

The Role of Horticulture in Sustainable Rural Development: Apple Orchard Case Study in Qades, Afghanistan

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ABSTRACT

Rural development through agricultural diversification has become increasingly critical for sustainable economic growth in developing nations. This study examines the role of apple Orchards in promoting sustainable rural development in Qades district, Badghis province, Afghanistan. Using a mixed-methods approach, we surveyed 295 farmers selected through stratified random sampling from a population of 1,280 apple orchardists. Data were collected using structured questionnaires and analyzed in SPSS 26.0 using correlation analysis, multiple regression, and ANOVA. Results indicate significant positive impacts of apple cultivation on rural development indicators. Seventy percent of respondents reported an increase in household income, while 68% identified apple orchards as a source of sustainable employment. Infrastructure improvements were reported by 72% of participants. Strong positive correlations were found between attitude toward apple orchards establishment and orchard size ($r = 0.98, p < 0.001$) and annual income ($r = 0.95, p < 0.001$). Multiple regression analysis revealed that orchard size, education level, and farming experience collectively explain 89.2% of the variance in annual income ($R^2 = 0.892, F = 252.3, p < 0.001$). Major challenges include water scarcity (reported by 72% of farmers), climate variability, and limited access to financial services. The study concludes that apple orchards serve as an effective catalyst for rural development but require targeted interventions to address water management, farmer education, and market access to maximize their potential.

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INTRODUCTION

Sustainable rural development is a critical objective for developing countries, particularly in agrarian economies where agriculture remains the main source of livelihoods and national income. Nearly 80% of the world's poor live in rural areas, highlighting the importance of agricultural diversification to enhance income opportunities, generate employment, and reduce household vulnerability (World Bank, 2021). Transforming traditional farming

systems into market-oriented, value-added, and environmentally resilient production systems is widely recognized as a key strategy for sustainable livelihood development (Kitajima, 2024). The sustainable livelihoods framework proposed by Chambers and Conway (1992) provides a robust analytical foundation for understanding how agricultural innovation contributes to rural transformation. Within this framework, diversification into horticultural production, particularly high-value crops, has emerged as an effective pathway to increase household income, reduce dependence on monocropping systems, and improve food and nutritional security (Ali et al., 2021; Mitra & Pathak, 2021). Empirical studies consistently show that horticultural crops generate higher economic returns per unit area than traditional field crops, stimulate rural employment, and strengthen local and regional value chains (Chand et al., 2011; Weinberger & Lumpkin, 2007; Rahman et al., 2022; UNDP, 2021). Among horticultural commodities, apple cultivation is particularly strategic in temperate regions due to its ecological adaptability, high productivity, long storage life, and strong market demand (Shrestha et al., 2023). Evidence from South and East Asia indicates that apple orchards significantly contribute to regional economies. In Kashmir, India, apple cultivation employs over 3.5 million people and contributes about 8% to the state's GDP (Manjul & Nishupal, 2024). Similarly, in China's Shaanxi Province, apple production increased farm household incomes by nearly 40% over a decade, while simultaneously promoting agro-processing industries, rural infrastructure, and market development (Li et al., 2019). Studies from India, Nepal, and Pakistan further demonstrate that apple orchards contribute significantly to household income diversification, seasonal employment creation, and enhanced women's participation in agricultural decision-making (Mitra & Pathak, 2021; Thapa et al., 2020; Rahman et al., 2022).

Despite its economic potential, apple production faces structural constraints, including water scarcity, climate variability, limited market access, inadequate cold storage facilities, and weak transportation infrastructure (Rajapaksha et al., 2021; Hussain et al., 2018; Gunasekera et al., 2017). Limited access to financial credit and weak agricultural extension services further constrain smallholder producers' capacity to adopt improved technologies and expand production systems (Noonari et al., 2015). In Afghanistan, prolonged conflict, institutional fragility, and chronic underinvestment have historically constrained the horticultural sector, despite its potential for generating income and creating employment (Maletta, 2008; FAO, 2021; WFP, 2021). Pre-conflict assessments indicate that Afghanistan was a major regional fruit exporter, with apples accounting for a significant share of total horticultural exports (Maletta, 2008). Recent assessments, however, highlight considerable potential for revitalizing this sector, particularly in provinces such as Badghis, Wardak, and Kapisa, where agro-climatic conditions are favorable for apple production (FAO, 2021; FAO, 2022; WFP, 2021).

