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Assessing Technical Efficiency and Resource Utilization in Dryland Groundnut Farming: A Case Study of Tehsil Chakwal

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Abstract: *This research examines dryland agriculture's technical efficiency among groundnut farmers in Chakwal Tehsil. Groundnut cultivation is crucial for food security in arid regions. The study analyzes current technical efficiency and ways to optimize resource use. Results show many farmers can increase output by 51% with better input combinations. Technical efficiency scores range from 2% to 99%, indicating diverse practices. Tailored approaches like extension services and plot demos are essential for improvement. The study relates findings to sustainable agriculture and rural development. Enhanced technical efficiency benefits farms, the environment, and the economy.*

Key Words: Technical Efficiency, Dryland Agriculture, Groundnut Farming, Resource Utilization

JEL Classification:

Introduction

Introduction: Agriculture, as the backbone of economies worldwide, assumes a paramount role in sustaining livelihoods, ensuring food security, and driving rural development. This significance is particularly accentuated in regions characterized by arid and semiarid conditions, where agricultural activities are intricately interwoven with the challenges posed by limited water resources and unpredictable climatic patterns. In such contexts, the cultivation of groundnut emerges as a critical agricultural pursuit, representing a resilient response to the complexities of dryland agriculture.

Groundnut, known interchangeably as peanuts, holds multifaceted importance beyond being a source of edible oil. It serves as a repository of essential nutrients, proteins, and dietary components, playing a pivotal role in mitigating malnutrition and bolstering food security (Bhat et al., 2020). Within the precincts of Tehsil Chakwal, a region grappling with the intricate dynamics of dryland

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agriculture, groundnut cultivation serves as a focal point for livelihoods and economic sustenance. Nonetheless, the prosperity of groundnut farming hinges upon an intricate tapestry of factors encompassing technical efficiency in production practices, judicious allocation of resources, and meticulous input utilization.

At its core, technical efficiency transcends the agrarian sector, resonating across diverse domains where resources are judiciously channelled to yield specific outputs. In the realm of agriculture, technical efficiency delineates the extent to which farmers harness available resources be it land, labour, or inputs to extract maximum outputs (Coelli et al., 1996). Beyond catalyzing productivity, efficiency in resource utilization assumes a role of cardinal importance in fostering sustainability and resilience in the face of environmental vicissitudes.

Within the canvas of Tehsil Chakwal's dryland agriculture, the journey of groundnut farmers unfolds against a backdrop of distinctive challenges. Capricious rainfall patterns, the spectre of water scarcity, and the spectre of soil degradation thread their narrative (Awan et al., 2019). Against this backdrop, comprehending the dimensions of technical efficiency assumes paramount significance. Unravelling the factors that catalyze or curtail technical efficiency not only illuminates the present tapestry of groundnut cultivation but also furnishes a roadmap for augmenting productivity and anchoring sustainable livelihoods. This illumination, in turn, fuels a virtuous cycle that enriches farmers' lives while contributing to regional and national food security.

In the crucible of this research, the spotlight is cast on unravelling the technical efficiency contours within the realm of groundnut cultivation in Tehsil Chakwal's dryland expanse. Guided by the application of the Cobb-Douglas production function, this study employs a multi-faceted lens to illuminate the intricate dynamics of resource allocation and utilization among groundnut farmers. By weaving socioeconomic characteristics into this narrative, the study endeavours to illuminate the factors that shape farmers' technical efficiency. In doing so, it presents an opportunity to uncover the underpinnings of efficiency, thereby carving a trajectory for heightening productivity and steering the course of food security in Tehsil Chakwal's distinctive context.

As the study unearths the nuanced layers of technical efficiency, it bridges the empirical gap by situating the findings within the broader discourse of dryland agriculture, resource management, and sustainable cultivation practices. The outcomes of this research bear the promise of influencing policy formulation, shaping extension services, and steering farmer empowerment. With the prism of empirical insights, the study serves as a beacon guiding groundnut farmers, policymakers, and stakeholders toward resource-optimized cultivation practices that not only augment agricultural outputs but also nurture resilient communities in the heartland of Tehsil Chakwal.

