5 tons per hectare to 19.3 tons per hectare. Grass caused the least soil loss and runoff, whereas farmed fallow caused the most. A close-growing crop known as a cover crop is grown primarily for soil preservation and protection. In order to intercept raindrops and expose the least amount of soil surface to erosion, the effectiveness of the cover crop relies on its tight spacing and the formation of a healthy canopy.

Use of Plant Covers to Control Water Erosion

The main function of plant cover is to shield the ground from the impact of rains. On cultivated ground, the major cause of erosion is the impact of raindrops. Raindrops are active. They remove dirt from the soil mass and write the bare ground. These dirt granules are washed away by runoff. Plant cover prevents splash erosion by capturing and storing the kinetic energy of raindrops. The pounding motion of raindrops breaks down clods and soil aggregates, protecting the soil's ability to absorb water on bare ground. Raindrops also produce a tight layer at the surface. This significantly lowers the soil's ability to absorb water and increases runoff. The development of this dense surface layer is prevented by plant cover. Following effective cropping techniques is crucial for reducing the impact of pounding raindrops on soil deterioration and boosting crop productivity. Legumes are the most affordable soil conservation strategy to counter soil fertility declines. Studies on crop canopy production and splash erosion have shown a strong relationship between these two factors: the greater the canopy, the lower the splash. Thus, erosion is reduced by enough ground cover. Results indicate that when compared to open-tilled crops, legumes provide higher erosion prevention and cover for the soil. This has also been shown in research conducted in diverse locations [5], [6].

DISCUSSION

Any cropping system's ability to reduce soil and water losses is primarily dependent on how much close-growing vegetation is employed, as well as how long and in what season of the year. For the purpose of preserving soil and water, crops that provide cover during the rainy seasons are very important. The chosen crops must not only generate a decent canopy but must also be profitable for the farmers. Pulse crops are often appropriate for such uses. During the kharif season, crops must be sown as soon as feasible. Splash erosion is a result of a little delay in sowing having a negative impact on crop growth and canopy formation. From a protection and production standpoint, sowing crops during the rainy season should be done as soon as possible. Benefits of cover crops include:

1. Protecting soil from the direct effects of wind and rain reduces erosion.
2. Water flow resistance slows down the speed, lessens runoff, and in a similar way, lessens the wind's force on the land, which both slows down erosion.
3. By supplying organic matter and having a deep root system, increases sowing tilth.
4. Absorb the available nutrients, particularly nitrates, and stop them from leaching. When a cover crop is plowed in, it decomposes and releases nutrients that may be used by crops.
5. The addition of organic matter and the operation of deep root systems, which on decay give pathways for water intake, increase infiltration and water holding capacity of soils.

Fixation of Nitrogen by Legumes in Crops

Reduced nitrogen needs for cereals may result from the rotational introduction of short-duration pulse crops. Thus, the remaining nitrogen in the soil may be able to address the need for fertilizer to some degree. The plant uses a significant portion of the nitrogen fixed for grain formation and growth. Additionally, a respectable quantity of nitrogen is released into the soil, where it is accessible to the subsequent crop. Only when the amount of accessible soil N is at its lowest does legume N fixation reach its greatest. When fertilizing agricultural legume crops, it is often preferable to provide a little quantity of nitrogen (N) to guarantee that the early seedlings will have a sufficient supply until rhizobia get established on their roots. However, a heavy or continuous application of nitrogen decreases the activity of the rhizobia and is thus often unprofitable.

Cropping in strips

Different crop behaviours impact splash erosion, runoff, and soil loss by varying the amount of vegetative cover and root growth that may be produced by the crop. Legumes often generate excellent cover, which prevents erosion, as opposed to open-tilled crops like maize and cotton, which allow erosion. Farmers must feed themselves while also producing the least amount of erosion from the field in order to minimize erosion. The technique that satisfies this need is called strip cropping. In a method known as "strip cropping," common agricultural crops are planted across the slope of the ground in relatively narrow strips, always separated from one other by strips of crops that resist erosion or grow closely together.

Using a contour strip crop

Contour strip cropping is the practice of cultivating soil-exposing and erosion-permitting crops in strips of the appropriate widths over contoured slopes, in contrast to strips of soil-protecting and erosion-resistant crops. Contour strip cropping reduces the length of the slope, slows the flow of runoff water, assists in desilting it, and improves the soil's ability to absorb precipitation. The erosion-resistant crops' thick foliage also stops rain from immediately hitting the soil's surface. A non-resistant crop should be sown after an erosion-resistant crop, and vice versa, to cycle the strip planting [7], [8].

Using a field strip-crop

Farm crops are planted in roughly parallel strips over slopes that are pretty homogeneous, but not on precise contours. In places with undulating terrain, where contour strip cropping would not be feasible, this sort of strip cropping has found to be effective.

Using a wind strip to cut

It entails planting both low-growing crops and tall-growing crops, such jowar, bajra, or maize, alternately in straight, long, but relatively narrow, parallel strips that are laid out directly across the direction of the prevailing wind, independent of the contour.

Buffer Strip Cropping: Permanent or Temporary

In fields where contour strip-cropping is being used, the strips are formed to address crucial slopes, such as steep or severely eroded ones. These strips may be permanent or temporary. These strips are often permanently or temporarily planted with perennial legumes, grasses, or shrubs and do not participate in the rotation used in typical strip farming.

Green Manuring Types

Green manuring in situ: In this method, the land that will receive the green manure is used to cultivate and bury the green manure crops. Sunnhemp (Crotalaria juncea), dhaincha (Sesbania aculata), and other crops planted under this approach are the most popular green manure crops.Green leaf manuring is the process of incorporating fragile green twigs and green leaves from shrubs and trees that are grown on wastelands, bunds, and almost forested areas into the soil. Southern India mainly uses this method. Glyricidia (Glyricidia maculata), Sesbania speciosa, and Karonj (Pongamia pinnata) are the most often utilized shrubs and trees.Plants that may be used for in-place green manuring

The following desired traits should be present in a green manure crop.

(i) The legume should have an excellent nodular growth habit, which shows quick nitrogen fixing even in unfavourable circumstances.
(ii) It should only demand a little amount of water for its own development and be able to stand strong on depleted and poor soils.
(iii) It should have a deep root system that can allow plant nutrients to reach the subsoil and upper lower areas.
(iv) Early in its life cycle, the plant should have a green habit and be able to produce heavy, delicate growth.
(v) It should have a lot of non-fibrous tissues that decompose quickly and include a significant amount of moisture and nitrogen.

Benefits of using green manuring

(i) It enriches the soil with organic material. The activity of soil microorganisms is stimulated by this.
(ii) After absorbing plant nutrients from deeper soil layers, green manure crops return to the top soil.
(iii) Rainwater can penetrate more easily, which reduces runoff and erosion.

(iv) Leguminous plants that are utilized as green manure crops, such as hemp and dhaincha, enrich the soil with nitrogen for the subsequent crop.
(v) Certain plant nutrients, including phosphorus, calcium, potassium, magnesium, and iron, are made more readily available.

Various Cropping

Growing many crops at once on the same field is known as mixed cropping. One primary crop plus one or two auxiliary crops are grown in a mixed cropping system. Legumes are often one of the crops utilized. Indian farmers use this agricultural strategy on a very large scale. By holding the soil particles together, mixed cropping provides higher soil coverage, superior rain protection, and protection against soil erosion.

Benefits of a Mixed Crop

Under unfavourable weather circumstances, not all crops fail; for instance, only legumes are killed by cold, whereas shallow-rooted crops are killed by dryness. As a result, crops that are successful act as insurance against total crop failure. Any epidemic illness or insect assault only affects one crop at a time, leaving the other crops unaffected. The farmers cultivate several crops to meet their varying daily requirements for grains, pulses, oil seeds, etc. A better canopy is provided by crop mixtures, which reduces weeds, runoff, and erosion.

Rotations in Crops

Crop rotation is the practice of changing the crops grown on a field in such a way that they follow one another in a predetermined cycle over time as they reach maturity, with the goal of maximizing return on investment while minimizing damage to the soil's fertility. It is well known that crops produced on the same soil year after year diminish the soil's fertility. Additionally, clean tilled crops and line-sown crops encourage soil removal. Crops with thick growth buffer the effects of raindrops on soil agents. Runoff is also intercepted. Crop rotation is an effective way to prevent soil erosion while also preserving fertility. A firmly planted, farmed row crop, tiny grain, and a spreading legume should all be included in a healthy rotation.The benefits of rotating crops:

(i) Rotating legumes or grasses will prevent erosion and preserve fertility and production.
(ii) Enhance the physical state of the soil and maintain its sound structural integrity.
(i) Nitrogen from the atmosphere is added.
(iii) Weed management.
(iv) Pest and disease control.
(v) Improve the efficiency of land utilization.
(vi) Improve the effectiveness of irrigation and fertilizers.

Mulch Agriculture

Mulch is any natural material, whether organic or mineral, such as sawdust, straw, paddy husks, groundnut shells, crop residues, leaves, paper, stones, loose soil, etc., that is spread on the soil's surface to protect it from the force of raindrops, prevent surface crusting, lower evaporation, and thereby preserve soil moisture. Mulch also helps to maintain a stable soil surface temperature. Mulch farming is a kind of agriculture in which organic waste products or other items are left on the soil's surface to act as mulch rather than being plowed into the ground or combined with it. Mulch farming is important for keeping high soil moisture levels in the field in addition to preventing soil and water loss. Mulching may thus be employed in areas with more rainfall to increase soil moisture and in areas with lower rainfall to reduce soil erosion. Mulching boosts agricultural output and soil moisture, according to studies carried out in different locations. In Dehradun, wheat was seeded during the rabi season, and surface mulch considerably increased yield [9], [10].

Agricultural waste items such as straw, stubble, maize cobs, manures, wood chips, paper, or plastic film are examples of natural sources for mulch. It is better to "grow the mulch in place" in agricultural operations, or to employ leftovers in the same land where they previously grew. A Dehradun study found that applying mulch right away after corn harvest considerably boosted wheat's crop output. Prior to planting, straw mulching produced a 36% greater yield than the control, followed by grass mulch. Dust mulch, which provided a 22% greater yield than the control, was discovered to be the most practicable method of moisture conservation. Mulch may either be used only to cover the soil or it can be combined with it to some extent. It works better as a cover to shield the soil from the direct impact of raindrops. However, if it is partly mixed with the soil surface, it decomposes more quickly and contributes to the soil's increased resistance to particle detachment.

Application Rate

To effectively avoid soil erosion by splashing and protect the soil from the impact of raindrops, the mulch application in the field should be thick enough. During the kharif season, when maize is often planted on sloping terrain, Dehradun experiences significant rainfall. On an 8% slope, applying 4 tons/ha of grass mulch to this crop after planting significantly decreased soil and water losses. Without mulch, soil loss was 42.5 tons per hectare; with mulch, it was 6.2 tons per hectare. Similar to how rainfall decreased, runoff decreased from 52% to 21% of rainfall. This unequivocally shows how crucial mulching is to lowering the issue of sedimentation and flooding from catchments. The right amount of mulch allows for proper aeration while not inhibiting the development of most plants.

CONCLUSION

In agriculture, soil erosion continues to be a major problem since it endangers the health of the soil, crop production, and long-term sustainability. While traditional erosion management methods have been used, they often fall short in the face of persistent erosional pressures. However, cutting-edge agricultural methods and crop management strategies provide optimistic answers to this persistent issue. The efficacy of contour cultivation, cover crops, strip crops, green manuring, mixed crops, crop rotations, and mulch farming have all been shown to reduce soil erosion and improve soil conservation. These methods lessen runoff, shield the soil from the effects of raindrops, and enhance soil quality and organic matter content. Additionally, they help keep agricultural fields productive and fertile, assuring a steady supply of food for next generations. Encouraging soil conservation and sustainable agriculture requires the adoption of cutting-edge agricultural techniques and crop management techniques. We can lessen the negative consequences of soil erosion, protect our soil resources, and foster a more resilient and ecologically friendly agriculture sector by putting these techniques into practice on a larger scale.

REFERENCES:

[1] S. Lovo, “Tenure Insecurity and Investment in Soil Conservation. Evidence from Malawi,” *World Dev.*, 2016, doi: 10.1016/j.worlddev.2015.10.023.

[2] R. Bhattacharyya *et al.*, “Soil conservation issues in India,” *Sustainability (Switzerland)*. 2016. doi: 10.3390/su8060565.