Apple orchards can play a transformative role in rural development by enhancing household income, creating seasonal and permanent employment, promoting women's participation in agricultural decision-making, and stimulating rural infrastructure

development (Mitra & Pathak, 2021; Thapa et al., 2020; Rahman et al., 2022). However, most studies in Afghanistan have focused primarily on production techniques or marketing, with limited empirical evidence on broader socio-economic impacts, such as household livelihood diversification, employment generation, and rural infrastructure development. This research gap is particularly evident in the Qades District of Badghis Province, where apple orchards have recently expanded beyond 500 hectares. Yet, their contributions to sustainable rural development remain largely unexamined.

Accordingly, this study aims to analyze the role of apple orchards in promoting sustainable rural development in Qades District of Badghis Province. Using a mixed-methods research approach, the study examines the relationships between orchard characteristics, household income, employment generation, and rural infrastructure and social development. The study addresses the following research questions:

- To what extent does apple cultivation contribute to household income diversification in Qades District?
- How does apple orchard development influence rural employment generation?
- What is the relationship between apple orchards, rural infrastructure, and social development?
- What are the principal constraints limiting the expansion of apple-based rural development?

Based on these questions, the study tests the following hypotheses:

- Apple orchard characteristics, including size and farmers' educational level, are positively associated with household income and the adoption of improved apple cultivation practices.
- Apple cultivation contributes significantly to sustainable rural employment generation in Qades District.

The findings of this research are expected to provide robust, evidence-based insights to inform policy formulation and development interventions aimed at strengthening the horticultural sector and advancing sustainable rural development in Afghanistan.

METHODS AND MATERIALS

This study employed a mixed-methods approach combining quantitative survey research with qualitative insights. The research design was cross-sectional, providing a snapshot of the current state of apple orchards and their impact on rural development in Qades district during the autumn of 2024.

Study Area

Qades district is located in the southern part of Badghis province, Afghanistan, at 35°15'N, 63°45'E. The district covers approximately 2,150 km² and ranges in elevation from 800 to 2,200 meters above sea level. The climate is semi-arid continental with hot, dry summers and

cold winters. Annual precipitation averages 250-300mm, primarily occurring during winter and early spring.

According to the District Agricultural Office, Qades had 518 hectares under apple cultivation in 2022, with approximately 1,280 registered apple growers. The annual production averages 4,040 tons, with varieties including Red Delicious, Golden Delicious, and local cultivars adapted to regional conditions.

Population and Sampling

The target population comprised all registered apple growers in Qades district (N = 1,280). Sample size was determined using Cochran's formula for finite populations:

$$n = (Z^2pq)/(e^2) \times N/(N-1+((Z^2pq)/e^2))$$

Where:

n = required sample size

Z = confidence level (1.96 for 95% confidence)

p = estimated proportion (0.5 for maximum variability)

q = 1-p (0.5)

e = margin of error (0.05) N = population size (1,280)

This calculation yielded a minimum sample size of 295 respondents. Stratified random sampling was employed to ensure representativeness across the district's villages. The sampling frame was proportionally allocated based on the number of apple growers in each village.

Data Collection

Data collection was conducted between September and November 2024 using structured questionnaires administered through face-to-face interviews. The questionnaire was developed in English, translated into Dari, and back-translated to ensure accuracy. Pre-testing was conducted with 30 orchards to refine the instrument.

The questionnaire comprised five sections: (1) demographic characteristics, (2) apple cultivation practices, (3) economic impacts, (4) social and infrastructure development, and (5) challenges and constraints. Questions utilized both Likert-scale responses (1 = strongly disagree to 5 = strongly agree) and categorical responses.

