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Determinants of Net Returns and Supply Chain Dynamics in Apple Production: Evidence from Balochistan, Pakistan

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ABSTRACT

Current study was conducted in Balochistan (Killa Saifullah and Pishin districts) province with main aims to analyze profitability and supply chain efficiency of apple growers. Primary data of 120 apple growers was analyzed to interpret results of the study by applying linear regression model and descriptive statistics. Results shows that growers' average net returns per acre in Pishin and Killa Saifullah are Rs. 567,850/- and Rs. 506,750. Selling orchards to pre-contractors in the ripening and blossom stage has lowered net returns by Rs. 53,292/- and Rs. 256,667/-. In inputs picking and packaging materials, transportation and irrigation cost was noted high. Commission agents in local and city market received 4% and 10 % of the overall sale respectively as their services charges. Contractors, local commission agents and transporters are essential participants in the apple supply chain. Regression analysis illustrated positive and significant association for producer age, relevant experience, orchard selling stage choices, marketing channel adopted by producers, irrigation water availability, climatic factors, distance to main road and infrastructure quality with growers' net returns. The study recommends drip irrigation systems, low interest credits, auction facility in local market, focus on improvement of farmers' technical abilities for improvement of efficiency, profitability and food security of growers along with all stakeholders in apply supply chain.

Introduction

Agriculture forms the basis of Balochistan's economy, contributing over 30% to the provincial Gross Domestic Product (GDP), engaging approximately 66% of the provincial workforce, and providing food for more than half of the provincial population. Balochistan, often addressed as the "Fruit Basket of Pakistan", occupies the position of the national primary fruit-producing province (Shah et al., 2011). Its agricultural sector has comparative advantage, particularly in the cultivation of minor crops, including vegetables and fruits. It excels in fruit production, yet fails to realize

satisfactory returns for its dedicated growers. Astonishingly, a mere 5% of the province's produce undergoes value-added processing, a neglected opportunity that hampers the expansion of the minor crop sub-sector (GoP, 2020). Farmers in developing countries often confront the inequitable reward for their produce, a dilemma rooted in a mass of challenges that include lack of market information, access, post-harvest processing and infrastructure. Simultaneously, an increasing number of consumers are demanding for high-quality agricultural commodities, raising concerns about the use of hybrid seeds, herbicides and other potentially hazardous compounds (Leach et al., 2020).

In Balochistan farmers face an array of obstacles in their quest for fair reward of their agricultural output. These challenges are deeply tangled with the socio-economic, geographic and infrastructural setting of the region. Furthermore, Balochistan has not been spared from the impacts of climate change, experiencing a notable increase in climate-related events like droughts and floods. These events wreak havoc on fruit orchards and reduce agricultural productivity, placing further strain on the incomes of farmers (Murtaza et al., 2021; Ashraf, et al., 2021; Rana et al, 2021).

Given the ongoing challenges of climate change, this study holds significant importance. As climate variations increasingly affect agriculture in Balochistan, identifying ways to manage these impacts becomes critically important. The study examines the socioeconomic attributes of households engaged in apple production, which are main players in this sector. These households often face challenges such as limited resources, lack of technical expertise and adherence to traditional beliefs, all of which influence their net returns. Insights from this research could offer valuable strategies to enhance apple supply chain economic as well as environmental benefits. A variety of climate factors and inputs has role in determining the health and yield of apple crop because of its open field nature. The interplay of climate and agriculture now is not merely an academic concern but has also policy related importance in terms of food security and economic stability. Current study contribute toward understanding the updated economic analysis, possible limitation of existing static supply chain model and inputs for planners and other stakeholders interested in the area. Such insights are essential for bolstering resilience against fluctuating climatic conditions. By addressing supply chain issues, particularly within agriculture, there's potential to narrow income gaps, particularly benefiting the rural communities and improving their quality of life. Key objectives of this study include examining the factors impacting net returns of growers' and evaluating the current state of the apple supply chain along with recommendations.