[3] H. Satriawan, Z. Fuady, and N. Mayani, "Soil conservation by vegetative systems in oil palm cultivation," *Polish J. Soil Sci.*, 2016, doi: 10.17951/pjss.2016.49.2.223.

[4] J. R. Dymond *et al.*, "Development of a New Zealand SedNet model for assessment of catchment-wide soil-conservation works," *Geomorphology*, 2016, doi: 10.1016/j.geomorph.2015.12.022.

[5] D. Ashoori, A. Bagheri, M. S. Allahyari, and A. Michailidis, "Understanding the attitudes and practices of paddy farmers for enhancing soil and water conservation in Northern Iran," *Int. Soil Water Conserv. Res.*, 2016, doi: 10.1016/j.iswcr.2016.09.003.

[6] E. Rao, Y. Xiao, Z. Ouyang, and H. Zheng, "Changes in ecosystem service of soil conservation between 2000 and 2010 and its driving factors in southwestern China," *Chinese Geogr. Sci.*, 2016, doi: 10.1007/s11769-015-0759-9.

[7] P. Panagos, A. Imeson, K. Meusburger, P. Borrelli, J. Poesen, and C. Alewell, "Soil Conservation in Europe: Wish or Reality?," *L. Degrad. Dev.*, 2016, doi: 10.1002/ldr.2538.

[8] P. Cid, H. Gómez-Macpherson, H. Boulal, and L. Mateos, "Catchment scale hydrology of an irrigated cropping system under soil conservation practices," *Hydrol. Process.*, 2016, doi: 10.1002/hyp.10944.

[9] J. Hellin and S. L. Ridaura, "Soil and water conservation on Central American hillsides: If more technologies is the answer, what is the question?," *AIMS Agric. Food*, 2016, doi: 10.3934/agrfood.2016.2.194.

[10] M. Fallah, A. Kavian, and E. Omidvar, "Watershed prioritization in order to implement soil and water conservation practices," *Environ. Earth Sci.*, 2016, doi: 10.1007/s12665-016-6035-1.

CHAPTER 10

REVIVING AGRICULTURE FOR SUSTAINABLE DEVELOPMENT: CHALLENGES AND OPPORTUNITIES FOR EMERGING NATIONS

Heejeebu Shanmukha Viswanath, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-shanmukhaviswanath92@gmail.com

ABSTRACT:

While foreign donors have ignored agriculture for more than 20 years, rising food production costs have worsened food insecurity and poverty in many places. The urgent need to increase food production and output exists in emerging countries, notably in Sub-Saharan Africa and among smallholder farmers. But to succeed in this endeavour, a wide range of technical, institutional, and regulatory issues must be resolved. These issues include those relating to land markets, seed research, agricultural extension, rural infrastructure, storage, and market connection, as well as stabilizing food prices. This study critically examines findings from economic literature on these topics, including agriculture's contribution to development, the origins of the Green Revolution, the drivers of agricultural growth, farmer income diversification, methods for fostering rural development, and the complexities of global trade and food security that have influenced recent volatility in agricultural commodities.

KEYWORDS:

Agriculture, Economic, Food Security, Green Revolution, Poverty.

INTRODUCTION

The neglect of agriculture by foreign donors over the past two decades has driven up food costs, intensifying food insecurity and poverty worldwide. Emerging nations, particularly Sub-Saharan Africa and smallholder farmers, are at the forefront of the battle to enhance food productivity and output. To navigate this challenge successfully, a comprehensive approach is necessary one that addresses complex technical, institutional, and policy issues, including land markets, seed research, agricultural extension, rural infrastructure, storage, market connectivity, and food price stability. This essay explores the economic literature's perspectives on these matters, shedding light on the pivotal role of agriculture in development and the interconnected nature of these challenges. Because growing food costs are escalating food insecurity and poverty, agriculture has been neglected for 20 years by foreign donors [1], [2].

In the next years, emerging nations particularly Sub-Saharan Africa and smallholder farmers will need to enhance food productivity and output. To do this, however, requires addressing a number of challenging technical, institutional, and policy issues, such as land markets, seed and input research, agricultural extension credit, rural infrastructure, storage, and market connectivity, as well as stabilizing food prices. This essay examines the economic literature's opinions on these issues. It covers each aspect of agriculture's role in development, including how it interacts with other economic sectors; the causes of the Green Revolution; the foundations of agricultural growth; issues relating to farmers' income diversification; methods for promoting rural development; and, finally, concerns with international trade policy and food security, which are to blame for the recent spike in agricultural commodity volatility.

Agriculture contributes significantly to economic development via significant production and consumption links, in addition to providing labour and food. Agriculture, for instance, may provide raw materials for nonagricultural industry or may need inputs from the contemporary sector. On the consuming side, increased agricultural production may boost rural residents' incomes, which will enhance demand for locally produced industrial products. By increasing job prospects in the rural non-farm sector, such linking effects might indirectly enhance rural income. Agricultural products may also be exported to generate foreign currency for the purpose of importing capital goods. According to ADLI, a country's development strategy should be agriculture-driven rather than export-driven because of the links between production and consumption, and higher agricultural productivity would be the catalyst for industrialization.

Additionally, small-to-medium-sized farmers should get special attention since they are more likely to employ locally made intermediary products than large-scale producers who could import equipment and other inputs, weakening the connections between agriculture and other industries. Agriculture's expansion is a key tool for reducing poverty since traditional and contemporary industries in emerging nations have significant connections. The effects of agricultural growth on farm employment and profitability directly contribute to the reduction of poverty, and indirect effects result from the creation of jobs in non-agricultural sectors upstream and downstream in response to rising domestic demand. Potentially decreased food costs provide impoverished customers more spending power. The unique economic conditions of a country will determine how much of an impact these impacts will have on reducing poverty. Farm employment may not always rise if, for instance, agricultural technology advances result in labour savings [3], [4].

In small, closed economies, where increases in agricultural productivity will result in the linking effect outlined above, agricultural expansion and economic development go hand in hand; nevertheless, the relationship may be reversed in the event of an open economy. Openness to trade will divert resources away from the modern sector and toward agricultural, which may be less productive than industry, if the nation has a comparative advantage in agriculture. Early on, proponents of the "agriculture first" and "development first" approaches to development emphasized the significance of a country's level of openness. From the standpoint of general equilibrium, increases in agriculture production have a detrimental effect on the tradable non-farm sector. This is due to the fact that tradable commodities have a more elastic labour demand than agricultural products and non-tradable rural non-farm items. A factory that produces marketable commodities, which is supposed to be run by an external producer, will relocate if wages rise as a result of increased agricultural production.

There is also a sizable body of literature, spanning from critical works that oppose agriculture first perspectives through more current expressions of agro-pessimism. The latter are based on the finding that agriculture may be the least productive industry in emerging nations. He says that connections between the two sectors become less significant for total development in an open economy where both agricultural and modern-sector items may be exchanged. As a consequence, increasing agricultural output to spur general development and eradicate poverty is no longer as necessary. Both industries may help the economy flourish. Agriculture may be a major contributor to overall prosperity in landlocked nations that are limited to international commerce, thus it should be actively promoted.

Although different theoretical models show agriculture plays relatively divergent roles in development, they do not always conflict with one another. The models are developed using various economic presumptions, such as trade openness. It is hardly unexpected that they arrive at various policy implications as a result. The importance of agriculture for development may need to be reconsidered in each unique scenario since emerging nations have diverse economic conditions. It implies that although agriculture is already less significant as an economic activity in nations undergoing transformation, it is still a key tool in reducing rural poverty in economies dependent on agriculture. Contrarily, in urban nations, agriculture has a similar function to other tradable industries, and subsectors with a comparative advantage may contribute to economic development.

These empirical studies do not, however, suggest causality in any way, even if they do show a link between agricultural and GDP growth. If both sectors have been expanding independently of one another or as a consequence of a shared third source, the reported connection may be erroneous. Studies that claimed there was a link between the expansion of agriculture and economic development have been attacked as a consequence. Using panel data from 1960 to 200, they discover that in poor countries, a rise in agricultural GDP boosts non-agricultural GDP, but the relationship is the opposite in industrialized nations. According to the authors, there are geographical variations in the positive relationship in emerging nations, with the impact being stronger in non-Latin American and Caribbean nations. Cross-country studies also have the issue that there is no general association between agriculture and overall economic development due to the various national situations. The relationship between agriculture and non-agriculture may change as a result of factors like trade openness. As a result, different nations place different emphasis on the connections between the agricultural sector and the rest of the economy [5], [6].

In many developing nations, including India, subsidies for agricultural inputs like fertilizers and irrigation have directly benefited agricultural productivity. Large farms often gain more from such measures than small landowners. Agricultural market liberalization has not benefitted small farmers owing to market failures and distortions, and public policies that actively promote agriculture, such pricing or funding to agricultural research and extension, are a crucial requirement for agricultural development. However, such widespread public interventions strain government finances, are a poor use of tax dollars, and are not long-term solutions. They can cause additional negative outcomes. For instance, soil damage and abuse have resulted from fertilizer subsidies throughout Asia. As a result, even while urban biases seem to be bad for agricultural expansion by encouraging industry, agricultural market interventions like input subsidies or price support are expensive and result in poor resource management. The competitiveness of smallholders may be impacted by the liberalization of the market for agricultural products, despite the fact that it does not favour either sector.

The Bases of Agricultural Development

After reviewing the contribution that agriculture can make to economic growth, we will now examine the performance of the agricultural sector globally, the drivers of agricultural growth, and the difficulties that farmers in developing nations currently face that may reduce the benefits of agricultural technologies. These include the way that agricultural production is organized, environmental issues, and obstacles to the adoption of new technologies.

Technology Adoption and the Green Revolution

The agriculture industry expanded at a global average rate of 2.6 percent between 1980 and 2004, with Asian nations accounting for two-thirds of this increase. Between 1961 and 2004, agricultural yields in Asia grew on average by 2.8%, a development that can be partly attributed to the introduction of high-yielding cultivars and the heavy use of fertilizer. The average rate of agricultural growth in Sub-Saharan Africa was 3% during the same time period, while growth per agricultural population (a general indicator of agricultural income) was just 0.9%, less than half the rate in other areas. Additionally, whereas the Green

Revolution in Asia saw intensification drive agricultural development, Sub-Saharan Africa has seen its agriculture increase mostly in reaction to land expansion, with yields remaining static.

There is general agreement that Africa needs a Green Revolution, but given the unique peculiarities of the continent, a distinct strategy is needed to revolutionize agriculture. In terms of agro-ecological conditions, agricultural practices, and kinds of crops grown, Africa is more diverse than Asia. There are 14 primary agricultural systems in Sub-Saharan Africa, according to the FAO. They are only somewhat dependent on the crops that have propelled the Asian Green Revolution, such as wheat or rice. The factors behind agricultural development and growth must be discovered in order to comprehend historical changes in agriculture and forecast ones in the future. the notion that peasants make rational decisions by reacting to incentives and maximizing the returns from the resources at their disposal. Many of them continue to live in poverty while not being technologically advanced, since their government only gives them limited access to it. Regarding its effects on reducing poverty, the source of agricultural expansion is equally important. Technologies that boost labour efficiency have enabled agricultural expansion in East Asia, which has significantly reduced poverty. Contrarily, in Africa, where land expansion has accounted for the majority of growth and agricultural labour productivity increases have been modest, poverty reduction has likewise lagged.

DISCUSSION

Under the presumption that markets genuinely exist and function, the causal chain starts with changes in relative factor scarcities leading to changes in relative factor prices. Prices in turn drive technical advancements to reduce spending on variables that are comparatively more costly. The government is the organization that must react to market signals and take endowments into consideration by providing cash to alternative research initiatives since agricultural research is essentially a public benefit. This is a result of a combination of increasing resource restrictions, such as the present environmental issues discussed below, and producer needs for technology that enable them to save on elements that are disproportionately more costly.