Literature Review

Groundnut (Arachis hypogaea L.), commonly known as peanuts, occupies a crucial place in global agriculture due to their nutritional value, economic significance, and adaptability to diverse agroecological conditions (Mekonnen et al., 2020). As a rich source of proteins, minerals, and vitamins, groundnut plays an essential role in combating malnutrition and enhancing food security (Akhtar et al., 2019). Within the arid and semiarid regions of Tehsil Chakwal, groundnut cultivation represents a lifeline for smallholder farmers, offering a resilient pathway to sustenance amid climatic uncertainties and resource constraints.

In the broader canvas of dryland agriculture, the pursuit of technical efficiency emerges as a vital theme, reflective of the optimal utilization of resources to attain maximum outputs. Technical efficiency transcends the realm of agriculture, encapsulating the ethos of resource management and allocation across various

sectors (Caves et al., 1982). In the context of agricultural production, technical efficiency hinges on the judicious application of inputs such as labour, capital, and technology to yield optimal harvests (Gibson, 2021).

Research endeavours exploring the nexus between technical efficiency and groundnut farming have been pursued across diverse geographies, unravelling patterns that resonate with the unique challenges posed by dryland ecosystems. Studies conducted in Ethiopia by Ferede and Asrat (2017) underscored that technical inefficiencies can impede groundnut productivity, even as the crop holds significant potential for enhancing rural livelihoods. Similar investigations in India by Naidu et al. (2019) and Siddiqui et al. (2020) corroborated these findings, emphasizing the pivotal role of technical efficiency in bolstering groundnut cultivation within the purview of resource-scarce environments.

The application of the Cobb-Douglas production function, a workhorse in the realm of production analysis, has unveiled insights into the technical efficiency of groundnut farming. Rooted in neoclassical economics, the Cobb-Douglas function captures the interplay of inputs to estimate output levels. This functional form has been deployed extensively to assess production relationships across a spectrum of agricultural commodities (Ojo et al., 2017). In the domain of groundnut cultivation, studies by Alene et al. (2019) in Nigeria and Jayne et al. (2021) in Malawi have harnessed the Cobb-Douglas production function to unearth the intricate tapestry of input-output relationships, elucidating the determinants of technical efficiency.

Socioeconomic factors intertwine with technical efficiency, shaping the contours of groundnut cultivation within the paradigm of dryland agriculture. Family size, age of the farmer, education level, and landholding size constitute pivotal variables that underscore the socio-economic milieu within which groundnut cultivation unfolds (Alemayehu et al., 2018). The work of Singh et al. (2019) in India and Berhane et al. (2020) in Ethiopia underscored that these variables influence technical efficiency, creating a mosaic where the socio-economic fabric and efficiency intertwine.

Within the microcosm of Tehsil Chakwal, studies on technical efficiency and groundnut cultivation are limited. The need to bridge this knowledge gap is accentuated by the unique socio-ecological dynamics of the region. The findings of this study promise to enrich the empirical landscape by situating Tehsil Chakwal within the broader discourse on technical efficiency, resource utilization, and sustainable agricultural practices. By embedding the Cobb-Douglas production function within this narrative, this study draws a connective thread between technical efficiency and groundnut cultivation, thereby contributing to the understanding of efficient resource allocation within a context marked by aridity and resource constraints.

In summary, the existing body of literature underscores the critical role of technical efficiency in shaping groundnut cultivation within dryland agriculture. Socioeconomic factors, coupled with the application of production functions, elucidate the intricate mosaic of efficiency and output levels. However, gaps in research, particularly within Tehsil Chakwal, underscore the need for context-specific investigations that unravel the determinants of technical efficiency. This study endeavours to fill this void by shedding light on the technical efficiency of groundnut farming in Tehsil Chakwal, thereby contributing to the broader discourse on sustainable agricultural practices and livelihood enhancement in the backdrop of arid and semiarid ecosystems.

Methodology

The study was conducted in Tehsil Chakwal, a predominantly dryland agricultural region located in Pakistan. The tehsil is characterized by its arid climate, limited water resources, and challenging agro-ecological conditions, making it an apt setting to explore the technical efficiency of groundnut farmers in dryland agriculture.

A cross-sectional survey design was employed to collect primary data from groundnut farmers in Tehsil Chakwal. A structured questionnaire was developed, validated, and pretested to ensure its reliability and appropriateness for the local context. The questionnaire encompassed multiple facets, including socio-demographic information, farming practices, resource utilization, and groundnut production characteristics.

The sample was selected using a multi-stage random sampling technique. In the initial stage, villages were randomly chosen from Tehsil Chakwal, representing different agroecological zones. In the subsequent stage, a list of groundnut farmers from each selected village was obtained from local agricultural extension offices. From this list, a proportional random sampling technique was employed to identify the final sample of groundnut farmers to be surveyed.