Data and Methodology

Study Area

Current study was conducted in Balochistan, being the largest province of Pakistan based on area (134,050 square miles) with total population of 12.34 million. It has sup tropical desert climate and experience annual average temperature of 25.34 °C, usually remain higher than national average temperature. Because of high temperature, low rainfall (12.96 mm) and lack of proper irrigation facility only 5.9 percent of its total land is cultivated. There is potential for conversion of waste land to agriculture subject to the availability of irrigation water. Despite these limiting factors the province contribute significantly in national fruits production of apples, pomegranates, grapes, dates, plums and almonds. Its contribution in total national apple production is 82 % . while in other mention fruits Balochistan contribution is more than 60 %. (GOP, 2020 and GOB, 2019)

Balochistan consists of 34 administrative districts, with the northern districts being particularly renowned for apple and other fruit production. Due to resource constraints, this study focused specifically on two districts within Balochistan: Killa Saifullah and Pishin. Both of these districts are situated in the northwestern part of Balochistan, in close proximity to the Afghanistan border.

Killa Saifullah

The district famous for its fertile soil, inhabited 342,932 people with conducive environment for fruits and vegetables cultivation. The district boasts numerous apple and apricot orchards that export their produce to various regions. Additionally, the commercial cultivation of vegetables like tomatoes, carrots, and chilies significantly contributes to the livelihoods of local residents. Agriculture in Killa Saifullah operates in both rabi and Kharif seasons. The district has also rich contribution in minerals such as chromite, gypsum and coal (GOB, 2018)

Pishin

District Pishin encompass 7,819 square kilometers area. Located between East longitudes 66º 46' 01" and 67º 49' 19" and North latitudes 30º 44' 02" and 31º 14' 02", Pishin consists of four Tehsils and 38 Union Councils. Positioned 670 km southwest (240 degrees bearing) of Pakistan's capital city, Islamabad, Pishin is strategically located just 45 km from the provincial capital. Its population was 736,903 as per 2017 census, comprising 380,615 males and 356,227 females respectively. The district primarily consists of rural residents, accounting for 80.62% of the population, with 19.38% residing in urban areas. The district's male literacy rate stands at 52.97%, while female literacy rate is low at 36.22%. (GOB, 2018).

In Pishin, farmers predominantly remain engaged in the cultivation of principal crops such as wheat, maize, barley and fruits including apples, grapes, and pomegranates. Furthermore, some farmers in Pishin cultivate crops like tomatoes, onions and potatoes. Livestock farming also plays a significant role in the livelihoods of Pishin residents.

Sampling and Data Collection

For the selection of apple growers in the study area, a multi-stage stratified sampling method was employed. In sampling process initially two districts namely Killa Saifullah and Pishin, and 120 apple growers across Killa Saifullah and Pishin districts were randomly selected for survey. This research relied on primary data collection methods. A comprehensive questionnaire was meticulously designed for the purpose of gathering data from apple growers. The application of Participatory Rural Appraisal (PRA) techniques allowed for the collection of valuable information pertaining to the apple supply chain, as well as the identification of major challenges within the supply chain.

Data Analysis

Descriptive statistical techniques, including frequency distributions, percentages and means were employed to analyze data pertaining to apple production, costs and returns. Furthermore, regression analysis was conducted to discern the factors influencing the net returns of apple growers. The regression analysis aimed to identify the variables that significantly affect growers' net returns.

Regression/ Empirical Analysis

This study employed econometric models to identify the factors impacting the net returns of apple growers and to propose policy recommendations for enhancing their returns. The application of

such regression models aligns with the methodology employed by, Ghalib et al. (2017), and Khan et al. (2018).

The general empirical model utilized in this study can be expressed as follows:

$NR = f(X)$… ……..(2)

Where:

- *NR* represents the Net Returns to apple growers/contractors.
- *X* comprises a matrix of explanatory variables.