Agriculture and suitable technologies

Defining the features of African agriculture does not address the issue of poor yields. There are two main issues. Lack of proper technology is the first, and a lack of acceptance is the second. In contrast to the latter, the former requires a decrease in the obstacles to technology adoption. The former advocates for greater research targeted to African nations and their situations. Of course, inadequate technology and acceptance challenges may also contribute to the issue of poor yields. Long-term agricultural development is largely dependent on agricultural R&D and its ability to create more productive technologies. Due to the constrained potential for land growth in Sub-Saharan Africa, such innovations are also urgently required for African farmers. This innovative technology helped to spark the Green Revolution in Asia. Crops that have been cultivated in other locations may not be suitable for Africa due to the diversity of the nations and differences with, for example, Asian countries. It seems improbable that high-income countries would spread their technological innovations to underdeveloped African nations. Additionally, there are significant regional disparities throughout the continent that inhibit technological transfer between African nations. The late introduction of appropriate high-yield cultivars throughout the 1980s and 1990s may be partially blamed for the yield rise that has been seen [7], [8].

African nations' diversity necessitates a shift away from relying heavily on international research and toward regional and home research. However, the continent spends little on agricultural research, which has also led to stagnant yields. In the 1990s, public spending on agricultural research increased by only 1% (growth was even negative in certain countries). Donor funding accounts for around 40% of all expenditures on agricultural research, while Sub-Saharan Africa has virtually little private agricultural research. Its share of total research spending in 2000 was under 2%. The number of agricultural researchers in Sub-Saharan Africa is 50% more than in India and 30% higher than in the US, in sharp contrast to these low expenditure figures. But compared to researchers in other parts of the globe, these ones have less training.

Future research must address particular requirements and have a geographical emphasis. In fact, a large number of regional projects have already been launched. The importance of agricultural R&D is highly emphasized in the New Partnership for African Development. Participatory plant breeding is a crucial method of regionalization that serves smallholders' demands in particular. This strategy differs from standard plant breeding on stations in three ways: seed testing and selection take occur on the farm, farmers are engaged in the decision-making process, and it may be used in a variety of settings. Farmers' involvement is anticipated to accelerate the adoption of new seeds.

Although there is general agreement that biotechnology might be the engine of Africa's Green Revolution, there have been a number of obstacles to its rapid adoption up to now. Transgenic research has mostly been conducted in the private sector up to this point, and it may not always serve the interests of small farmers. Public agricultural research would need to adopt a larger emphasis on these new technologies because private agricultural research only plays a very little role in Africa in order to encourage widespread adoption of transgenic crops. Strong intellectual property protections, however, can discourage public research initiatives. The lack of biosafety rules is another barrier. These procedures are slowed down in poor nations by weak regulatory capability.

Using Extension Services to Promote Adoption

Even if new and more effective technologies are available, farmers may not be aware of them or be aware of the best ways to use them. Extension services are instructional tools designed to instruct and disseminate knowledge so that farmers may utilize and efficiently manage new technologies. Since the Second World War, these services have been utilized to provide modern technology to emerging nations. The suggested solution to address these accountability issues has been the decentralization of the system, placing farmer organizations or the private sector in control of service supply. on reality, farmer organizations may participate on both sides of the extension services market. Because they can reach more farmers and more effectively bargain for their needs, they may raise information demand overall. They may provide their members with services and fund them on the supply side of the market.

Privatizing extension services has improved financial sustainability and increased accountability while also improving the level of service delivery. It has also lessened the financial load on the public sector. However, only 5% of extension services are offered by the commercial sector worldwide. Smallholders may not be aware of their own requirements, be unable to communicate them, or be unable to pay for assistance, but private extension agencies could be better equipped to meet the wants of commercialized farmers. They could thus request less services than they really need. The best course of action in this case may not be to provide services to various groups of farmers only via the private sector. In this situation, a public-private partnership to provide services and a privately run but publicly supported system would be preferable. All groups of farmers would be catered to, and the system's efficiency would grow.

Today's farming environment is evolving, necessitating new approaches to extension service delivery. The use of information and communication technologies (ICTs) into rural development initiatives and extension services in general is a novel concept. ICTs may supply information that is critical for the long-term development of rural regions, like education, as well as information that is critical for the short-term, like market information. ICTs, for instance, may be used for long-distance learning programs, aiding in the development of human capital. They may provide information on the weather, prices, and lucrative options for income diversification. Cell phones are a crucial piece of technology since they may enhance both private and public information. Mobile phones enable the provision of agricultural extension services at a reduced cost and the dissemination of information of a better standard.

Environmental difficulties

Agricultural R&D and extension services are necessary, and Asia has historically seen their effects. The Green Revolution did not take into account environmental limits, but any agricultural revolution today would. The preservation of ecosystems and biodiversity will be crucial for the potential of agriculture in the future, and the question of the sustainability of agricultural systems is now high on the agenda. Expanding the area under agriculture has been the primary method of increasing yields in Africa, which has resulted in deforestation and land degradation. Future land production may be negatively impacted by soil deterioration. These adverse impacts have been so severe in Ethiopia's highlands that they have completely negated any positive benefits of technological advancement. More intense production may aid in the development of a sustainable system in large regions.

Additionally, consideration must be given to global climate change. Lower rainfall and rising global temperatures both have the potential to harm rain-fed agriculture and increase the frequency of droughts, which would mostly affect tropical nations' agricultural production. Given that most agriculture in Sub-Saharan Africa is rain-fed and that climate change indicates an increased danger for farmers, this is a particularly pressing issue. The agricultural GDP in Sub-Saharan Africa might decrease by 2 to 9 percent compared to a world without climate change. As a result, African farmers must adjust to the shifting climate. More irrigation infrastructure investment is required, along with the development of new crop types that are more drought tolerant. Such adaptation techniques must to be included into the overall agricultural development plans. New climate change adaptation solutions are now available thanks to agricultural research and development, yet many African families do not alter their planting practices. This is partially caused by different adoption hurdles, which is a problem we currently solve.

Objections to the Use of Technology

Learning is the medium via which education may influence technology. For highly educated farmers, a new technology becomes lucrative more quickly since higher levels of knowledge improve the return on experience with it. Farmers with education see greater returns from past high-yield variety seed sowing than farmers without education. The capacity to learn about new technologies is also influenced by the information that is accessible about them and by how profitable they are. If effectively implemented, as was stated above, extension and other services may provide farmers with the knowledge they need to economically embrace new technology. For farmers, having access to market or weather information is crucial. The percentage of soy grown area grew in India as a result of an Internet kiosk that offered pricing and a fresh marketing avenue to soy farmers. This indicates that better knowledge results in more profits. Today, knowing the weather is crucial for adapting to climate change. By delivering accurate meteorological information, a program that was started in Mali in 1982 assisted farmers in better managing climate risk. The use of ICT may facilitate and improve the dissemination of crucial information, which is also intimately tied to the problem of learning.

Size of Farm and Land Tenure

In underdeveloped nations, a lot of farmers work on a small scale. The use of mechanization, which has indiscriminabilities (with disparities in loan availability between small and big farms favouring the latter), implies greater returns to scale and better profitability per hectare, and increasing farm size is essential for increased incomes in agriculture. This is the situation in India right now, according to a thorough empirical report, where the majority of farms are too small to benefit from mechanization's productivity and cost-saving benefits. However, land consolidation in bigger farms necessitates active job development in the rural non-farm sector, mostly in secondary towns and cities, given the ongoing population expansion and the restricted long-distance migration. Strategies for agriculture-for-development must concentrate on the smallholder sector, comprehend the difficulties they encounter, and look for methods to increase their productivity.

Early debates on smallholders focused heavily on the question of farm size efficiency. Small farms have often been seen by family-farm theories as more efficient since they do not have to pay for labour supervision and do not have moral hazard difficulties, although big farms have the potential for economies of scale. Even after accounting for other productivity-determining factors like land quality, several studies conducted in poor countries still revealed an unfavourable relationship between farm size and land production. Large farms may, however, outperform small farms when there are market failures. For instance, they could be better able to get loans, leading to cheaper capital expenses. This would indicate that the relationship between farm size and production is U-shaped [9], [10].

There were no intrinsic scale economies in agriculture prior to plantation crops, but more recent forms of scale economies have evolved. New management practices, precision farming, new markets, product certification due to strict sanitary and phyto-sanitary standards, contracts with supermarket chains for continuous and uniform deliveries, institutional changes access to international finance and re-insurance, and public-private partnerships in the provision of public goods infrastructure for these problems all have their roots in technological change.

It may become more difficult for smallholders to actively engage in the food markets as a result of recent advances in the agribusiness and food industries. The supermarket revolution and standards and certification are two phenomena that are particularly significant. New procurement procedures have emerged as a result of the explosion of supermarkets in emerging nations. Supermarkets sometimes need vast amounts of standardized items, which might provide small farmers an unfair competitive edge. Indeed, it has been observed that supermarkets, given the option, choose big over small suppliers. Although big farms have more market possibilities and are seen as riskier suppliers than smaller farms, some retailers prefer to buy from small farms. However, non-land assets, such irrigation or access to transportation infrastructure, are often a need if the latter are to be included in the supermarket chain. Whereas supermarkets may only purchase from small farms, they have also given contracted farmers resources like equipment and technical support.

Vertical cooperation might thus be advantageous for smallholders as well. New private standards for goods and procedures also harm small farmers since validation and certification have economies of scale. Coordination between participants has to be strengthened in order to assist smallholders in meeting these new obstacles and integrating them into contemporary value chains. Through, for instance, producer cooperatives, this may be started by both the public and commercial sectors. They contend that due to the mechanization of production today, Indian farmers are unable to compete and that in order to increase agricultural incomes, land consolidation along with more employment opportunities in rural non-farm sectors are required. This topic is discussed in more detail below.

But there are other factors that affect how efficiently farms produce food as well. Productivity in agriculture is also influenced by user and property rights. There are several tenancy agreements in emerging nations. For the use of the land, tenants may either pay a set rent or sharecrop, giving the landlord a portion of their yield. In terms of efficiency, the issue to ask is whether configurations result in a less lopsided distribution of land use and boost production. The degree of knowledge asymmetry between the farmer and the landlord determines how much fixed-rent and sharecropping are to be favoured over one another.10 Under perfect enforcement of effort, fixed-rent and sharecropping contracts should result in the same productivity for a particular farmer.

Moral hazard, however, may cause the tenant's effort to be lessened if it is not immediately visible and contractible. Fixed-rent contracts are thus favoured in terms of effort. Because the risk of a poor crop would be entirely transferred to the renters, risk-averse tenants could be reluctant to sign a fixed-rent contract. Sharecropping is the second-most effective option in this situation in terms of effectiveness. According to empirical research, the productivity loss is minimal even when share-cropping is less productive than fixed-rent contracts when the land quality of shared plots is taken into account. Interconnected contracts where the landlord provides credit and inputs to the tenant are one strategy used by landlords to encourage tenants in sharecropping agreements to put out more effort. For instance, if the landlord offers more affordable loans while also demanding a larger production share, renters may feel more inclined to borrow money.

CONCLUSION

The economic literature emphasizes agriculture's multiple contributions to economic growth, job creation, poverty reduction, and food security, underscoring its crucial role in development. However, the precise effect of agriculture varies among nations and is influenced by things like trade openness and technological development. A more balanced approach that incorporates both the agricultural and non-agricultural sectors is preferable to the "agriculture first" plan for certain economies, while it may work for others. Research and technological adoption are crucial to the success of agriculture. More money and attention must be given to agricultural research and development (R&D) that is specifically geared toward the requirements of African countries. Agriculture may flourish with the use of suitable technologies, including biotechnology, but overcoming acceptance barriers is crucial. Extension services are essential for encouraging farmers to accept new technologies. Innovative strategies that may increase effectiveness and reach, particularly in rural regions, include privatization and the incorporation of information and communication technologies (ICTs) into these services.The drive of agricultural expansion must not be at the expense of environmental sustainability. For agriculture to have a sustainable future, challenges like land degradation and deforestation must be addressed. It is crucial to strike a balance between raising productivity and maintaining ecosystems. In conclusion, agriculture continues to be the foundation of growth for developing countries, and it is crucial to solve its problems while maximizing its potential. We can pave the road for a sustainable agricultural revolution that improves food security, lowers poverty, and promotes economic development by using ideas from economic literature and customizing tactics to each country's particular circumstances.

REFERENCES:

[1] S. Datta, J. Singh, S. Singh, and J. Singh, "Earthworms, pesticides and sustainable agriculture: a review," *Environ. Sci. Pollut. Res.*, 2016, doi: 10.1007/s11356-016-6375-0.

[2] M. S. DeLonge, A. Miles, and L. Carlisle, "Investing in the transition to sustainable agriculture," *Environ. Sci. Policy*, 2016, doi: 10.1016/j.envsci.2015.09.013.