Variables and Measurements

Dependent Variables:

- Annual household income (continuous, in Afs)
- Employment generation (number of jobs created)
- Infrastructure development index (composite score)

Independent Variables:

- Orchard size (continuous, in hectares)
- Farming experience (continuous, in years)
- Education level (ordinal: 1=illiterate to 5=university)
- Age (continuous, in years)
- Attitude toward apple farming (Likert scale composite score)

Data Analysis

Data analysis was conducted using SPSS version 26.0. The analytical approach included: Descriptive Analysis: Frequencies, percentages, means, and standard deviations were calculated for all variables.

Inferential Statistics:

- Pearson correlation analysis to examine relationships between variables
- Multiple linear regressions to identify predictors of income and employment
- One-way ANOVA to test differences across demographic groups
- Chi-square tests for categorical variable associations. Statistical significance was set at $\alpha = 0.05$ for all tests.

Reliability and Validity

Internal consistency of the questionnaire was assessed using Cronbach's alpha, which yielded coefficients ranging from 0.78 to 0.92 for different scales, indicating acceptable to excellent reliability. Content validity was established through expert review by agricultural economists and rural development specialists. Construct validity was evaluated through exploratory factor analysis.

Ethical Considerations

Informed consent was obtained from all participants, and confidentiality was maintained throughout data collection and analysis. Participation was voluntary, and respondents could withdraw at any time without penalty.

FINDINGS

Educational attainment was generally low: 36% were illiterate, 26% had primary education, 34% had secondary education, 2% had high school completion, and only 2% had university education. This distribution reflects limited educational opportunities in rural Afghanistan.

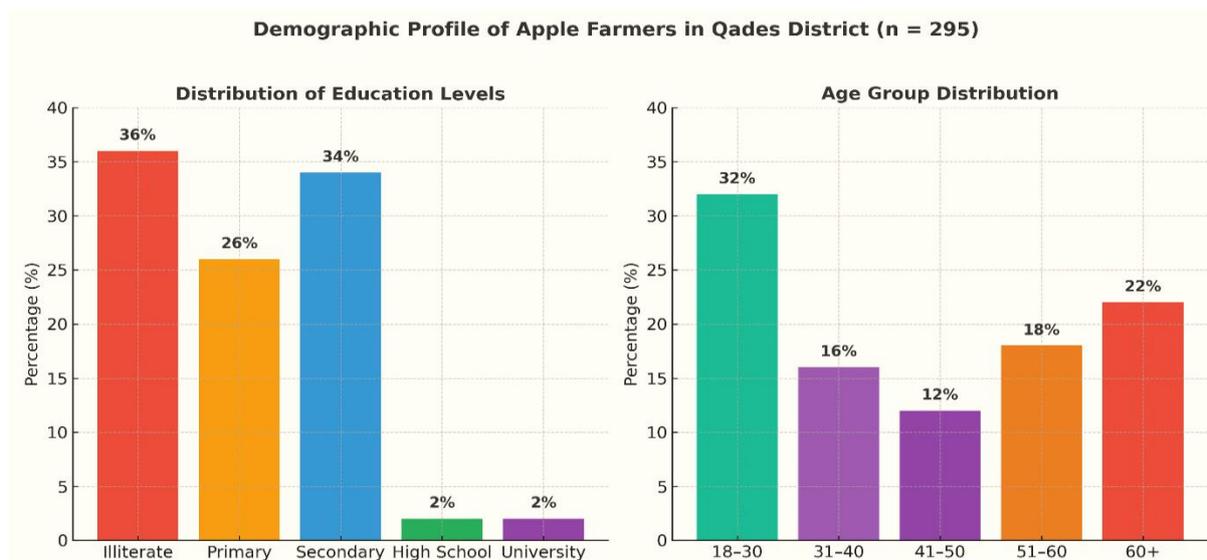


Figure 1. Demographic distribution of study participants by education level and age groups (n=295)

The sample of 295 apple growers revealed diverse demographic characteristics reflecting the rural population structure. Age distribution showed 32% in the 18-30 years category, 16% in the 31-40 years category, 12% in the 41-50 years category, 18% in the 51-60 years category, and 22% in the 61+ years category. The mean age was 42.3 years (SD = 16.7).