Following linear regression model was estimated through Ordinary Least Square (OLS) estimation technique :-

- $NR = \beta_0 + \sum_{i=1}^{n=11} \beta_i x_i + \varepsilon$ ……..(3)

Ln represent natural log, β_0 and βi are intercepts and coefficients and ε is the error term

The variables included in the matrix *X* are as follows:

- *Age* = Head's Age (Years)
- *Education* = Head's Education (Years)
- *Household size* = Household size (categorized into four groups)
- *Experience* = Head's Experience (Years)
- *Area under orchards* = Area under orchards (in Acres)
- *Orchard Sold level* = Dummy in nature, (0) for apples sold directly in the market, (1) sold early in fruiting stage, (2) sold at flowering stage by the growers
- *Water insufficiency* = Dummy, (1) indicating water sufficiency, (2) otherwise
- *Climatic factors* = Dummy, (1) indicating conducive climatic conditions, (0) otherwise
- *Infrastructure quality* = Dummy, (1) indicating quality infrastructure, (0) otherwise
- *Distance to road* = Dummy, (1) indicating proximity to the road, (1) otherwise
- *Marketing channel* = Dummy, (0) indicating sale through local commission agent (0), (1) otherwise or non-local commission agents

Results and Discussion

Demographic characteristics of Respondents

This section examines into the socio-economic profiles of apple growers in the study area including factors like age, education, experience, household size, area under apple orchard and sources of irrigation. These socio-economic factors provide essential context for understanding apple growers' decision-making, productivity and hence economic capacity dimension of food security.

Data regarding farmers age are presented in table 4.1. Age of the farmers was classified into four class boundaries i.e less than 30, 31- 45, 46-60 and above 61. Table shows that majority of the growers in both districts belong to the age group of 46-60 years, the percentage is 41.67 and 33.33

for killa saifullah and pishin respectively. Age descriptive in table 4.2 shows that majority of the farmers having the age from middle one to the upper limits i.e average age in Killa saifullah was noted 47.61 years while in district Pishin it was 48.26 years which shows that the average age across both districts is approximately 48 years, with slight variations. Respondents up to 50 years have positive attitude toward new innovation and dynamic scenarios as reported by Israr et al., (2020)

Table 4.1: Categorization of respondents on the basis of Age

Age (Years)	Killa Saifullah		Pishin		Grand total
	No.	%	No.	%	
< 30	10	16.67	10	16.67	20
31-45	17	28.33	16	26.67	33
46-60	25	41.67	20	33.33	45
> 61	8	13.33	14	23.33	22
Total	60		60		120

Source: Primary data analysis, 2023

Table 4.2: Age Descriptive of farmers in study area.

Districts	Mean	Std. Dev	Min	Max
Killa Saifullah	47.61	12.87	23.3	72.1
Pishin	48.26	14.20	25.1	75.3

Source: Primary data analysis, 2023

Literacy and Education

Literacy and education has important role in timely decision making, adaptive strategies, awareness and taking risk. It is a general sense where individual knowledge, skills and learning habits get improved. Education system in Pakistan is generally divided into five levels: Primary (1-5 years), middle (grade six to eight), high (10 years), intermediate (12 years) and university program (above 15 years). Table 4.3 shows that overall in both districts 25.83 % of the respondents were illiterate. Among districts 38 % of the respondents were illiterate in Killa saifullah, 13 % in district Pishin. Moreover, out of total 120 respondents, 16.67 % have primary education, 31.67 % matric, 12.50 % bachelor and 13.33 % were found literate up to master or university level. Table 4.4 shows that respondent's average education was higher in Pishin district (8.8 Years) middle level compare to primary level in Killa Saifullah (5.81)

Table 4.3: Distribution of respondents on the basis of Education

Education level(Years)	Killa Saifullah		Pishin		Grand total	
	No.	%	No.	%	No.	%
0	23	38	8	13	31	25.83
1 to 5	11	18	9	15	20	16.67
6 to 10	13	22	25	42	38	31.67
11 to 14	7	12	8	13	15	12.50
Above 15	6	10	10	17	16	13.33
Total	60		60		120	100

Source: Field survey, 2023

Table 4.4: Descriptive statistics related to education

Districts	Mean	Std. Dev	Min	Max
Killa Saifullah	5.81	5.71	0	16
Pishin	8.8	5.06	0	16

Source: Source: Primary data analysis, 2023

Relevant Experience of respondents in study area

Data regarding growers average relevant experience in Kalla Saifullah was 22.41 years ranging from minimum 5 to maximum 40 years. In district Pishin average relevant experience was noted 20.35 years with minimum 7 and the maximum 40 years. Abedullah et al., (2006) pointed that relevant experience have association with inputs use, other related practices and economic efficiency. Kide (2014) stated that experience farmers comparatively know more about weather and other related issues and its implication on crop production compare to those who have less experience.