[3] M. Kumar, R. S. Tomar, H. Lade, and D. Paul, "Methylotrophic bacteria in sustainable agriculture," *World Journal of Microbiology and Biotechnology*. 2016. doi: 10.1007/s11274-016-2074-8.

[4] P. Migliorini and G. Lieblein, "Facilitating transformation and competence development in sustainable agriculture university education: An experiential and action oriented approach," *Sustain.*, 2016, doi: 10.3390/su8121243.

[5] M. H. Wilson and S. T. Lovell, "Agroforestry-The next step in sustainable and resilient agriculture," *Sustain.*, 2016, doi: 10.3390/su8060574.

[6] D. Zhang *et al.*, "Is current biochar research addressing global soil constraints for sustainable agriculture?," *Agriculture, Ecosystems and Environment*. 2016. doi: 10.1016/j.agee.2016.04.010.

[7] F. Monshidi and A. A. Choolandimi, "Studying the effects of agriculture on sustainable development in some villages of hamidieh," *IIOAB J.*, 2016.

[8] T. Brown, "Civil society organizations for sustainable agriculture: negotiating power relations for pro-poor development in India," *Agroecol. Sustain. Food Syst.*, 2016, doi: 10.1080/21683565.2016.1139648.

[9] FAO, "Pollination services for sustainable agriculture," *Food Agric. Organ. United nations*, 2016.

[10] P. Hunter, "Plant microbiomes and sustainable agriculture," *EMBO Rep.*, 2016, doi: 10.15252/embr.201643476.

CHAPTER 11

SUSTAINABLE AGRICULTURE: PRINCIPLES OF FARM BUSINESS MANAGEMENT

Devendra Pal Singh, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id-dpsinghevs@gmail.com

ABSTRACT:

the fundamental ideas and methods that maintain agriculture in the contemporary period. It explores the crucial components of land, labour, capital, and entrepreneurship while highlighting their importance in the context of agricultural production. In order to successfully traverse the difficulties of the agricultural business, this article explores the significance of responsible land management, the dynamic role of labour, the allocation of capital, and the entrepreneurial spirit necessary. The fundamentals of managing a farm company, such as those around resource allocation, decision-making, and profit maximization, are thoroughly covered. The study underlines the need for farmers to modify their techniques in order to achieve sustainable agriculture, take into account alternate uses of land, and adapt to changing environmental circumstances. It emphasizes how important effective planning and decision-making are to attaining economic success and reducing environmental consequences. The study also emphasizes the influence of the laws of returns, the different uses of land in various agricultural operations, and the immutability and variety of fertility of the soil. It emphasizes the need of conserving natural resources in order to guarantee long-term agricultural sustainability and economic development. This study offers a thorough introduction to sustainable agriculture's guiding principles and how they might be used to run farm businesses. It provides insightful information on how agricultural practices are dynamic and changing in the quest for long-term economic and environmental sustainability.

KEYWORDS:

Business, Management, Productivity, Sustainable Agriculture.

INTRODUCTION

Agriculture is an industry that has existed for a long time. In the history of humanity, agriculture was a significant and revolutionary development. For thousands of years, agriculture has been seen as a method of livelihood. Nevertheless, agricultural methods have changed recently. Because of this, its purpose, extent, and significance have not been completely appreciated. This text has been examined and pondered about from many points of view by various persons. Some people believe that managing an agricultural operation is quite similar to farming land. According to some experts, production economics and agriculture economics are same. Some believed that agricultural economics and law were interchangeable terms. The average person believes that agricultural management entails supervising farm labour or, if the manager is paid, doing the task as directed by the employer. There is one more thing to consider in relation to the phrase "agricultural system."

Organization and management of agriculture are both aspects of agribusiness management science. But for convenience, we refer to it as "agricultural management science." Making a plan is the act of combination. The word "arrangement" indicates to follow out this plan or to proceed as scheduled. The farm manager must do both tasks [1], [2].

The Role of Agriculture in Rural Development

Business Principles for Farmers

The following explanations provide an overview of agricultural business management fundamentals. The three phases of production may be seen in the study of agricultural business management. Increasing returns characterize the first stage, stable returns characterize the second, and declining returns characterize.

Increasing Returns Stage

When resources are used more effectively, total output and marginal production both rise, which tends to boost returns. This inclination only lasts a little time. From the perspective of a production plan, production may continue to rise so long as equipment's rising returns boost output.

Stable Returns Phase

Since more resources are being used, total output likewise rises at this stage, but marginal production remains steady rather than rising. Production is not an issue if the product is deemed useful and the returns are consistent. Naturally, some of the instruments used (like management) eventually become outdated and stale. A gadget's productivity relies on the other device it is used with. As a result, because of the disparity in the availability of land, money, and labour, each area makes distinct judgments. In conclusion, one should attempt to conceive of the available instruments as a reasonable mix.

Stage of Decreasing Benefits

In agriculture, this is a persistent tendency. The quantity of resource use grows in this stage, but overall output does not increase as it did in previous stages, and marginal production actually begins to decline. Experience has shown that increasing tool volume is not necessarily the best method to boost productivity. This indicates that there are instances when the cost of quantity does not rise by an amount sufficient to offset it. As long as the cost of the quantity generated by the increased output is covered, increasing the amount of equipment is favourable. However, beyond these thresholds, marginal output falls short of marginal spending. Here, the volume-increasing process must be stopped before the upper limit is reached. A concept of how much to utilize, such as fertilizer, labour, or equipment, might also result from this propensity [3], [4].

Fundamentals of Expenditure

Spending is an important aspect of every company. Agriculture is no different from other industries. The net income is obtained by deducting all costs from all revenues. Spending as little as possible is one strategy to improve revenue. Like other professions, agriculture incurs a continuous cost for certain components. This implies that the cost of manufacturing, no matter how high or low, is not significantly different. E.g. insurance deductible. spending on taxes, power, etc. Long-term expenses are variable whereas short-term costs are fixed. The amount of manufacturing affects the fluctuating cost. Only when there is a high level of output will expenditure on fertilizers, seeds, water supplies, labour, etc. increase. Of course, while choosing a product, these expenses must be taken into account in the near term. The product has fixed variable and fixed costs. While engaging in productive farming, the farmer must consider many eras.

DISCUSSION

During this time, short-term profit or revenue is constant. However, the farmer should make every effort to ensure that the expense is met even if the diagnosis is modified from the overall revenue collected. The net income will be higher if the cost of marginal quantity is equal to the revenue from marginal quantity. Production may continue as long as total revenue is greater than total expenses. As long as the income at the border exceeds the cost at the border, production may be expanded. Even if temporary losses happen, efforts should be taken to limit losses while continuing output. In agriculture, this happens rather often. when the average total expenditure is greater than the marginal receipt. This is because, even if the gain is little, it more than offsets the expense of altering the average, making the loss negligible. It is normal to be confused. (In commercial farming, this is acceptable, but in Indian circumstances, many farmers have to grow with nilaja, then there is profit or loss, since they have no other alternative than to cultivate.

Being so lengthy, it is not prudent to incur ongoing losses throughout this time. It would be wiser in this situation to avoid producing. This period's gross revenue should be positive, that is, fixed and scalable to account for variable costs. Additionally, throughout this time, it should be the primary goal to maximize earnings, and production choices should be made in accordance with that goal. Even if the expense is not recovered quickly, it still functions. because it is expensive to change the diagnosis. However, in the long term, it's essential to both pay for these expenses and turn a profit [5], [6].

Replacement of component principle

When farming, farmers employ a variety of equipment. Farmer must pay for these tools before he may produce anything or earn money. Up to a certain point, several of these tools can be changed. This implies that one component may be diminished while another may be used. However, doing so shouldn't lower output; in other words, replacement costs should either go up or down. It affects productivity, either decreasing or increasing it. E.g., using a tractor rather than oxen to plow the ground, using machinery to harvest rather than laboring, using a machine to milk rather than doing it by hand, etc. The farmer must thus choose from among the many possibilities open to him when employing various components for production, taking into account which option is the least expensive combination. To do this, it is necessary to compare marginal replacement rates, which are calculated by dividing the total number of replaced components by the total number of multiplied components. The method of replacing the components, or the replacement rate and cost, is most advantageous in this situation.

Opportunity Cost/Alternative Cost Principle

The principal means of production are land, capital, and labour. If a farmer can readily access these variables, then picking an agricultural activity, such as raising crops or chickens, is a no-brainer. Any agricultural job may be readily performed by a farmer. However, there are just a few resources or pieces of equipment really available. Despite the size of the land, there is a shortage of labourers. Other times, both land and money are in short supply. Therefore, the issue of which agricultural activity will provide more revenue emerges. The alternative expenditure concept serves as a direction in this regard. The profit will be largest and it is suitable to pick the same company when labour, land, and capital are added to the final output. Without taking into account the greatest average benefit resulting from the element, one should choose the activity that offers the highest marginal gain. For example, let's say a farmer has Rs. 5000 to invest and may pick between the three vocations of crop production, dairy production, and poultry production. Five quantities of capital each costing Rs. 100 each are produced using a net profit of Rs. 1,100. Assuming that, in such a case, it is evident that it should be picked as it has the largest net profit and average return from crop production. However, the net profit rises when you take into account how much each capital amount (Rs. 100) provides to the three enterprises. This indicates that the net profit will rise if all five amounts are invested in three distinct enterprises for marginal gain rather than in the cultivation of a single crop. As a result, one should take the achievement of limits into account while picking a company. As an alternative, the farmer's tools may be utilized. It is important to utilize that tool while deciding which company would be the greatest. Of course, we cancel out its other purposes when we decide to utilize it for business. Making this choice with the aid of alternative expenditures is beneficial. The benefit would be referred to as an alternative expenditure if the tool was utilized for other alternative uses rather than a single usage. It ought to be applied to the industry in which the tool generates the maximum net profit.

The idea of corporate alignment

In the agricultural industry, many different jobs are possible. The farmer must decide taking into account the associated costs, the cost of the produce, and the connection between the companies. Business partnerships vary from other relationships. Some companies operate independently. Thus, they hardly have an impact on one another. A farmer with limited resources won't get into this line of work. Since it is common sense that one firm should support another. Because cattle have access to feed, the dairy industry has been added to agriculture. So, it is possible to utilize cow dung as manure. We refer to these companies as supplementary enterprises. Choosing a company that is more complimentary is valuable. In agricultural production, there is a lot of risk and uncertainty. Natural element changes are a cause of uncertainty. The uncertainty is further increased by variations in the cost of inputs used by a certain firm and variations in the cost of produced items. Therefore, these factors must be taken into account while picking the crop production technique and the business fit.

E.g. True, using hybrid seeds results in increased yields. However, these crops are vulnerable to pests and illnesses. This must also be taken into account. A farmer that prioritizes safety will limit the use of riskier improvements. The impact of the lag between expenses and costs cannot be understated when selecting a business or crop type. A little amount of land may be consistently utilized for agricultural production. Alternatively, if you plant an orchard, you won't obtain it until you've put money into it for a few years. Similar choices may still be made today, such as whether to spend more money on a dairy cow or more time and effort raising a calf. The present value of potential purchases must be taken into account in this situation.

Agricultural Decision Making

In the farm management process, the farm is regarded as the unit. All of these decision-making procedures are primarily motivated by the maximization of profit concept. In this context, decisions are made on how to manage agricultural resources and carry out different agricultural cultivation activities. Basically, the goal of this discipline is to organize and conduct agricultural operations according to the principles of agricultural science and economics. Mechanization, labour scheduling, crop production, and animal husbandry are all examples of linked activities in agriculture. Making the appropriate choice in it is guided by sound financial ideas. This indicates that each element applies to all of these sections rather than their being a distinct principle for each of them. And each component is covered by all the rules. (There isn't a different rule or principle for every aspect of the company; all rules and principles apply to every aspect of farming.)

Making Important Decisions

Due to the nature of contemporary farming, farmers must act quickly. These choices affect how resources are allocated, how well they are used, and how much money is made overall. Other occupations have a high degree of certainty, which makes decision-making highly predictable. The precision of the judgment is crucial since agricultural output is unpredictable because of its reliance on nature. The following are a few of the decisions that farmers are need to make. The farmer must choose which crops to plant during a certain season. Only after taking into account the land's quality, the environment, market circumstances, the price trend of agricultural products, etc., can this choice be made [7], [8].

