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Innovative Approaches for Afghanistan's Agricultural Water Management

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ABSTRACT

Due to the difficulties of water shortages and climate change, innovative water management solutions in agriculture are essential for food security, environmental sustainability, and economic viability. This study addresses several innovative techniques for agricultural water management in Afghanistan, considering specific issues in the region. Afghanistan's dependency on imported food reveals the ineffectiveness of the irrigation system, as well as a lack of new agricultural technologies and infrastructure. This study was conducted at the Paktika Higher Education Institute to analyze key irrigation challenges and provide innovative approaches to water management in Afghanistan's agriculture. Sixty-nine agricultural faculty students participated in the study. The primary data for this quantitative descriptive study were collected through questionnaires. SPSS version 24 was used to analyze the data. The analytical methods used were frequency and percentage. According to the findings, the key problems were drought, lack of a plan for managing water in agriculture, failure to apply water management regulations, lack of modern irrigation systems, and farmers' lack of knowledge regarding crop water requirements. Water management in Afghanistan's agriculture can be enhanced by precision agriculture, rainwater collection, the reuse of treated wastewater, conservation tillage, crop rotation, cover crops, smart irrigation, and drip and sprinkler irrigation systems.

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Introduction

Significant effects of climate change in Afghanistan include crop failure, starvation, drying up of water supplies, and food inflation (Sarwary et al., 2022). In Afghanistan, devastating droughts and floods occur more frequently due to climate change's impact on water resources (Nasimi et al., 2021). Afghanistan's economy is based mainly on agriculture, and managing irrigation water is crucial to the agricultural sector's performance (JICA, 2019). Afghanistan's dependence on food imports exposes the weaknesses of the irrigation system and the organizations in charge of it, highlighting the need for investment in more advanced farming practices and infrastructure (Akhtar et al., 2018). Irrigated agriculture accounts for more than half of Afghanistan's GDP and gives most rural residents a stable source of income

and food (Rout, 2008). Afghanistan's heavy reliance on water resources for agricultural purposes. However, this allocation of water resources may not be sustainable in the long run. Therefore, Afghanistan must explore more efficient irrigation techniques and implement water management strategies to ensure a balanced distribution of water resources among the different sectors (SHAMS, 2016). Effective irrigation techniques may guarantee the sustainable use of water resources, promoting community access to clean water and food production. Afghanistan is one of the countries that can optimize its water resources using irrigation techniques (Coles and Camkin, 2023). Two types of water irrigation methods are currently in use in Afghanistan: informal and formal. Surface water conveyance (canals), underground water irrigation, and Karez irrigation account for 90% and 10% of irrigation, respectively (Azami et al., 2020). Due to drought and poor groundwater management, the water table has dropped nearly everywhere in the country (Alim, 2006). Drought, population growth, and inefficient agricultural use worsen Afghanistan's water scarcity and freshwater depletion. Addressing these issues requires sustainable water management and water-efficient irrigation technologies (Habib, 2014). Therefore, this study aimed to identify the main problems related to irrigation and suggest innovative approaches for Afghanistan's agricultural water management.

Problem Statement

Afghanistan faces significant challenges in managing its agricultural water resources. The country's agriculture relies heavily on irrigation, but inefficient water management practices and limited infrastructure have led to water scarcity, soil degradation, and reduced crop yields. Additionally, the impacts of climate change are exacerbating these issues, further threatening the livelihoods of millions of Afghan farmers.

Significance of the Study

It is impossible to overestimate the importance of novel strategies for managing Afghanistan's agricultural water resources. Increasing food demand and a rapidly expanding population make optimizing water use in agriculture imperative. Water scarcity is made worse by the unpredictability of rainfall patterns and extended droughts brought on by climate change. Therefore, achieving sustainable development in Afghanistan requires creative ways to enhance agricultural water management.

Research Questions

1- What are the key challenges of Afghanistan's agricultural water management?

2- What innovative approaches can be implemented to improve agricultural water management in Afghanistan?