Table 4.5: Experience Descriptive

Districts	Mean	Std. Deviation	Minimum	Maximum
Killa Saifullah	22.41	9.23	5	40
Pishin	20.35	7.53	7	40

Source: Primary data analysis, 2023

Household size Descriptive

Data presented in table 4.6 shows that average family size Killa Saifullah was 5.78 members per households ranging from minimum 2 to maximum 14. In District Pishin average family size (8.4) was noted larger than Killa Saifullah. Family labors facilitate growers' at peak time but also causes inefficiency due to hidden unemployment (Ali ,2018). Average family size of 7 people was more prevalent in Pishin (8.3) compared to Killa Saifullah (5.71).

Table 4.6: Household size in study area

Districts	Mean	Std. Dev	Min	Max
Killa Saifullah	5.71	3.51	2	14
Pishin	8.3	2.82	2	14

Source: Primary data analysis, 2023

Area under orchard's cultivation Descriptive

Data given in table 4.7 revealed that average land under apple orchard was 14.32 acres in district Killa Saifullah, with maximum 50.1 and the minimum 1.5 acres. While in Pishin district area under apple orchard was 6.54 acre up to maximum 30 acres. Table shows variation in average and maximum area under apple orchard. Orchard size serves as an important resource for production, economic activities , employment generation and livelihoods. Adoption of an innovation tends to take place earlier on large size of land. Daberkow and McBride (2003). In orchard, varieties such

as Ture Kulu, Shine Kulu, and Kaja dominate, with Ture Kulu being the most prominent, grown by 95.85% of the apple growers due to its economic value.

Table 4.7: Area under Apple orchard

Districts	Mean	Std. Dev	Min	Max
Killa Saifullah	14.32	11.13	1.5	50.1
Pishin	6.54	5.03	1.5	30

Source: Primary data analysis, 2023

Distribution of farmers on the basis of sale out of their produce

Table 4.8 shows sale out and marketing of apple production in study area. Best returns from resources depends on type of strategy growers adopted for delivering their produce to customers. Data shows that in Killa Saifullah, 43.33 % growers sale their produce to pre-harvest contractors either at fruiting or flowering stage. While in Pishin district about 30 % growers has sale their expected produce at fruiting or flowering stage. Pre-harvest contractors are specialist in performing various function related to marketing. In order to realize the economy of scale and overcome the difficulty of small produce they contract more than one orchard at a time. They perform maximum marketing functions by themselves. Data also shows that about 56.67 % apple growers in killa Saifullah, 70 % in Pishin has sold out their production directly to market. Forwarding agents arrange transport, packaging and other materials to the orchardists for fruits delivery from farm to market. Forwarding agents are specialized persons operating in major apple producing areas, their main business is to arrange logistics for apple growers.

Table 4.8: Distribution of growers' based on sale out

District	Market		Fruiting Stage		Flowering stage		Grand Total
	No.	%	No.	%	No.	%	
Killa Saifullah	34	56.67	21	35	5	8.33	60
Pishin	42	70	16	26.67	2	3.33	60
Total	76		37		7		120

Source: Primary data analysis, 2023

Distribution of farmers on the basis of sources of Irrigation

Groundwater from tube wells is the primary water source for irrigation in study area. Data given in table 4.9 shows that tube wells, either electric or solar or combination of both are used for ground water pumping. It pose a potential concern for groundwater depletion, particularly in Pishin, where 32% of growers reported insufficient groundwater. According to Iqrar (2024) over pumping of ground water in Balochistan will yield man made desertification in area. In Balochistan a major dry land mass (desert) is already unattended due to lack of water. Climate change add to forecast for more drought, floods, long spell of rains and occurrence of more unpredictable events. In recent past drought caused misery and migration in Balochistan like Ethiopia and Somalia. Gravity run design of water flow and flood irrigation practices has outlived its utility specially for Balochistan being a water scarce province. It is time to redesign water flows, ensure its sustainable use to prevent the current green fields from becoming deserts. It national level measures like "land degradation neutrality" by Ministry of Climate Change with main aims of judicious water use

through alternatives like drip irrigation and use of mulches for preventing further land degradation and desertification was pointed important.