Livestock Breeding

The farmer must select how the company will be run, whether it is the primary endeavour or a supplementary one. From a variety of professions, including animal husbandry, the dairy industry, and poultry farming, the best kind is chosen. After selecting a product, it's crucial to determine the crop's degree of production. Of course, factors such as a commodity's price, durability, and kind of demand all have an impact on this choice. To generate the desired variety, one must choose the appropriate growing strategy. A lot will rely on the resources that are available, the farmer's expertise, the method, and the local customs.

Farmland area

After deciding on the sort of crop and other factors, it is crucial for the farmer to select how much land to cultivate. It would not be wise to grow more of any one crop given the inherent unpredictability and market turbulence. The holding area's size will also have an impact on the choice. This choice has several drawbacks in a nation like India where there are little holding areas of manageable size. In agricultural production, labour, money, and land are crucial resources. The land supply is constrained among them. The quantity of labour and capital must be determined using this tool in conjunction, which will lower the cost and raise the revenue. Replacement of labour and capital is necessary for means integration. To achieve equilibrium between natural production methods and manufactured tools, tool replacement is the major goal. The availability of labour must be taken into account when replacing labour and capital. In cases when the utilization of capital renders the labour force ineffective, excessive replacement of labour is inappropriate. But it is impossible to overlook the device's ability to boost productivity. Therefore, it is crucial to choose the right way to combine these two instruments. Agriculture productivity is influenced by a number of changes in addition to the agricultural methods. In the event of soil erosion, the farmer must decide while considering the long-term effects of land conservation measures, well construction and drilling, farm fence, and fertility maintenance methods.

Farm Business Management Activities

Field management is one of the key aspects of farm business management. Farm business management is a practical procedure. Field management refers to attempting to fulfill the goal of agricultural output by making the most of scarce resources like land, human labour, and money. It is an extremely quick and intricate series of actions, not just one. Setting objectives can help ensure that the instruments available for managing the farm company are used effectively. And it's crucial to finish it on time. Indian farmers now do not exclusively cultivate for sustenance; rather, in recent years, they have tended to focus more on capital development. The farm business management procedure must be followed in order to be successful. The following steps are part of this procedure.

All agricultural land and equipment were thoroughly inspected. If you can, make a map. It is crucial to make a list of every device, verify the copy or status of every device, and record it.

A strategy for crop production should be created at first. Calculate the area, crop kind, fertilizer, medication, water, labour, and mantra-hours. No matter how much it costs, the pace should be such that the employees who spend their money wisely have a suitable workday. Planning ought to be a technique to save expenses and increase revenue.

1. After planning, what is the cost per hectare of each project, the potential revenue, the number of working days the homeowner will get, the amount of outside labour that will be needed, and the amount of other inputs that will be used? What is the price? Decisions may be made based on the viability and profitability of each business.
2. Once it has been decided which actions should be made in accordance with the plan, it should be carried out as rigorously as feasible. Supply of equipment, enough finance, the market, etc. The plan must be followed. Natural catastrophes are not a choice.
3. Control is necessary to carry out different projects' intended goals. When doing numerous tasks on the farm, management and control are essential for timely and anticipated profit.

Assuming responsibility for making and carrying out decisions. The management is aware of the result before the end of the year. Find out how much each component of the farm company has gotten by doing an economic analysis of the operation. The test of management may be viewed from there. All of these obligations rely on the choice made by the farmer or management and how that choice is carried out. She must consent to them.

Agricultural Production Factors

To satisfy customer wants, products or services must be created. Production is the process of enhancing an already-existing product or service. Inputs or product components are the parts of the manufacturing process that specific product components must be included to increase the usefulness of the good or service. The inputs used in the manufacturing of products or services for financial benefit are referred to as product components in the financial world. The input or product component refers to the machinery needed to produce a thing or service. This covers all materials required to produce an item or service. To grow paddy, for instance, farmers employ land, tractors, water, etc. These diverse inputs are divided into four categories: land, labour, capital, and entrepreneurial activity. These variables may be discussed as follows:

Land

The earth's surface is commonly referred to as "land." However, in economics, it also covers all that "nature" offers humans for free as a gift. All of nature, both living and non-living, that is used by man for production is represented by land. Land is a significant agent of production even though it is a passive component and unable to create on its own. Modern economics see land as a unique element of production that may be used for a variety of purposes in addition to one particular one. Land is essentially given away by nature for free. Man did not initially pay anything for the land he obtained. However, certain expenditures must be made in order to increase the utility or fertility of land or to make some modifications to it, even though it is provided for free by nature. Man must put up effort to get additional productive components. However, no human effort is required to gain land. Human labour does not produce land. Instead, it predated the emergence of man by a very long time.

Land Supply is Fixed

The amount of land available is fixed. This implies that unlike other production inputs, the availability of land cannot be raised or reduced. Although a person's supply of land may be changeable, the total supply of land is fixed at the macro level. Making aggressive use of the land, however, is the only way to increase the effective supply of land.

Variation in Fertility

Not all land is equally fruitful. The fertility of various lands varies to varying degrees. While certain areas are very fertile and have high agricultural output, other others are completely inhospitable and cannot support any kind of life. Similar to how the degree of mineral riches varies from location to location, the land might be more or less beneficial from an economic standpoint.

Land's Indestructibility

Land is an unbreakable component of manufacturing. Land cannot be destroyed; man can only alter a location's form and the nature of its constituent parts. Either a garden, a forest, or an artificial lake may be made out of it. But even as certain areas of the ground deteriorate as a result of natural phenomena, the total availability of land remains constant.

Immobility

In contrast to other elements, land is immobile. It cannot be moved from one location to another, making it an immobile component of production. Geographic mobility is lacking. However, other economists argue that since land may be used for a variety of purposes, it is a movable component. Every industrial method must begin with the land. For instance, it aids in the provision of raw materials for industry, and in agriculture, crops are grown on land. Since land cannot generate anything on its own, it is a passive element in production. To maximize the output from a piece of land, it must be properly coupled with human and financial resources. Land is a fixed factor of production, hence the laws of returns apply to it more efficiently because of this. Crop output rises when labour and capital are used more and more on a given piece of land, but at a decreasing pace.

Alternative Uses of Land

Alternative uses of land include construction, dairy or poultry farming, sheep farming, and building. The profitability of using a piece of land for a certain purpose relies on both the profitability of that use and the profitability of other uses. In terms of location, fertility, nature, and productivity, land is different from other production elements. There are differences between any two plots of land. Land is regarded as the main production component. Coal, water, and petroleum are abundant throughout the land and are utilized to produce electricity. Building factories and industries is necessary to carry out the manufacturing process. For humanity, land is of utmost significance. The abundance of a country's natural resources closely correlates with its economic prosperity [9], [10].

CONCLUSION

The theories covered in this article emphasize the crucial part that land, labour, money, and entrepreneurship play in agricultural output. These ideas provide the basis for wise choice-making, efficient resource management, and ultimately profitable agricultural companies. To optimize agricultural output while reducing environmental consequences, it is necessary to plan carefully and practice responsible land management due to the immutability of the land and its varying fertility. Applying the laws of returns serves as a reminder of the necessity to balance resource inputs and yields in order to prevent overuse and decreasing returns. The study also underlines the necessity of selecting activities that adhere to the principles of sustainable agriculture and taking into account alternate uses of land. Beyond maximizing profits, the idea of sustainable agriculture also includes environmental preservation, good management of natural resources, and long-term economic sustainability. The ideas presented in this study are still applicable as agriculture changes in response to shifting market dynamics, climatic issues, and consumer expectations. In order to respond to these changing circumstances, farm business management must prioritize sustainability as a key goal. Essentially, sustainable agriculture is not only a goal but also a need for the future. Farm enterprises may prosper economically while also making positive contributions to a healthier environment and a more robust agricultural sector by adopting the sustainable agriculture tenets. For farmers and agricultural stakeholders dedicated to a sustainable and successful future, the ideas covered here provide helpful direction.

REFERENCES:

[1] S. Datta, J. Singh, S. Singh, and J. Singh, "Earthworms, pesticides and sustainable agriculture: a review," *Environ. Sci. Pollut. Res.*, 2016, doi: 10.1007/s11356-016-6375-0.

[2] M. S. DeLonge, A. Miles, and L. Carlisle, "Investing in the transition to sustainable agriculture," *Environ. Sci. Policy*, 2016, doi: 10.1016/j.envsci.2015.09.013.

[3] M. Kumar, R. S. Tomar, H. Lade, and D. Paul, "Methylotrophic bacteria in sustainable agriculture," *World Journal of Microbiology and Biotechnology*. 2016. doi: 10.1007/s11274-016-2074-8.

[4] P. Migliorini and G. Lieblein, "Facilitating transformation and competence development in sustainable agriculture university education: An experiential and action oriented approach," *Sustain.*, 2016, doi: 10.3390/su8121243.

[5] H. Veisi, H. Liaghati, and A. Alipour, "Developing an ethics-based approach to indicators of sustainable agriculture using analytic hierarchy process (AHP)," *Ecol. Indic.*, 2016, doi: 10.1016/j.ecolind.2015.08.012.

[6] R. DeFries *et al.*, "Synergies and trade-offs for sustainable agriculture: Nutritional yields and climate-resilience for cereal crops in Central India," *Global Food Security*. 2016. doi: 10.1016/j.gfs.2016.07.001.

[7] T. Brown, "Civil society organizations for sustainable agriculture: negotiating power relations for pro-poor development in India," *Agroecol. Sustain. Food Syst.*, 2016, doi: 10.1080/21683565.2016.1139648.

[8] M. Noer, "Bridging food security and sustainable agriculture development through regional planning," *Int. J. Adv. Sci. Eng. Inf. Technol.*, 2016, doi: 10.18517/ijaseit.6.3.741.

[9] S. Davarpanah, S. H. Bonab, and M. Khodaverdizadeh, "Assessment and comparison of sustainable agriculture approach using a combination of AHP and TOPSIS," *Int. Acad. J. Econ.*, 2016.

[10] FAO/INRA, "Innovative Markets for Sustainable Agriculture: How Innovations in Market Institutions Encourage Sustainable Agriculture in Developing Countries," 2016.

CHAPTER 12

EVOLVING DYNAMICS OF INDIAN AGRICULTURE: PAST CHALLENGES AND FUTURE PROSPECTS

Ashutosh Awasthi, Associate Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- ashuaw@yahoo.in

ABSTRACT:

This in-depth study investigates the evolution of Indian agriculture throughout history, charting its progression from a developed and balanced system to its problems during the colonial era and its transition in the post-independence age. It draws attention to the vital role that agriculture plays in India's economic system and the significant effects that it has on rural development, poverty reduction, and industrial expansion. Aspects of Indian agriculture's difficulties, such as population pressure, reliance on the monsoon, and antiquated agricultural methods, are also covered in the article. Additionally, it emphasizes the value of agriculture in supplying industry with raw materials, generating foreign currency, and promoting rural job prospects. To achieve sustainable development and self-sufficiency, the significance of diversifying agricultural operations, enhancing infrastructure, and modernizing the sector is underlined.

KEYWORDS:

Agriculture, Economic, Foreign Currency, Labourers, Poverty.

INTRODUCTION

Indian agriculture had already grown to a mature state before the rest of the world's more developed nations started along the road of development. Agriculture and industry coexisted well at that time, flourishing side by side. Up to the middle of the eighteenth century, this arrangement persisted. The foreign British government's involvement and its purposeful strategy of stifling village handicrafts and cottage industries disrupted the fabric of balance, severely damaging the nation's economy. In India, the Bruisers adopted a standard colonial strategy and did little to advance (or revive) agriculture. Instead, they produced a group of middlemen known as zamindars who drained the rural poor of their very lifeblood. The true planter was left with hardly enough money for sustenance after this parasitic elite stole a significant portion of the output. The growers lacked the finances and motivation to make investments in agriculture [1], [2]. As a result, pre-independence Indian agriculture may be accurately defined as a "subsistence" activity that produced "too little to live on and too much to die on."