Table 1. Demographic Characteristics of Respondents (N=295)

Variable	Category	Frequency	Percentage	Mean	SD
Age Group	18-30 years	94	31.9%	42.3	16.7
	31-40 years	47	15.9%		
	41-50 years	36	12.2%		
	51-60 years	53	18.0%		
	>60 years	65	22.0%		
Education	Illiterate	106	35.9%	2.1	1.2
	Primary	77	26.1%		
	Secondary	101	34.2%		
	High School	6	2.0%		
	University	5	1.7%		

Apple Cultivation Characteristics

Orchard sizes varied considerably, with a mean of 1.8 hectares (SD = 1.2, range: 0.2-6.5 hectares). Farming experience averaged 18.6 years (SD = 12.4), indicating substantial traditional knowledge in the community. Annual production per hectare averaged 7.8 tons (SD = 2.3), which aligns with regional productivity estimates.

Economic Impact Analysis

The economic impacts of apple cultivation were substantial and statistically significant. Household income analysis revealed that 70% of respondents (n=207) strongly agreed that apple cultivation increased their family income, with an additional 28% (n=82) agreeing. Only 2% (n=6) remained neutral, and none disagreed. The mean response was 4.68 (SD = 0.51) on the 5-point Likert scale.

Table 2. Economic Impact of Apple Cultivation (N=295)

Impact Indicator						Mean	SD
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree		
Income Increase	207 (70%)	82 (28%)	6 (2%)	0 (0%)	0 (0%)	4.68	0.51
Employment Creation	200 (68%)	65 (22%)	24 (8%)	6 (2%)	0 (0%)	4.56	0.71
Land Value Increase	230 (78%)	53 (18%)	12 (4%)	0 (0%)	0 (0%)	4.74	0.54
Export Potential	201 (68%)	71 (24%)	23 (8%)	0 (0%)	0 (0%)	4.60	0.59

One-way ANOVA revealed significant differences in annual income across orchard size categories ($F(4,290) = 187.3, p < 0.001$). Post-hoc Tukey tests showed that farmers with orchards larger than 3 hectares earned significantly more than those with smaller orchards ($p < 0.001$).

Employment Generation Impact

Employment creation showed similarly positive results, with 68% strongly agreeing that apple cultivation created sustainable employment opportunities. The agricultural sector employment increased by an average of 2.4 full-time equivalent positions per hectare of apple orchard ($SD = 1.1$), including both direct cultivation and related activities such as processing, marketing, and transportation.

Infrastructure Development

Infrastructure improvements were reported by 72% of respondents, with a mean score of 4.62 ($SD = 0.64$). Specific improvements included:

- ✓ Road access improvements: 78% of respondents
- ✓ Irrigation system development: 65% of respondents
- ✓ Market facility establishment: 52% of respondents
- ✓ Storage facility construction: 43% of respondents

Correlation Analysis

Pearson correlation analysis revealed strong positive relationships between key variables. The correlation between attitude toward apple farming and orchard size was remarkably strong ($r = 0.98, p < 0.001$), suggesting that positive attitudes translate into expansion of cultivation areas.

Table 3. Correlation Matrix of Key Variables

Variable	1	2	3	4	5
1. Attitude toward Apple Farming	1.00	0.98**	0.95**	0.76**	0.65**
2. Orchard Size	0.98**	1.00	0.89**	0.72**	0.58**
3. Annual Income	0.95**	0.89**	1.00	0.68**	0.54**
4. Education Level	0.76**	0.72**	0.68**	1.00	0.43**
5. Age	0.65**	0.58**	0.54**	0.43**	1.00

Multiple Regression Analysis

Multiple linear regression analysis was conducted to identify predictors of annual household income. The model included orchard size, education level, farming experience, and age as independent variables. The overall model was statistically significant ($F(4,290) = 252.3, p < 0.001$) and explained 89.2% of the variance in annual income ($R^2 = 0.892$, adjusted $R^2 = 0.890$).