Method and Materials

The study gathered data on Afghanistan's irrigation water management issues and suggested innovative approaches using primary and secondary sources. Surveys using

questionnaires were used, and the descriptive analysis benefited from using questionnaires in the Pashto national language of Afghanistan. Secondary data was gathered from journals, conference proceedings, and publications. The survey comprised closed-ended questions and was given to 69 agriculture faculty students at Paktika Higher Education Institute. Since each survey participant gave the same responses, the questionnaire can be considered dependable and uniform.

Data Analysis

A descriptive analysis of the results was conducted using SPSS 24. The research analytical methodologies of frequency and percentage were selected because of their suitability and efficacy in evaluating test questions.

Findings

The questionnaire asked participants general questions and details about the crop type, water resources for irrigation, types of irrigation, implementation of modern irrigation techniques, precision agriculture, priority of water conservation in agricultural practices, practical irrigation approaches for Afghanistan, rainwater harvesting, reuse of treated wastewater, conservation tillage, crop rotation, smart irrigation systems and challenges of water management in Afghanistan agriculture. The survey results are presented in Table 1.

Table 1: The results of the questionnaire

Questions	Parameters	Survey responses participants	
		Frequency	*Percentage*
Respondents Gender	Male	69	100.0
	Female	0.00	0.00
	Total	69	100.0
Respondents Education level	Second class	26	37.7
	Third class	18	26.1
	Fourth class	25	36.2
	Total	69	100.0
Cropland	Yes	67	97.1
	No	2	2.9
	Total	69	100.0
Crop types	wheat	12	17.4
	vegetables	2	2.9
	Alfalfa (Reshqa)	3	4.3
	Maize	0.00	0.00
	all	52	75.4
	Total	69	100.0
Garden	Yes	50	72.5
	No	19	27.5
	Total	69	100.0
Water Resources for irrigation	Karez	14	20.3
	spring	10	14.5

	Borewells	44	63.8
	wastewater	1	1.4
	Total	69	100.0
Types of Irrigation	Flood	35	50.7
	Pond	20	29.0
	Drip	12	17.4
	Sprinklers	2	2.9
	Total	69	100.0
Challenges of irrigation water management in your area.	a-lack of a plan for water management in agriculture.	8	11.6
	b- no enforcement of water management regulations.	6	8.7
	c-lack of modern irrigation systems.	9	13.0
	d-lack of farmers' awareness about water management in agriculture.	4	5.8
	e-All of them	42	60.9
	Total	69	100.0
Public interest in implementing modern irrigation techniques.	a-Yes, we are already using modern irrigation techniques	18	26.1
	b-No, but we are interested.	47	68.1
	c-No, we have not considered it and are not interested	4	5.8
	Total	69	100.0
By using advanced technology such as sensors, drones, and satellites, precision agriculture enables farmers to optimize irrigation schedules and apply only needed water.	Agree	41	59.4
	strongly agree	26	37.7
	disagree	2	2.9
	strongly disagree	0.00	0.00
	Total	69	100.0
Prioritize water conservation in agricultural practices.	a) Water conservation is a top priority for us	31	44.9
	b) We consider it important but have limited resources to invest in conservation measures	36	52.2
	c) Water conservation is not a priority for us	2	2.8
	Total	69	100.0
Effective irrigation approaches for Afghanistan water management in agriculture.	Traditional irrigation	11	15.9
	drip irrigation	34	49.3
	sprinkler	19	27.5
	pond	5	7.2
	Total	69	100.0

Rainwater harvesting can be an effective way to conserve water in agriculture.	Agree	23	33.3
	strongly agree	45	65.2
	disagree	1	1.4
	strongly disagree	0.00	0.00
	Total	69	100.0
Reuse of treated wastewater can help with water management in agriculture.	Agree	31	44.9
	strongly agree	35	50.7
	disagree	3	4.3
	strongly disagree	0.00	0.00
	Total	69	100.0
Conservation tillage reduces evaporation and improves water infiltration into the soil.	Agree	37	53.6
	strongly agree	32	46.4
	disagree	0.00	0.00
	strongly disagree	0.00	0.00
	Total	69	100.0
Crop rotation and cover crops help improve soil health and reduce water requirements	Agree	27	39.1
	strongly agree	37	53.6
	disagree	3	4.3
	strongly disagree	2	2.9
	Total	69	100.0
Smart irrigation systems can prevent overwatering and reduce water waste.	Agree	28	40.6
	strongly agree	40	58.0
	disagree	1	1.4
	strongly disagree	0.00	0.00
	Total	69	100.0