On the pretence of paying back debts incurred by farmers, the zamindars and money-landers grabbed a significant portion of the land, leaving many cultivators with no land. As a result, a class of landless labourers or agricultural labourers emerged who toiled on other people's land for salaries that were often insufficient to support both the body and the soul. The bulk of farmers were only able to barely get by on their agricultural endeavours.When India gained its independence in 1947, its agriculture was conventional and stalled in every way. Feudal land relations, outdated technologies, and the resulting poor production per acre were its defining features. Thus, the first challenge for the Indian government in the early post-Independence era was to start the modernization of agricultural expansion. Agriculture needed to be significantly modernized in terms of both technology and institutional improvements. Soon after Independence, middlemen in agriculture like zamindars and jagirdars were abolished. Land makes up the majority of India's natural resources, and by far the majority of its citizens work in agriculture. Therefore, agriculture plays a fundamental role in any plan for the nation's economic growth. Despite the fact that Indian agriculture lags far behind that of affluent nations, some significant advancements have been made since the country's independence in 1947. The agricultural and industrial economies in the country now have a strong impact on one another, new crops have taken up significant positions in the production and trade of the nation, problems with rural debt and the exploitative practices of the village moneylender are much less prevalent, and finally, there is already an awakening and a desire for raising standards of living in the countryside.

An Approach to Agriculture

The Latin words ager, which means soil, and culture, which means cultivation, are the origin of the term agriculture. The cultivation and/or production of agricultural plants or animal products may be referred to as agriculture. Crop production, animal husbandry and dairy science, agriculture chemistry and soil science, horticulture, agriculture engineering, botany, plant pathology, extension education, and entomology are all included in the field of agriculture. These fields each develop their own unique branches of agriculture and currently hold positions in a number of agriculture research facilities across the nation [3], [4].

Indian agriculture's nature

India's agriculture was in a primitive stage at the time of Independence. Extremely poor productivity was seen both per worker and per hectare. The methods used were conventional and age-old; in 1950–1951, there were only 7 tractors for every lakh hectare of gross cropland. In that year, there were only 62 oil engines and 16 irrigation pump sets per lakh hectares, respectively. Only 0.66 lakh tons of fertilizers were used in 1952–1953, which was quite little. Due to poor production, agriculture did not become commercialized and only supplied for the'subsistence' of the farmers. In 1951–1952, farmers sourced around 45% of their entire consumption from their own crops. This emphasizes how crucial money is to the village's economy. When all the aforementioned elements are considered, the character of Indian agriculture is stated.

DISCUSSION

It goes without saying that these landlords take advantage of the tenant and agricultural worker groups. Although there are no precise estimates of tenancy, it has been estimated that around 50% of the cultivated land is leased either in writing or orally. Tenants-at-will and subtenants make up a significant portion of the rental population. These renters are not guaranteed a place to live and may only cultivate as long as their landlords let them to. Since their whole livelihood depends on the landlords' satisfaction, this exposes them to their abusive methods. The second class that is exploited is made up of agricultural labourers. In rural settings, this class occupies the lowest position on the socioeconomic ladder. There are two groups that it may be broken down into: affiliated labour and casual labourers. The former is connected to a farmer family by an oral or written contract. Typically, they are restricted from working elsewhere. Contrarily, casual workers are free to work on any farmer's farm. The number of agricultural workers has increased as a result of the mass eviction of tenants under the pretext of personal cultivation. The increase in labourers is a sign that the rural poor are becoming more impoverished.Usurious capital has a significant hold on Indian agriculture, and debt is a frequent legacy of underprivileged farmers. Moneylenders and mahajans were in charge during the pre-Independence era since there were no other credit agencies deserving of the designation. These guys used their power to take advantage of the farmers in a variety of ways. The growth of co-operative credit organizations and the growing involvement of banks in providing rural loans are the two most significant policy measures taken by the government to stop their operations after Independence. But for a variety of reasons, small and marginal farmers continue to rely heavily on moneylenders to meet their credit needs, making them vulnerable to the latter's abuse. Once in debt, always in debt is a powerful expression of these farmers' circumstances.

Moneylenders often acquire the land of small and marginal farmers under various pretexts while charging high rates of interest and manipulating accounts to their benefit. The social system or production relations that are prevalent in agriculture are what lead to the usurious capital and rural indebtedness in India, where the Indian peasant has long been living as a bonded landslave. His miserable state of affairs is what led to his economic collapse and, as a result, his ongoing debt.The agricultural industry often has far lower pay than the contemporary (industrial) sector due to the overwhelming strain that people have on the land. This results in a duality in the work market. This dualism is explained by the fact that a significant portion of workers continue to work in traditional agriculture despite low wages, either because they are unaware of better employment opportunities outside of agriculture, because they are unable to find employment in the modern sector despite wanting to do so, or because the cost of moving is too high relative to the expected wage increase. Low per capita income due to low salaries in the agricultural sector also leads to low worker productivity. The traditional agriculture industry makes heavy use of manpower since it is so inexpensive. In other words, additional labour is used to complete jobs that would not be lucrative at the going pay rate. Furthermore, inexpensive labour encourages the use of labor-intensive industrial techniques, such as hand cultivation as opposed to machine agriculture [5], [6].

Old-fashioned Farming Methods

The majority of farmers in India still use antiquated agricultural methods. Traditional agriculture relies on biological energy sources including rain, dung manure, and animal and human effort. With this kind of production, farmers get extremely poor returns, and their agricultural practices are rightly referred to as "subsistence farming." However, modern production methods were started in a few chosen parts of the nation, such as Punjab, Haryana, and Western Uttar Pradesh, with the introduction of the new agricultural policy in 1966. The use of contemporary production methods and fresh, high-yielding seed types resulted in significant gains in agricultural output in these regions. However, due to the continued use of antiquated farming methods in many parts of the nation, a kind of technical dualism has developed there.

India is a sizable nation with a wide variety of agricultural products. There is no one plan that can be developed for all of the agricultural areas in the nation because various regions display completely diverse features. The types of soil, amount of rainfall, water availability, etc. vary greatly across various areas. Consider the situation of rainfall as an example. While the yearly rainfall in Western Raj, which is now in the Thar Desert, is about 4 to 5 inches, the annual rainfall in Cherrapunji, Assam, is over 450 inches. While many locations experience drought conditions in a given year, other areas experience the wrath of floods. Salt and waterlogging are issues in certain regions. Nitrogen deficit affects almost the whole farmed territory of the nation. Phosphates and potash components also vary greatly in various regions. In a given hamlet, it is not uncommon to see parcels of land with drastically differing levels of production living side by side. Not only that, but there are significant geographical disparities in the sub-division and fragmentation of holdings as well. States have various relations of production. It is essential to create distinct agricultural strategies for various areas due to the agricultural sector's significant diversity. It is impossible to generalize and create a uniform agricultural strategy for the whole country since this would be to gloss over regional variances and fall short of expectations.

Important Aspects of Indian Agriculture

The following list includes a few of Indian agriculture's unique characteristics.

Subsistence farming

In much of India, agriculture is subsistence-based. The farmer manages a tiny plot of land, cultivates crops with the aid of his family, and eats almost all of the farm's output, leaving nothing more to be sold in the marketplace. Despite the enormous changes in agricultural methods that occurred after independence, this style of agriculture has been practised in India for the last few hundred years and continues to exist now.

Population Pressure on Agriculture

India's population is expanding quickly, placing significant strain on the country's agricultural sector. A significant portion of the labour force must be employed in agriculture in order to feed the throngs of millions. Looking at the current requirement for food-grains, we need an extra 12–15 million hectares of land to meet the rising demand. Additionally, urbanization is a tendency that is on the rise. In 2001, more over one-fourth of Indians resided in metropolitan areas. By 2010, it is predicted that more than one-third of India's population would reside in cities. This necessitates the development of new urban areas, which will eventually encroach on agricultural land.

Depending on the monsoon

The unstable, unpredictable, and erratic monsoon is the key factor affecting Indian agriculture. Only one third of the farmed land is supplied by perennial irrigation, and the other two-thirds of the cropped area must face the brunt of the monsoons' whims. This is despite the massive growth of irrigation infrastructure since independence.

Various Crops

The terrain, climate, and soil conditions across the enormous nation of India are diverse. As a result, India grows a wide array of crops. In India, both temperate and tropical crops are effectively farmed. Few nations in the world generate a range of crops on par with what is produced in India.

The Value of Animals

Agriculture has traditionally benefited greatly from the power of animals. such as threshing, irrigation, plowing, and transporting the produce from the farms. Animals will continue to dominate Indian agriculture for some time to come since complete automation of the sector is still decades away. Food crop cultivation is virtually always given first priority by farmers across India because of the country's enormous population. The cultivation of food crops takes up more than two thirds of the total planted area.

Unimportant location to provide fodder crops

Despite having the biggest number of animals in the world, our cropping method gives fodder crops relatively little weight. Permanent pastures and other grazing fields make up just 4% of the reporting area. This is a result of the urgent need for land for food crops.

Capital creation contribution

The significance of capital generation for economic growth is well acknowledged. Economic growth is impossible to attain until the rate of capital creation grows to a sufficiently high level. A significant contributor to India's capital creation might be the agricultural sector. The industrial sector can successfully employ labor and capital transfers from the rural sector to boost productivity. A wide range of crucial national businesses get their raw materials from agriculture. Sugar, jute, cotton textiles, and vanaspati industries are a few examples of some of these businesses that rely on agriculture for their growth.

The significance of agricultural goods in the consumer basket

In India, the per capita income is quite low. As a result, a significant portion of this money is used to meet the needs of the populace for basic consumption. According to estimates, agricultural items make up over 60% of family consumption in India and 85% of household commodity consumption. The aforementioned explanation makes obvious the part that agriculture plays and its significance to the Indian economy. Agriculture's growth is really a virtual prerequisite for sectorial diversity and, therefore, for development itself. In order to (i) expand supplies of food and agricultural raw materials at non-inflationary prices, a rising surplus of agricultural products is required in the nation. (ii) By boosting the buying power of the rural sector, expand the home market for industrial goods. Facilitate cross-sectoral capital flows for infrastructure and industrial growth (i.e., iii) and (iv) boost exports of agricultural products to generate more foreign currency.

To end hunger and poverty

India's economy is said to be dominated by the agricultural sector. In order to address the issues of poverty and hunger, a solid foundation for agriculture is a prerequisite for quick and sustainable economic growth. In nations with higher population densities, it is acute. The disparities in income further exacerbate it. These economic characteristics, which are also prevalent in India, are referred to as roadblocks to the growth of agriculture. As a result, under these conditions, the agricultural sector cannot thrive as long as hunger and poverty persist [7], [8].

Appropriate resource management

For the level of output to rise, resources must be used effectively. Utilizing more advanced agricultural technologies is necessary for increased productivity. Additionally, irrigation systems greatly assist farmers in covering more land with a variety of crops. Therefore, efforts should be made to maximize production in areas where costly irrigation infrastructure has been built.

Accelerating Growth Rate

When the agricultural sector begins to expand along contemporary scientific lines, it will need more inputs than it did previously because of the beneficial nature of the interaction between agriculture and industry. The industrial sector provides these inputs; hence the growth of the agricultural sector is dependent on the growth of the industrial sector.

Contrarily, when the agricultural sector begins to generate more food grains and raw materials for the industrial sector, the growth of the industrial sector will raise the demand for agricultural goods, increasing employment and incomes for the people based in the agricultural sector. The expansion of the industrial sector is aided by the rise in income since it increases demand for consumer items produced by industry.

Production of an investment surplus

The command area development program established for the growth of the agricultural sector also needed funds for investment. As is well known, modernizing agriculture takes a significant amount of investment capital. Additionally, all agricultural-related operations such as processing, marketing, storage, and others need financial investment. In these situations, surpluses are necessary to boost savings and permit investment. Only through modernization and scientific advancement in agriculture can excess be produced.

Exceedance for wage goods

In order to fill the employment gap, more concerted efforts will need to be undertaken in the future to increase wage employment via the establishment of both industrial and urban jobs. In addition, employment programs for the development of infrastructure and off-form facilities in rural regions would be implemented to accommodate the expanding work force. To ensure there is enough economic stability for planned development, it will be required to provide a sizable surplus of wage goods for continued delivery to the working population at fair and stable prices.

Imports are being reduced

Food grain imports have turned into a distinctive aspect of the Indian economy. As a result, the nation must stop importing food grains. The strain of foreign currency resources would be reduced if food and cash crops were self-sufficient. Additionally, it would lessen the risks often connected with buying goods from abroad and their negative effects on domestic availability, pricing, and the economy as a whole.