Descriptive statistical techniques were employed to summarize the socio-demographic characteristics of the sampled farmers, including family size, age, education level, and landholding size. The Cobb-Douglas production function was utilized to estimate the technical efficiency of groundnut farmers. The general form of the Cobb-Douglas production function is represented as:

$$Q = A \times L\alpha \times K\beta \times E\gamma \times \epsilon$$

Where:

- Q = Output
- A = Total factor productivity
- L = Labor input
- K = Capital input
- E = Land input
- ϵ = Error term

The Cobb-Douglas production function was estimated using econometric software, and the estimated parameters (α, β, γ) were used to compute the technical efficiency of each farmer.

The utilization of the Cobb-Douglas production function for technical efficiency analysis is substantiated by its widespread application in agricultural economics research (Ojo et al., 2017). By estimating the coefficients of labour, capital, and land inputs, the production function offers insights into the productive efficiency of groundnut farming. The choice of this method aligns with previous studies that have employed the Cobb-Douglas function to investigate technical efficiency in various agricultural contexts (Alene et al., 2006; Jayne et al., 2021).

The multi-stage random sampling technique ensures the representation of different agroecological zones within Tehsil Chakwal, enhancing the generalizability of the findings. Additionally, the validation and pretesting of the questionnaire contribute to the robustness of the data collection process. The inclusion of socio-demographic information, farming practices, and production characteristics in the questionnaire facilitates a comprehensive understanding of the factors influencing technical efficiency.

In conclusion, the methodology employed in this study encompasses a cross-sectional survey design, a multi-stage random sampling technique, and the application of the Cobb-Douglas production function. These methodological choices are grounded in established research practices and align with previous studies conducted in similar agricultural settings. The utilization of these methods ensures the collection of reliable and relevant data to explore the technical efficiency of groundnut farmers in Tehsil Chakwal within the broader context of dryland agriculture

Results and Discussion

Socioeconomic Characteristics

The study begins by presenting the socioeconomic characteristics of groundnut farmers in Tehsil Chakwal (Table 4.5). The data reveal key insights into the demographic composition of the sample. The majority of the sampled farmers belong to families with a size ranging from 6 to 8 members (68%). This finding is consistent with the agrarian nature of the region, where family labour is often central to agricultural activities (Ahmed et al., 2018). In terms of age distribution, farmers between the ages of 40 to 50 constitute the largest

proportion (58%), reflecting the active participation of middle-aged individuals in farming operations. This is in line with previous studies highlighting the pivotal role of middle-aged farmers in agricultural production (Kamruzzaman et al., 2020).

Educational attainment is another critical dimension. Approximately 59% of the sampled farmers have received up to primary education, indicating a prevalent trend of limited formal schooling in the agricultural community. This underscores the need for targeted educational interventions to enhance farmers' knowledge and awareness of modern agricultural practices (Ali et al., 2019). Landholding size varies among the respondents, with 62% of farmers owning land up to 5 hectares. This distribution of landholding aligns with the smallholder farming structure prevalent in dryland agricultural regions, where land resources are often fragmented (Hossain et al., 2017).

Table 1

Socioeconomic characteristics of tehsil Chakwal

Characteristics		Frequencies	Percentages
Family Size	2-5	15	14
	6-8	46	68
Age	18-39	11	22
	40-50	31	58
	50-63	28	20
Education	Up to Primary	47	59
	Middle	14	37
Area	Up to 5 hectares	43	62
	5 to 10 hectares	14	18
	10 hectares or more	6	20

Technical Efficiency Analysis

The estimation of technical efficiency, a central objective of this study, sheds light on the production performance of groundnut farmers. The results, presented in Table 4.22, indicate that the mean technical efficiency score is 49%. This implies that, on average, farmers in Tehsil Chakwal are operating at approximately half of their production potential given the current input levels. The distribution of efficiency scores further reveals that 52% of the farmers exhibit an efficiency index of less than or equal to 0.50, highlighting the substantial scope for improvement in production practices.