Table 4.9: Distribution of farmers on the basis of sources of Irrigation

District	Electric tube wells	Solar Tube wells	Combination of electric and solar	Grand total
Killa Saifullah	50	6	4	60
Pishin	53	1	6	60
Total	103	7	10	120

Source: Primary data analysis, 2023

Inputs Availability

Availability and quality of fertilizers vary, with 67% of respondents indicating low-quality fertilizers affecting production. Pesticides and herbicides are generally considered insufficient for growers' needs, and skilled labor availability varies seasonally, with 73.3% indicating it meets demand.

This section explores key input factors for apple orchards, including water, fertilizers, pesticides and herbicides, and skilled labor. Fertilizer availability varies, with 67 respondents indicating low-quality fertilizers impacting production. The majority of producers find pesticides and herbicides insufficient for their needs and skilled labor availability is generally in line with demand but can fluctuate during peak seasons, such as harvest. These inputs are critical for apple orchard productivity and play a crucial role in shaping the overall outcomes of apple growers in the study area.

Cost of Production of Apple per Acre

Table 4.10 delve into the intricacies of apple orchard production costs, which comprise both fixed and variable elements. Fixed costs encompass expenses like land rent and machinery depreciation, while variable costs encompass a wide range of inputs and activities essential for apple cultivation.

Fixed Cost

Establishment Costs: These represent the initial expenses incurred during the orchard's early years, including plant and labor costs, irrigation, and chemicals for the first four years before fruiting begins. On average, this amounts to Rs. 200,000 per acre, equivalent to Rs. 10,000 per acre annually over the orchard's 20-year fruiting period. This cost is added to the land rent to calculate the total fixed cost per year.

- **Land Rent:** Land rent varies by district, with an average of Rs. 35,000 per acre in Killa Saifullah and Rs. 50,000 per acre in Pishin. Consequently, the total fixed cost per acre per year is estimated at Rs. 45,000 in Killa Saifullah and Rs. 60,000 in Pishin.

Variable Costs

Pruning Cost: Pruning, a crucial practice for maintaining tree health and productivity, costs Rs. 7,200 per acre in Killa Saifullah and Rs. 7,200 per acre in Pishin.

Hoeing: Common in apple orchards, hoeing, which involves soil management and weed control during fertilizer application, costs Rs. 5,400 per acre in both districts.

Pesticides Cost: To control insect pests, pesticides are used and cost Rs. 60,000 per acre in Killa Saifullah and Rs. 75,000 per acre in Pishin, with the higher cost in Pishin due to excessive pesticide use.

Organic and Inorganic Fertilizer Cost: Fertilizers, including organic and inorganic types, cost Rs. 54,800 per acre in Killa Saifullah and Rs. 53,200 per acre in Pishin.

Irrigation Cost: Tube wells are the primary source of irrigation, with costs of Rs. 111,000 per acre in Killa Saifullah and Rs. 135,000 per acre in Pishin.

Picking and Packaging Cost: Labor, grading, and packaging costs, including wooden crates, rice straws, newspaper, and nails, total Rs. 2,83,000 per acre in both districts.

Transportation Cost: Transportation expenses vary, with Rs. 1,78,800 per acre in Killa Saifullah and Rs. 2,08,800 per acre in Pishin. Loading and unloading costs are Rs. 8,800 per acre in both districts, these costs are included in transportation costs.

Commission Agent Cost: Commission agents charge a 10% commission on product sales, resulting in costs of Rs. 1,43,000 per acre in Killa Saifullah and Rs. 1,59,500 per acre in Pishin.