Discussion

According to the findings of this study,63.8 percent of the study participants use groundwater for irrigation. Fifty percent use flood irrigation. Flood irrigation is a common practice that wastes water and is costly for farmers who are remote from water supplies (Azami et al., 2020). According to Qureshi (2002), in Afghanistan, farmers commonly do not understand the water needs of their crops, and overirrigation is a typical practice. As shown in Table (1), the lack of a plan for water management in agriculture, no application of regulations related to water management, lack of modern irrigation systems, and lack of farmers' awareness about water management in agriculture are the key challenges of agricultural water management in Afghanistan. Effective irrigation techniques such as drip and sprinkler irrigations, rainwater harvesting, reuse of treated wastewater, conservation tillage, crop rotation, cover crops, and smart irrigation systems are the main innovative approaches that can help with Afghanistan's agricultural water management. According to the Kyr Ministry of Agriculture and Melioration (2015), there is a need to decrease the harmful consequences and minimize the effects of climate change on the natural environment. Given the current situation of irrigated agriculture, climate change will worsen water scarcity and pose additional risks to agriculture. Determining the agriculture industry's long-term water resource requirements necessitates knowledge of cutting-edge irrigation systems. Water supplies must be protected through dams, desalination, sewage treatment, and pipeline

monitoring. Furthermore, sustainable agricultural practices such as crop rotation, organic fertilizers, and accurate irrigation can mitigate the detrimental effects on soil and water resources. Furthermore, increasing farmers' understanding of the necessity of conservation and offering incentives to use eco-friendly techniques can contribute to long-term environmental and agricultural sustainability (SAAD et al. 2020). Drip irrigation can significantly enhance crops' growth and physiological indices and improve crop quality (Yang et al ., 2023). Drip irrigation system significantly enhances water productivity and efficiency in crops like maize, cabbage, sunflower, sugar beet, garlic, barely, and onion, resulting in significant water savings (Moursy et al.,.2022).To solve problems like feeding a growing population while minimizing environmental impact, precision agriculture uses cutting-edge technologies like drones, GPS, data analytics, and artificial intelligence to increase crop yields, reduce waste, and improve environmental impact. (Karunathilake et al,.2023). Rainwater harvesting systems save domestic water, reduce network usage, and generate income in many nations, especially in remote areas without clean water access (Ertop et al.,.2023). Conservation tillage techniques, crop rotation, and diversification significantly improve nutrient cycling, suppress pests, and mitigate agricultural diseases (Indira et al., 2023).

Conclusion

Innovative approaches to agriculture water management are crucial for Afghanistan to overcome water scarcity challenges and ensure sustainable agricultural practices. Water harvesting, drip irrigation, sprinkler irrigation, water-efficient crop selection, and appropriate farming techniques have shown promising results in enhancing water availability, improving productivity, and reducing water wastage. These approaches, supported by various studies and research, can serve as practical solutions for enhancing Afghanistan's agriculture sector in the face of limited water resources and climate change challenges. By implementing these water-saving techniques, farmers in Afghanistan can increase their crop yields and mitigate the risks associated with water scarcity and unpredictable weather patterns. Additionally, adopting these sustainable practices can contribute to water resource conservation for future generations and promote long-term food security in the country.

Recommendations

1. Strengthening institutional capacity: Government agencies managing agriculture and water resources must build capacity to implement policies and programs to improve agricultural water management effectively.
2. Promoting public-private partnerships: Partnerships amongst governmental bodies, businesses, and non-governmental groups can assist in mobilizing the capital and know-how required to execute cutting-edge methods of agricultural water management.

3. Investing in research and development: Funding research projects to create innovative techniques and technologies for effective agricultural water management can spur creativity in this important field.
4. Enhancing farmer education: Training and education programs on modern irrigation technologies and sustainable farming methods can help farmers better manage water resources.

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