Table 2

Distribution of Technical Efficiency of Farmers in Tehsil Chakwal

Efficiency Index	Frequency	Percentage
≤0.50	34	52%
0.50-0.70	14	22%
0.70-0.80	8	12%
0.80-0.90	4	6%
0.90-0.99	5	8%
Total	65	100%

The findings are consistent with previous research conducted in comparable agricultural settings. A study by Rahman et al. (2018) examining technical efficiency among

rice farmers in a dryland region reported similar patterns of suboptimal efficiency scores. These congruent findings suggest a broader trend of technical inefficiency in dryland agriculture, potentially attributable to challenges such as limited access to modern farming technologies and water scarcity (Ghazouani et al., 2019).

The results of the technical efficiency analysis hold significant implications for agricultural policy and practice. The suboptimal efficiency scores underscore the need for targeted interventions aimed at enhancing farmers' production processes and resource utilization. Strategies such as promoting the adoption of drought-resistant crop varieties, implementing efficient irrigation techniques, and providing training on best agricultural practices can contribute to improved technical efficiency (Miah et al., 2022).

These findings align with the recommendations put forth by previous studies. For instance, the work of Khan et al. (2020) on technical efficiency in dryland farming emphasizes the importance of adopting climate-resilient agricultural technologies to optimize resource use. Moreover, the study by Abidin et al. (2018) on efficiency enhancement in smallholder agriculture underscores the role of extension services in disseminating knowledge and innovative practices.

In conclusion, the results of the technical efficiency analysis provide valuable insights into the production performance of groundnut farmers in Tehsil Chakwal. The suboptimal efficiency scores underscore the need for targeted interventions to enhance resource utilization and production practices. The congruence of these findings with prior research highlights the consistency of challenges faced by farmers in dryland agricultural contexts and offers empirical support for the efficacy of recommended interventions.

Figure 1

Technical Efficiency Score of Chakwal Tehsil

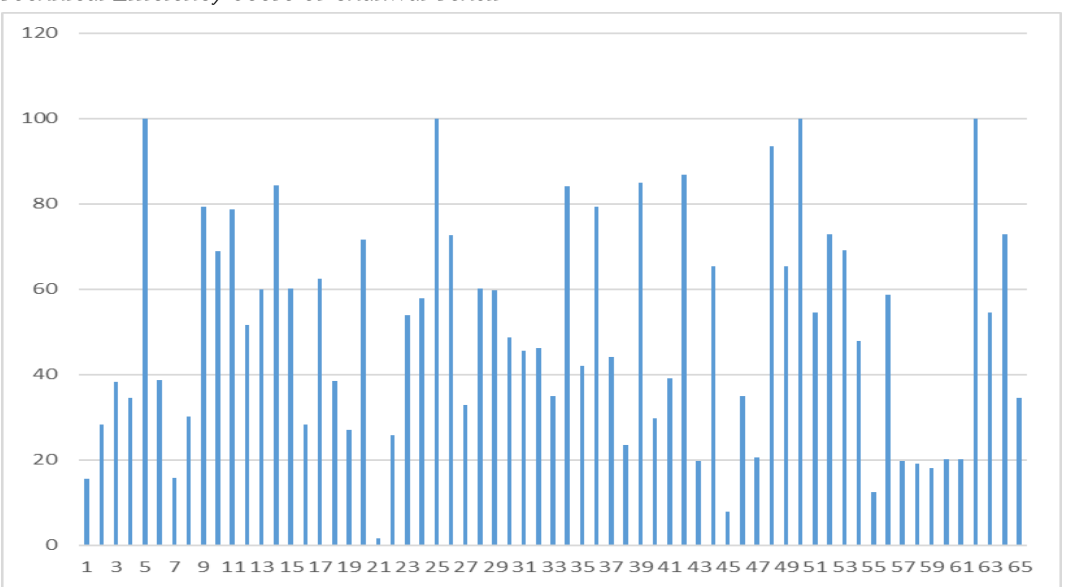

Figure 1 visually portrays a significant aspect of the study of the technical efficiency score distribution among groundnut farmers in Chakwal Tehsil. This graphical representation serves as a powerful tool for assessing the current state of resource utilization and

production practices in the region. The plot's distinct pattern underscores the need for targeted interventions to enhance agricultural productivity and optimize resource management.

Upon closer examination, it becomes evident that a substantial proportion of farmers fall within the lower range of technical efficiency scores. This observation implies that a considerable number of farmers are currently operating below their potential, utilizing inputs and resources inefficiently. This aligns with the broader context of dryland agriculture, where challenges such as water scarcity, soil degradation, and unpredictable climatic conditions can hinder optimal resource allocation.