Miscellaneous Cost: Miscellaneous costs, covering worker food, and occasional machinery repair, are Rs. 35,050 per acre in Killa Saifullah and Rs. 40,050 per acre in Pishin. Inputs use noted during survey are annexed in picture 3.

Table 4.10: Cost of Production of Apple Per Acre

Activities	Unit	Kill Saifullah	Pishin
Fixed Cost /Land Rent	Acre	45000/-	60000/-
Pruning	Rs	7200/-	7200/-
Hoeing	per Tree	5400/-	5400/-
Pesticides	Litre	60000/-	75000/-
Organic and Inorganic Fertilizer	Parcel (Kg)	54800/-	53200/-
Irrigation Cost	Tube well	111000/-	135000/-
Picking & Packaging Cost	Rs.	283000/-	283000/-
Transportation	Mazda (Truck)	178800/-	208800/-
Commission	10%	143000/-	159500/-
Miscellaneous Cost	Rs.	35050/-	40050/-
Gross expenses	**Rs**	**92,3250/-**	**10,27150/-**

Rs. Represent Pakistani Currency Rupee

Source: Primary data analysis, 2023

Production and Net Returns

Production refers to total quantity produced within a specific region and time period, typically measured in terms of volume. Pishin, with its favorable weather conditions, tends to yield higher-quality apples compared to Killa Saifullah, and the cold winter season plays a vital role in apple quality.

Table 4.11 shows that apple growers in Killa Saifullah district earned a gross income of Rs. 14,30,000, while those in Pishin district earned Rs. 15,95,000. Net returns in Killa Saifullah amounted to Rs. 5,06,750, calculated by subtracting gross expenditure (Rs. 9,23,250) from gross income (Rs. 14,30,000). In Pishin district, net returns reached Rs. 5,67,850, derived by subtracting gross expenditure (Rs. 10,27,150) from gross income (Rs. 15,95,000). These net returns indicate the profitability of apple cultivation in the respective districts, considering the comprehensive production and cost factors discussed earlier.

Table 4.11: Apple Production and Net returns to Growers (Rs.)

Activities	Sale Rate/Crate*	Quantity(Crates)	Gross Income	Gross Expenditure	Net Returns
Killa Saifullah	1300	1100	14,30,000/-	9,23,250/-	5,06,750/-
Pishin	1450	1100	15,95,000/	10,27,150/-	5,67,850/-

Crate*: local unit equivalent to 15 Kg
Source: Primary data analysis, 2023

Efficient market serve as a pathway in improvement of food security and livelihoods. Viable supply chain system that overcome barriers of growers' participation in local and international markets and link all stakeholders potentially contribute to food security, was added in following section:-

Existing Apple Supply Chain in Study area

A supply chain encompasses all the entities, activities, resources, and technological advancements involved in the production and distribution of a product. It begins with the acquisition of raw materials and concludes with the final delivery of products to customers. Supply chain, incorporate inputs supply, crop production , picking, packaging , processing if any and finally marketing. Encompassing all steps in production from raw material until the end products reaches the final customers represent a strategic thinking in the industry. Main objective of Supply chain as a concept is to govern enterprise activities efficiently. Fruit safety, waste, freshness, production process, logistic activities and managerial competencies of actors are areas that could be considered and improved to enhance the chain. Customer preferences and requirements has evolved food supply chain in terms of Integrity, sharing of information, e-commerce enterprises, startups and digitalization.. Lean methodology in current operations, improvement of legacy system, unification of digital technologies, structuring analytical capabilities and sustaining a culture of freshness are steps suggested by Tort et al., (2022) for improvement in food chains. Rise in social awareness regarding significance of food chains, enriched literature on supply chain by academia and declarations of Sustainable Development Goals (SDGs) to overcome issues like poverty and hunger highlight relevance and importance of the current study. Literature review by Tort et al., (2022) shows that a total of 38,170 research articles has been published on importance of supply chain as a topic, while a total of 158 studies conducted has focused supply chain of fresh fruits and vegetables from 2000 to 2020. In current study provision of enough information on main aspects of fresh apple fruit supply chain in study area was ensured for contribution to the existing literature and filling the research gap.