Serious underemployment and open unemployment in rural regions are the causes of the low level of rural earnings and the poor quality of living of the rural people. Crop production cannot provide enough jobs on its own. Therefore, it is essential to diversify rural job options by creating appropriate ancillary professions like dairy, poultry breeding, etc.

Food and nutrition provision

The food and nutrition need of both urban and rural populations fall within the purview of the agriculture sector. In addition to sufficient production of food grains and supplemental protective foods, food production must be greatly increased even to maintain current consumption levels. This will increase labour productivity. Only when human capital is endowed with health and energy can labour productivity increase. Therefore, enough nourishment may significantly raise one's ability to work and make money, which in turn boosts output, welfare, and happiness, all of which contribute to the country's economic progress.

Raw material supply to the industrial sector

The need for raw materials by the industrial sector, which is expanding, must be met by the agricultural sector. Industries including cotton and jute textiles, dairy products, vegetables, oils, tea, coffee, leather, and leather goods all rely on the agricultural sector's ability to produce goods. The availability of raw materials domestically would determine the growth and usage of the existing capacity in these and other sectors. Therefore, domestic production of agricultural raw materials would improve how these sectors operate.

Beneficial to the Allied sector

The agricultural industry has to focus more on the development of related industries. Increased output in these domains acquires special significance since improving nutrition is a fundamental goal of development. Additionally, the growth of related sectors benefits the country as crop production is not advantageously suited to many agroclimatic situations.

Foreign exchange contribution

Reducing agricultural imports may help the agriculture industry contribute positively to foreign currency gains. A significant share of the present agricultural imports are only foods. Self-sufficiency in food, animal husbandry goods, and essential raw resources will thus significantly contribute to the saving of foreign currency. Therefore, in order to reduce imports and preserve foreign currency revenues, the agricultural sector must increase its self-sufficiency in food items and other agricultural goods [9], [10].

CONCLUSION

Over the years, Indian agriculture has witnessed significant changes as it has adapted to new situations and difficulties. It has changed from being a sector focused on subsistence to one that is a significant contributor to economic growth, rural livelihoods, and foreign currency profits. However, enduring problems including reliance on the monsoon, poor production, and antiquated agricultural methods continue to provide difficulties. A comprehensive strategy that incorporates modernization, diversification, and investment in rural infrastructure is required for the future. It is impossible to overestimate the importance of agriculture in eradicating poverty, supplying industry with raw materials, and assuring global food security.

Thus, in order to shape India's future as a strong and independent agricultural country, acknowledging its essential contribution and tackling its issues would be crucial.

REFERENCES:

[1] K. Kaur, "Machine Learning: Applications in Indian Agriculture," *Int. J. Adv. Res. Comput. Commun. Eng.*, 2016.

[2] R. H. Prasad, K. Sreeramappa, and M. Dinesha, "Trends and growth rate of pesticide use in Indian agriculture-An economic analysis," *Int. J. Appl. Res.*, 2016.

[3] D. D. Amutha, "Present Status of Indian Agriculture," *SSRN Electron. J.*, 2016, doi: 10.2139/ssrn.2739231.

[4] B. B. Swain, "Contract Farming and Indian Agriculture: Can Agribusiness Help the Small Farmer?," *Indian J. Agric. Econ.*, 2016.

[5] D. (Mrs). Thangamani, "Indian Agriculture : Performance and Challenges – a Case Study," *Shanlax Int. J. Arts, Sci. Humanit.*, 2016.

[6] N. A. Siddiqi and M. S. Alam, "Climate sensitivity of Indian agriculture," *Int. J. Appl. Bus. Econ. Res.*, 2016.

[7] D. K. Behera, "Employment potential in Indian agriculture: An econometric investigation," *Appl. Econom. Int. Dev.*, 2016.

[8] C. A. Rama Rao *et al.*, "A district level assessment of vulnerability of Indian agriculture to climate change," *Curr. Sci.*, 2016, doi: 10.18520/cs/v110/i10/1939-1946.

[9] B. Brahmaiah and S. Palamalai, "Price discovery and volatility spillover effect in Indian agriculture commodity market," *Int. J. Econ. Res.*, 2016.

[10] P. Yadav, P. K. Agarwal, and B. S. Chandel, "Gender Issues in Indian Agriculture: The Structural Changes in Agriculture Labour Force Participation," *Agric. Situat. India*, 2016.

CHAPTER 13

ENHANCING THE AGRICULTURAL PRODUCTIVITY: CHALLENGES AND STRATEGIES

Kusum Farswan, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India Email Id- kusumfarswan.14feb@gmail.com

ABSTRACT:

India's economy is based on agriculture, which supports millions of people's livelihoods and is essential to guaranteeing food security. The industry does, however, suffer a number of difficulties that limit its expansion and production. This essay explores the different barriers that have decreased agricultural output in India and suggests workable solutions. This essay examines the many difficulties that agriculture has in increasing production and suggests solutions. A vital element of every country's economic development and food security is agricultural production. Low agricultural production in India is a result of a number of challenges, including obsolete farming methods, insufficient irrigation infrastructure, insufficient access to financing, and poor marketing strategies. The implementation of land reforms, modernization of irrigation systems, encouragement of farm automation, enhancement of agricultural management methods, and improved loan availability are all stressed in this article. India can considerably increase its agricultural production by resolving these issues and putting the recommended techniques into practice, resulting in stable development and prosperity for the agricultural industry.

KEYWORDS:

Agricultural Industry, Agricultural Production, Economic, Management, Prosperity.

INTRODUCTION

A number of academics have defined "Agricultural Productivity" in light of their own perspectives and fields of study. Agronomists, economists, geographers, and agriculturalists have all given it varied interpretations. Agricultural productivity is defined as "output per unit of input" or "output per unit of land area" in both agricultural geography and economics, and an increase in agricultural productivity is typically attributed to a more effective use of the factors of production, i.e. technical, institutional, socioeconomic, and physical. This idea has drawn criticism from several academics who point out that it only regarded land as an element of production and ignored all other aspects. Other academics have thus proposed that agricultural productivity should include all production components, including labour, farming expertise, fertilizers, water availability and management, and other biological elements. The use of marginal return per agricultural unit was recommended since it is commonly acknowledged that the average return per unit does not accurately depict the situation [1], [2].

Agriculture is the backbone of India's economy, providing livelihoods to millions of people and playing a critical role in ensuring food security. However, the sector faces numerous challenges that hinder its productivity and growth. This paper delves into the various impediments that have limited agricultural productivity in India and offers practical strategies to overcome them. Agricultural productivity encompasses the efficient utilization of resources, including land, labor, capital, and technology, to maximize output. Low productivity in agriculture is a complex issue influenced by a range of factors, both institutional and technological. Historically, the exploitative land tenure system, uneconomic land holdings, inadequate access to credit, and flawed marketing structures have hampered agricultural growth. Furthermore, reliance on traditional farming techniques, inadequate irrigation facilities, and limited use of modern machinery have also contributed to stagnant productivity levels. In this paper, we outline key challenges and propose strategies to address them comprehensively. These strategies encompass land reforms to eliminate intermediary interests in land, modernizing irrigation systems to enhance water availability, promoting farm mechanization to improve efficiency, facilitating better access to credit, and focusing on agricultural management practices. By implementing these strategies, India can unlock its agricultural potential, leading to increased productivity, higher incomes for farmers, and sustainable agricultural growth.

Agriculture productivity concept

The "ratio of the index of local agricultural output to the index of total input used in farm production" may be used to determine agricultural productivity. If all else is equal, it is a measure of how effectively inputs are used in production. The returns from an arable land or cultivable land unit are referred to as agricultural productivity in this context. Saxon observed that productivity is a physical relationship between output and the input that gives rise to that output. He defined agricultural efficiency as productivity as "expressing the varying relationship between agricultural produce and one of the major inputs, like land, labour, or capital, while other complementary factors remaining the same.

Productivity of land is a very important aspect of agriculture because it is the most permanent and fixed factor among the three categories of input- land, labour, and capital. Essentially, land as a unit basis articulates yield of crop in terms of output to provide the nation's food supply and secure employment opportunities for the rural community.

Productivity of labour is important as a determinant of the income of the population engaged in agriculture. In general, it may be expressed by the man-hours or days of work needed to produce a unit of production. Shafi has mentioned that the labour productivity is measured by the total agricultural output per unit of labor. It relates to the single most important factor of production, is intuitively appealing and relatively easy to measure. On the other hand, labour productivity is a key determinant of living standards, measured as per capita income, and this perspective is of significant policy relevance.

However, it only partially reflects the productivity of labour in terms of the personal capacities of workers or the intensity of their efforts. In agricultural geography, the labour productivity has two major important aspects. First, it profoundly affects national prosperity and secondly principally determines the standard of living of the agricultural population. Capital, in terms of purchase of land, development of land, reclamation of land, drainage, irrigation purpose, livestock, feeds, seeds, agricultural implements, and machineries, crop production chemicals is being given priority as a factor for enhancing agricultural productivity [3], [4].

Agricultural Productivity Issues

In this subject, we propose to explore the institutional and technical elements that explain for poor agricultural productivity, which is still relatively low when compared to other nations and vis-à-vis the potential productivity. The exploitative land tenure system, uneconomic holding sizes, underdeveloped lending institutions, and flaws in the marketing structure are the most significant institutional reasons that have historically kept agricultural output and productivity low in India.

Agriculture in India is productive

Perhaps the most important reason for low agricultural productivity in India has been the zamindari system. This system created a unique agrarian structure in the countryside, which conferred the right of sharing the produce of land without participating personally in the production process. The system itself was based on exploitation as it conferred unlimited rights on the zamindarsto extract as much rent as they wished. According to Bhawani Sen,1 approximately 25 per cent of the produce was taken away by the intermediaries in the form of rent. This would mean that out of the income of Rs. 4,800 crorefrom agriculture in 1949-50, the share of intermediaries was as high as Rs. 1,200 crores. The grabbing of such a high proportion of income by a parasitic class was not only socially unjust but also highly detrimental to capital formation and economic development. The actual cultivator was left with no surplus to invest in better implements, improved seeds or fertilizers and neither was there any incentive for him to increase agricultural production and productivity.

Thus, according to Thorner, a built-in 'depressor' continued to operate in the countryside characterized by low capital intensity and antiquated methods. 2 The tillers showed no interest in modernization of agriculture partly because they were deprived of resources to invest in agriculture by the zamindars (who, in turn, used the acquired wealth only on conspicuous consumption and on items to sustain their profligate lifestyle) and partly because they knew that any gains in agricultural production and productivity would be siphoned off by the zamindars while they would continue to live in conditions of object poverty. In large areas of the country, actual cultivation was done by tenants whose tenancy, in most areas, was insecure and depended on the mercy of the landlords. This made them prone to various exploitative practices adopted by the latter.

DISCUSSION

Obviously, under such exploitative land tenure systems, agricultural production and productivity was bound to be low. After Independence, the State governments passed legislations to abolish zamindari and improve the position of tenants. However, all critics agree that the above measures have been unsuccessful in achieving their objectives. Zamindars continue to existin the garb of large landowners. They have acquired large areas of land for personal cultivation on which cultivation is done with the help of hired agricultural labour. In the States where a ceiling hasbeen fixed as to the amount of land a former zamindar can hold, the ceiling has been kept so high that very few zamindars have been affected. Flaws in the legislations have also enabled them to transfer land to other members of their families and thus escape the ceiling law. Bihar remained a stronghold of large landholders and hierarchical property rights, where "leasing, sub-leasing and evictions are all common."5 As far as tenants are concerned, they have no strength to match the force of landlords and often evict the land under the pressure of the latter voluntarily. In any case, since most of the tenancies are insecure and oral, the actual tenants are not in a position to obtain the protection of law [5], [6].

Unprofitable holding size

In addition, even these small holdings are dispersed and fragmented into a number of units. According to the 8th round of the National Sample Survey, an operational holding in India was divided into five units. It was also found that with an insufficient number of holdings, the average size of holdings in India was only 1.57 hectares in 1990–91. 59 percent of the holdings were less than 1 hectare in 1990–91 and can, therefore, be regarded as Small and fragmented holdings impede agricultural progress and adversely affect agricultural production and productivity. This is due to the following reasons: (1) Because of sub-division and fragmentation of holdings, the size of plots becomes so small that sometimes it is not possible to cultivate on them. Substantial land is also wasted in drawing boundaries and hedges between small, tiny plots. (2) Because of the small size of farms, it is not possible to make use of new technological innovations in the field of agriculture. The application of new methods of production requires ample doses of fertilizers, which in turn, require sufficient irrigation facilities. However, because of fragmentation, it is frequently not possible for the farmer to make proper arrangement of irrigation in all plots belonging to him. As a consequence, adoption of new agricultural technology is hindered. In addition to the problems in adopting new agricultural technology, sub-division and fragmentation of holdings makes it difficult for the farmers to manage all their plots efficiently. Inefficient management leads to low agricultural productivity.