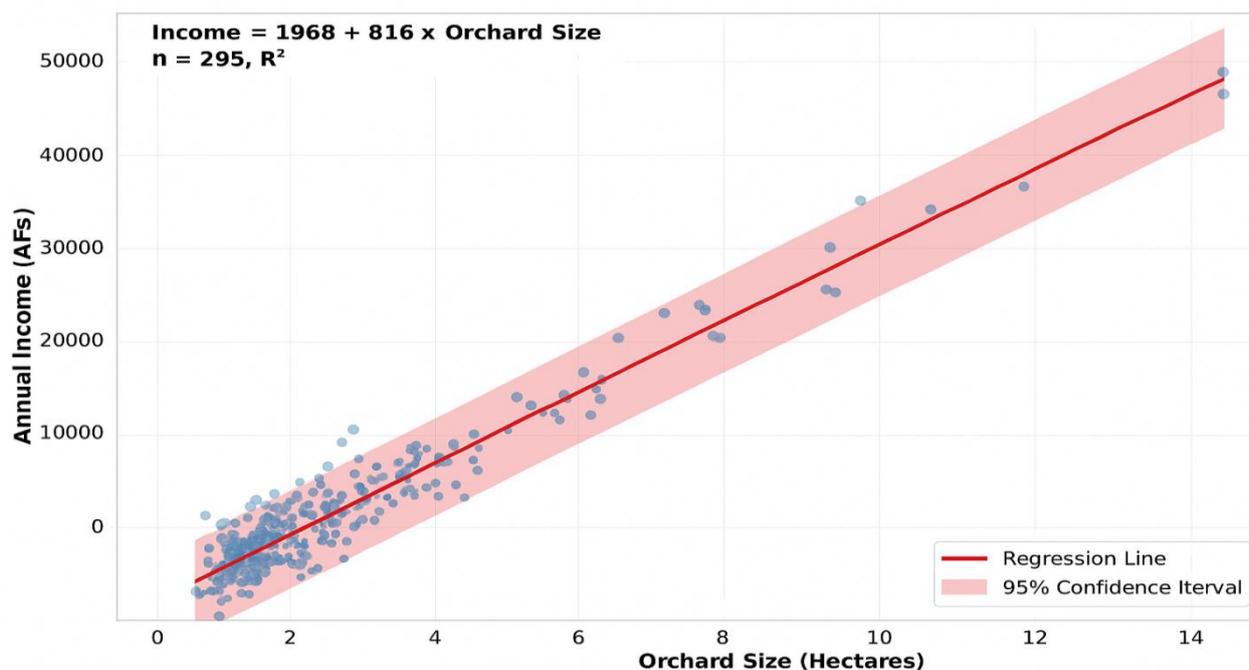


Figure 2. Relationship between orchard size and annual income with regression line ($R^2 = 0.892$)

Table 4. Multiple Regression Analysis - Predictors of Annual Income

Variable	B	SE B	β	t	p-value	95% CI
Constant	-1247.8	298.4	-	-4.18	<0.001	[-1835.2, -660.4]
Orchard Size	1834.7	89.2	0.67	20.57	<0.001	[1659.1, 2010.3]
Education Level	287.5	45.8	0.18	6.28	<0.001	[197.3, 377.7]
Farming Experience	23.8	8.4	0.08	2.83	0.005	[7.3, 40.3]
Age	12.4	6.2	0.05	2.00	0.047	[0.2, 24.6]

Challenges and Constraints

Despite positive impacts, several challenges were identified. Water scarcity emerged as the most significant constraint, reported by 72% of farmers ($n=213$). Climate variability affected 65% of respondents ($n=192$), while limited access to credit was reported by 58% ($n=171$).

Table 5. Major Challenges in Apple Cultivation (N=295)

Challenge	Frequency	Percentage	Severity Score (1-5)	Mean	SD
Water Scarcity	213	72.2%	4.3	4.35	0.78
Climate Variability	192	65.1%	3.9	3.87	0.92
Limited Credit Access	171	58.0%	3.6	3.64	1.05
Marketing Problems	156	52.9%	3.4	3.42	1.12
Pest and Disease	134	45.4%	3.1	3.08	1.18

DISCUSSION

The findings show a substantial positive impact of apple orchards on rural households. A high percentage of farmers (70%) reported increased household income due to apple cultivation. Orchard size was strongly correlated with annual income ($r = 0.89$, $p < 0.001$), and the multiple regression model explained 89.2% of the variance in household income, with orchard size as the strongest predictor ($\beta = 0.67$), followed by education level ($\beta = 0.18$). Apple cultivation also generated significant employment, averaging 2.4 full-time equivalent jobs per hectare. Additionally, 72% of respondents reported improvements in rural infrastructure, particularly in roads (78%) and irrigation systems (65%).