Figure 4.1 shows the existing supply chain followed by apple growers in study area. It is based on field survey and discussions with producers, contractors, and other stakeholders.

Inputs Suppliers

Inputs supply is basic component in supply chain, production depends on land fertility and location specific apple varieties. It also involve tasks like land clearance, weed and rock removal, and soil structure and fertility enhancement. Soil testing helps assess nutrient content and pH levels for appropriate adjustments. Professional and unskilled labor is essential throughout the apple supply chain, from orchard establishment and maintenance to fruit harvesting. Labor-intensive tasks include pruning, irrigation, fertilization, and apple picking. Capitals like machinery, equipment, tools, and infrastructure are utilized in various stages of storage, and distribution.

During survey it was seen that packaging is critical in keeping quality during storage, shipping and delivery. Traditional materials like wooden boxes, rice straws, old papers are used for packaging in study area. Products safety, quality, postharvest and transportation losses and shelf life related inefficiencies noted could reduce the share of producer in price paid by consumers. Fertilizers promote tree growth, replenish nutrients and increase fruit production. Soil test results guide growers for type and quantity of chemical fertilizer, however, in study area this practice was not common. In routine FYM, DAP, and potash are applied to orchards based on growers experience. Dry nature of soil in Balochistan, demand for steady water supply to ensure production. For steady water supply, efficient methods like sprinklers and drip irrigation need to be promoted in study area. With installing micro-irrigation system water efficiency would increase.

Orchards are prone to pest attacks and different diseases. In order to ensure maximum production harmful insects, pests and diseases need to be managed properly. Integrated Pest Management (IPM) practices offers sustainable and environmentally friendly approaches are possible options to be exploited. In study area pesticides such as Amamactin, Omite, and Chloro are traditionally applied insect control without any concern of environmental degradations and health hazards. Pruning shape apple trees, promote optimal growth, ensure proper sunlight and air circulation. Limiting factors were increasing cost of irrigation, picking and packaging, transportation and commission along with growers concern of inputs quality.

Contractors

In study area it was realized that contractors remain in contacts with producers at fruiting and flowering stages of apple fruit production. However, sale out the orchards during the fruiting and flowering stages reduce the net returns of growers by Rs. 53,239 and Rs. 25,666/.compared to those who sell in market after full maturity.

In study area, as common in all developing countries many players and agents were found involved with farmers at one end and consumers at the other. Supply chain was found linked with social structure in study area. Producers contacts with markets was observed limited, instead of reduction in net returns by selling its produce pre-harvest contractors.