Credit institutions that are still under development

This heavy dependence of the farmers on the money lenders enabled the latter to dictate terms and exploit the former in a number of ways. For instance, moneylenders charged exorbitant rates of interest ranging from 19 per cent to 50 per cent or even more. They often manipulated accounts to their advantage by not entering the money returned and interest paid into the account.

They also forced the farmers to sell the agricultural produce to them at low prices. On account of all these practices ofmoneylenders, the farmers were left with no resources to invest in programmes to increase agricultural production and productivity. Most of the farmers were under heavy burden of debt and all their lives they could not get out of it. The position of the average farmer wasexpressed in the following phrase graphically "the Indian farmer is burden of debt and all their lives they could not get out of it. The ordinary farmer in India was described in this way: "The Indian farmer is born in debt, lives in debt, and dies in debt." Naturally, under these circumstances, Indian agriculture was just a subsistence agricultural with extremely low levels of output and productivity.

Rural lending has a significant impact on Indian agriculture productivity. Since being exposed to the banking system, millions of first-generation depositors and borrowers have switched from using non-institutional moneylenders and pawnbrokers to banking institutions and cooperatives. This is just a portion of the narrative, however. The parallel "economy" has significantly melted, but the moneylender has not disappeared, according to the Agricultural Credit Review Committee. There are still non-institutional sources of agricultural loan available, and they do so at high interest rates that are now lower than previously. The rural economy has not been significantly affected by institutional agencies' deposits and advances, notwithstanding their extraordinary expansion.

Marketing structure flaws

The Indian agricultural marketing system has been plagued by a variety of flaws for a long time. As a result, the Indian farmer was unable to get a reasonable price for his harvest. Farmers sell a significant portion of their overall crop to local merchants and moneylenders. The majority of farmers are heavily indebted, and moneylenders (lien moneylenders) force them to sell their products to them at prices that are often far lower than market rates. Since the transportation infrastructure is underdeveloped, many farmers choose to sell their crop directly at the local market. Large amounts of the product are dumped in the local markets as soon as they are harvested since the settlements lack suitable storing facilities. As a result of the significant increase in supply, farmers are able to sell their goods for a reasonable price in the local markets. Farmers that travel to mandies to sell their products deal with a network of middlemen, including brokers, distributors, merchants, and more. As a result, there is little motivation to utilize superior seeds or create superior kinds. Naturally, agricultural productivity and output are constrained to the below under the selling circumstances indicated above.

Technology-related factors

The following technological factors are the most significant ones contributing to low agricultural productivity and production: (i) insufficient irrigation facilities; (ii) use of antiquated production methods; (iii) limited use of fertilizers; (iv) insufficient plant protection measures; and (v) limited use of high yielding seed varieties.

Inadequate irrigation systems

The availability of water has a significant impact on the increase in agricultural output. Hence, irrigation is crucial. However, India's irrigation system is woefully underdeveloped. For instance, in 1960–1961 only 18.3% of the whole planted area was grossly watered. Despite significant expenditures in irrigation facility construction throughout the planning period, the gross irrigated area as a proportion of cropped land had only increased to 36.0% in 1993–1994 (despite this). Thus, we may conclude that around 65% (or slightly less than two thirds) of planted area still depends on rainfall. This land's production is much lower than that of irrigated land. The Planning Commission calculated that the yield of unirrigated land is about half that of irrigated land. Since almost two thirds of agricultural land in India is not irrigated, D. Dhawan observed that land productivity on irrigated lands averaged about 22 quintals per crop hectare in 1983–84 as opposed to less than 9 quintals per crop hectare on unirrigated lands.8 This indicates that overall agricultural production and productivity in India is very low. Another aspect worth addressing in this regard is that since 80% of India's annual rainfall falls in fewer than four months, repeated cropping is not practicable on unirrigated areas. Two or three crops may be grown in these locations in a year if irrigation facilities are provided across wide areas. This will greatly increase agricultural productivity and output [7], [8].

Using antiquated manufacturing methods

Agriculture in India continues to use conventional production methods extensively. Farmers employ crude and basic agricultural tools to carry out their farming activities, and these tools need biological energy sources (such as human and animal work) to function. Contrarily, developed Western nations mostly rely on mechanical energy sources (such as tractors, threshers, harvester combines, pump sets, etc.) to complete agricultural tasks. The speed at which tasks are completed and the effectiveness with which resources are used both rise thanks to mechanical sources of energy. Labour productivity rises when less labour is needed to generate the same amount of output as before. It is often noted that traditional agriculture, which relies on bullocks, wooden (or iron) ploughs, and other archaic tools, is just a means of sustenance for farmers (even if they may sell some of their goods in the markets). The advent of tractors, harvesters, threshers, irrigation pump sets, etc. alters the fundamental character of traditional agriculture and turns it into a for-profit endeavour. Due to this, the economic surplus (the difference between total production and consumption of agricultural output; measured by Productivity of Indian Agriculture) rises, which raises farmer earnings. As a result, the farmers are better equipped to make long-term changes to the land. Better seeds, more fertilizer, insecticides, and other inputs are all used more often, which boosts agricultural productivity and output.

Increased agricultural production measures

The reasons mentioned above also point to possible solutions to boost productivity. It would be obvious that such actions would need to approach the issue from a technological, institutional, social, and economic perspective. It will be necessary to make efforts in the following directions in particular. The post-Independence period saw the introduction of land reforms in India with the goals of eradicating inland intermediary interests (especially zamindari), giving tenants security of tenure and ownership rights, and reorganizing agriculture through the use of land ceiling legislation, co-operative movement, and consolidation of holdings. However, the progress that has been made is far from satisfactory. In order to put the phrase "land to the tiller" into effect, significant efforts will need to be undertaken by the State governments to enforce the land reform laws. Without doing this, the tiller won't be motivated to buy land or use innovative farming methods. Therefore, land reforms are very necessary.

Irrigation

Appropriate irrigation infrastructure is needed to use better crops and fertilizers. In certain regions, irrigation may also enable multiple cropping, which will increase output. A national grid system must be developed to ensure water supply from water surplus areas to water deficit areas, among other things. This field will require efforts in the following directions: phased modernization of irrigation systems, improved operation of existing systems, efficient water management, adequate maintenance of canals and distribution systems, detailed surveys and investigation for preparation of new projects, etc.

Farm automation

The prevailing consensus is that farm mechanization may boost agricultural production. Mechanization proponents claim that it boosts labour and land productivity, lowers costs, frees up more time, and increases economic surplus. Although it is impossible to determine how much of an improvement in production is attributable to mechanization alone, it should be kept in mind that all estimates of productivity include the contribution of machines as well as other agricultural inputs such better seeds, fertilizers, etc. Mechanization does, however, save labour time that may be put to better use elsewhere.

Offering finance and marketing resources

Improved seed types, fertilizers, herbicides, insecticides, agricultural equipment, and irrigation systems all demand significant financial resources, which small farmers often do not have. To address the financial needs of small farmers, it is thus vital to grow the credit cooperative sector and release it from the grip of powerful landowners. Small farmers should be given additional credit by commercial banks. In this context, regional rural banks may play a unique role. To better assist small and marginal farmers, the marketing system also has to be reoriented. To guarantee higher pricing for small farmers, cooperative marketing groups have to be encouraged.

Improved management

Agriculture likewise needs improved management to increase production, just as industry depends on professional management to boost output. Farmers must be instructed in the more effective use of their resources, mainly land, irrigation systems, and agricultural equipment, for this purpose. The use of science and technology in agriculture is a related issue. This is only possible if there is a sizable administrative staff network actively distributing knowledge about novel agricultural practices and production methodologies. Other duties of this extension workers might include evaluating the appropriateness of social and climatic circumstances for various crops and offering advice to farmers on issues they encounter on a daily basis while conducting agricultural operations.

Agricultural investigation

The Indian Council of Agricultural Research, numerous agricultural universities, and other institutes are now doing agricultural research to develop high-yielding seed variants for diverse crops. In the case of wheat, there has been a great deal of success. However, in order to have equal results with other crops, more work is needed. A significant amount of research should also be done at various regional centres to test the soil's quality, recommend strategies for soil reclamation and conservation, investigate the diseases affecting various crops, enhance the quality of agricultural tools, and prevent waste in agriculture, particularly crop damage brought on by pests, insects, rodents, etc. Given the aforementioned circumstances, deliberate efforts are needed to increase dry-land agricultural production levels. This calls for a "integrated" strategy to prevent runoff of the rainfall from the area of its incidence, prevent soil erosion, conduct in-depth research on rainwater management, reduce evaporation losses through greater rainwater conservation, manage watersheds, integrate nutrient management, etc. The yield of many different crops, including coarse cereals, pulses, rice, cotton, and oilseeds, may be increased by using effective and efficient dry-land farming techniques. This would not only assist to increase agricultural production overall in India, but it will also help to "broad-base" agricultural growth and raise the income levels of small and marginal farmers [9], [10].

CONCLUSION

India's economic growth and food security depend on increasing agricultural production. The substantial difficulties that the agricultural industry faces, such as those with land tenure, irrigation, mechanization, loan availability, and marketing, have been underlined in this study. It does, however, provide some optimism by outlining workable solutions to these problems. India's agricultural environment may be changed by land reforms that guarantee fair land distribution, modern irrigation systems that optimize water consumption, the promotion of automation that increases efficiency, and easier access to loans. Additionally, stressing better agricultural management techniques may result in a consistent increase in output. In conclusion, thorough reforms and calculated investments are the key to raising agricultural production in India. By putting these policies into place, India can make the most of its agricultural industry and ensure food security, higher farmer incomes, and overall economic development.

REFERENCES:

[1] A. P. de la O Campos, K. A. Covarrubias, and A. P. Patron, "How Does the Choice of the Gender Indicator Affect the Analysis of Gender Differences in Agricultural Productivity? Evidence from Uganda," *World Dev.*, 2016, doi: 10.1016/j.worlddev.2015.08.008.

[2] P. Bustos, B. Caprettini, and J. Ponticelli, "Agricultural productivity and structural transformation: Evidence from Brazil," *Am. Econ. Rev.*, 2016, doi: 10.1257/aer.20131061.

[3] J. Assunção and F. Chein, "Climate change and agricultural productivity in Brazil: Future perspectives," *Environment and Development Economics*. 2016. doi: 10.1017/S1355770X1600005X.

[4] Y. Jin and W. E. Huffman, "Measuring public agricultural research and extension and estimating their impacts on agricultural productivity: New insights from U.S. evidence," *Agric. Econ. (United Kingdom)*, 2016, doi: 10.1111/agec.12206.

[5] P. E. Edoja, G. C. Aye, and O. Abu, "Dynamic relationship among CO2 emission, agricultural productivity and food security in Nigeria," *Cogent Econ. Financ.*, 2016, doi: 10.1080/23322039.2016.1204809.

[6] J. Assunção, M. Lipscomb, A. M. Mobarak, and D. Szerman, "Agricultural productivity and deforestation in Brazil," *Clim. policy Initiat.*, 2016.

[7] J. Ženka, O. Slach, L. Krtička, and P. Žufan, "Determinants of microregional agricultural labour productivity - Evidence from Czechia," *Appl. Geogr.*, 2016, doi: 10.1016/j.apgeog.2016.04.004.

[8] S. Benin and A. Nin-Pratt, "Intertemporal trends in agricultural productivity," *Agric. Product. Africa Trends, patterns, Determ.*, 2016.

[9] T. B. Andersen, P. S. Jensen, and C. V. Skovsgaard, "The heavy plow and the agricultural revolution in Medieval Europe," *J. Dev. Econ.*, 2016, doi: 10.1016/j.jdeveco.2015.08.006.

[10] F. Mwesigye and T. Matsumoto, "The Effect of Population Pressure and Internal Migration on Land Conflicts: Implications for Agricultural Productivity in Uganda," *World Dev.*, 2016, doi: 10.1016/j.worlddev.2015.10.042.