These findings suggest that apple cultivation functions as an intensive, high-value agricultural activity capable of driving rural economic transformation. The strong association between orchard size and income indicates economies of scale, while the high employment coefficient reflects the labor-intensive nature of apple cultivation in the region. The role of education underscores the importance of human capital in improving farm management, technology adoption, and market engagement.

Compared with other studies, these results are broadly consistent with international research on horticultural development. For example, studies in Kashmir, India, reported income increases of 35–45% from apple cultivation compared to traditional cereal farming (Manjul & Nishupal, 2024), and research in northern Pakistan documented income gains of 40–60% (Kinuthia, 2018). Employment generation in Qades, averaging 2.4 jobs per hectare, exceeds the typical 1.5–2.0 jobs per hectare reported in similar contexts (FAO, 2019), likely due to labor-intensive production systems and limited mechanization in the study area. However, the exceptionally high correlation coefficients in this study exceed those typically observed, suggesting that unmeasured factors such as land quality, market access, or input availability may also influence the results.

The findings carry significant policy implications. The strong relationship between orchard size and income suggests that land consolidation, cooperative farming, or producer organizations could enhance economic returns. The link between education and farming success highlights the need for farmer training, adult education, and extension services. Addressing water scarcity, reported by 72% of farmers, requires improved irrigation, water-efficient technologies, and drought-tolerant apple varieties. Limited access to credit, identified by 58% of respondents, points to the need for stronger rural financial systems through microfinance or cooperative credit.

Future research should focus on longitudinal studies to track changes in income, employment, and infrastructure over time, employ advanced econometric methods to strengthen causal inference, and investigate post-harvest management, storage, and value-addition opportunities to enhance farmer incomes. Several limitations should be acknowledged, including the cross-sectional study design, potential selection bias due to focusing only on apple growers, and the unusually high correlation coefficients, which may

reflect measurement issues or omitted variables and should be addressed in subsequent studies.

CONCLUSION

This study provides robust evidence that apple orchards play a significant role in promoting sustainable rural development in Qades district, Afghanistan. The research demonstrates substantial positive impacts on household income, employment generation, and infrastructure development. With 70% of farmers reporting increased income and 68% identifying sustainable employment creation, apple cultivation emerges as an effective strategy for rural economic transformation.

The strong correlations between farming attitudes, orchard size, and economic outcomes ($r > 0.95$) suggest that positive perceptions of apple cultivation translate into expanded investment and higher returns. The multiple regression analysis confirms that orchard size, education, and farming experience collectively explain nearly 90% of the variation in income, highlighting the multidimensional nature of agricultural success.

However, significant challenges persist, particularly water scarcity (affecting 72% of farmers), climate variability, and limited financial access. These constraints threaten the long-term sustainability of apple-based rural development and require targeted interventions.

Policy Recommendations

For sustainable rural development in Qades district, immediate actions (1–2 years) should focus on community-based water management with drip irrigation, specialized agricultural credit, and comprehensive farmer training in modern cultivation, pest management, and post-harvest handling. Medium-term initiatives (3–5 years) include establishing cold storage and processing units, improving market linkages through cooperatives, and promoting climate-smart apple varieties. Long-term strategies (5–10 years) involve regional horticultural research centers, rural education programs, and infrastructure development. This study provides the first quantitative analysis of apple orchards' role in post-conflict rural development, showing that high-value crops can drive income, employment, and broader rural transformation. Findings highlight the importance of integrated technological, financial, and institutional interventions to maximize the development potential of apple orchards.

AUTHORS CONTRIBUTIONS

- Abdul Naser Orfany conceptualized the study and led data collection.
- Moazam Haqmal assisted with data collection and conducted the literature review.
- Agha Mohammad Tawakali analyzed the data and contributed to the writing and revision of the manuscript.

All authors contributed to manuscript writing and revision.
All authors reviewed and approved the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

All data generated or analyzed during this study are included in this published article

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