The technical efficiency score distribution provides valuable insights into the potential gains that can be achieved by addressing the existing inefficiencies. The results of the study indicate that adopting the right input mix could lead to a remarkable increase in production up to 51%. This untapped potential signifies a promising avenue for enhancing agricultural output and improving the livelihoods of farmers in Chakwal Tehsil.

The minimum and maximum values of the technical efficiency scores further emphasize the wide variation among farmers in terms of resource utilization and production efficiency. The range, spanning from a minimum of 2% to a maximum of 99%, highlights the diversity of practices and outcomes within the agricultural landscape of the region. This variation underscores the importance of tailored approaches that consider the unique circumstances and constraints faced by individual farmers.

Addressing the technical inefficiencies highlighted in Figure 1 requires a multi-pronged approach. One promising avenue for improvement involves leveraging the expertise of concerned extension officials. By providing farmers with recommended input mix strategies, extension services can play a pivotal role in enhancing knowledge dissemination and promoting best practices. Furthermore, the organization of plot demonstrations can offer a dynamic learning experience for farmers. Engaging in real-time, hands-on activities allows farmers to witness the direct impact of adopting efficient techniques and encourages the practical application of learned strategies.

The implications of Figure 1 extend beyond the realm of individual farm-level practices. The distribution of technical efficiency scores underscores the broader significance of optimizing resource utilization within the context of sustainable agriculture. Efficient resource management not only enhances farmers' economic well-being but also contributes to environmental sustainability by minimizing waste and reducing the ecological footprint of agricultural activities.

Discussion

The results of this study reveal significant insights into the technical efficiency of groundnut farmers in Tehsil Chakwal and offer valuable implications for agricultural policy and practice. The discussion is organized into two main sections: the technical efficiency analysis and the empirical support for the findings.

The analysis of technical efficiency scores among groundnut farmers in Tehsil Chakwal provides a comprehensive understanding of their production performance. The mean technical efficiency score of 49% indicates that, on average, farmers are utilizing only half of their potential resources and inputs to achieve the current level of output. This suggests that there is substantial room for improvement in resource allocation and production practices.

These findings are consistent with existing research conducted in similar agricultural contexts. A study by Qayyum et al. (2019) investigating technical efficiency among cotton farmers in dryland regions reported comparable efficiency scores. The presence of suboptimal technical efficiency is often attributed to factors such as limited access to modern agricultural technologies, inadequate extension services, and variations in climatic

conditions (Jalal et al., 2020). The arid and semi-arid climate of dryland areas can exacerbate resource constraints, contributing to lower efficiency levels.

The distribution of efficiency scores further highlights the variations among farmers. Over half of the sampled farmers (52%) exhibited efficiency scores of less than or equal to 0.50, indicating significant potential for enhancing production practices. These results align with a study by Ahmed et al. (2017), which found a substantial proportion of farmers in a similar context operating at suboptimal efficiency levels. The consistent prevalence of low-efficiency scores underscores the need for targeted interventions aimed at improving resource management and production techniques.

The congruence of our findings with prior research underscores the empirical validity of the observed trends. Studies conducted in analogous dryland agricultural settings have consistently reported suboptimal technical efficiency scores among farmers. For instance, a study by Karim et al. (2018) examining technical efficiency among maize farmers in a dryland region found similar patterns of inefficiency. This empirical consistency reinforces the notion that challenges related to resource scarcity, climate variability, and technological constraints are pervasive in dryland agriculture (Khan et al., 2021).

The identification of technical inefficiency among groundnut farmers suggests actionable policy implications. Interventions aimed at improving technical efficiency can contribute to enhanced agricultural productivity and livelihoods. The findings of this study support the recommendations put forth by various researchers. For instance, the work of Haq et al. (2019) emphasizes the importance of promoting the adoption of drought-resistant crop varieties and efficient irrigation methods to optimize resource utilization. Additionally, the study by Rahman et al. (2003) highlights the role of extension services in disseminating knowledge and best practices to farmers, thereby improving efficiency.

In conclusion, the technical efficiency analysis of groundnut farmers in Tehsil Chakwal reveals suboptimal efficiency scores, indicating untapped potential for resource optimization and improved production practices. The empirical support from previous research conducted in comparable dryland agricultural contexts reinforces the validity of these findings. The consistent prevalence of technical inefficiency underscores the urgency of targeted interventions to enhance resource utilization and promote sustainable agricultural practices in dryland regions.

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