Commission Agents

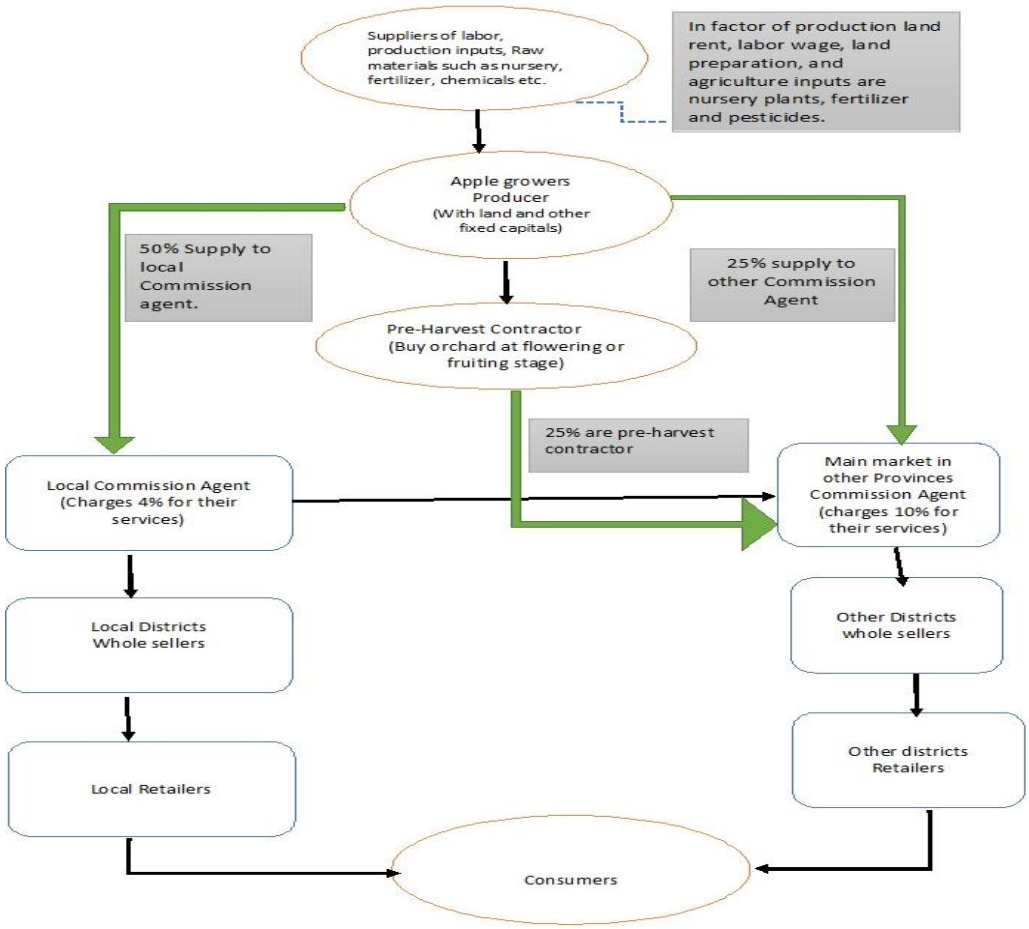
Many growers, who face economic challenges, depends on commission agents for inputs and transportation services to markets, for a 4% commission on earnings. Approximately 25% of growers transport their apples to major markets, where they are further transferred to district commission agents, incurring a 10% commission after sales. The primary market for apple fruits is the Sargodha district of Punjab, where auctions, known as Handabaar, determine crate prices based on apple quality, especially the type. This market auctions 80,000 to 1,00,000 apple crates.

These commission agents promote the sale on behalf of suppliers and received commission based on amount of goods sale. It was observed that a number of these intermediaries are playing its role and received its charges which are ultimately added to final price paid by consumers. The key players were inputs suppliers, contractors, commission agents and transporters. Local commission agents charges 4% of the total sale, while in major city markets they charge 10%.

Wholesalers and Retailers

Wholesalers purchase products in bulk and resell in smaller quantities to retailers or other businesses. it maintains extensive warehouses for product storage, handling logistics to ensure retailers have a consistent supply. They contribute to market stability by managing inventory storage and organization. Wholesalers may also offer financial and credit facilities to retailers, such as extended payment terms or loans, to aid cash flow management and inventory investment.

Figure 4.1: Existing Supply Chain



Source: Field survey, 2023

Findings reported by Jiang et al.,(2021) has highlighted that horticultural practices and inputs optimization can enhance apple fruit production. They also pointed that coordinated apple supply chain has potential to improve economic benefit and reduce environmental emission. Supply chain of Traditional Practices (TP) farmers were compared with High-yield-High- Efficiency (HYHE) farmers in North China. Their findings illustrated that HYHE farmers has achieved 33 % increase

in apple production and 63 % in overall economic effect of the apple supply chain. It has also the potential to improve the sustainability level of the whole supply chain.

Jeong and Choi (2023) has focused on the need for adaptive supply chain system in prevalent pace of environmental changes in USA. Because of climate change some regions may see decline in apple production, while other could emerge as new production hubs. These expected and unavoidable changes call for prompt adjustment in broader supply chain strategies. Role of incorporating climate change consideration into core business and supply chain strategies was emphasized.

Comparing Balochistan's apple supply chain challenges with developed countries, like the US and China, there's a notable disparity in infrastructure and technology, water management and market access. Inputs costs, limited irrigation water, expensive tube wells, inadequate storage and constrained market reach were found prevalent in study area. In contrast to developed nations that employ precision agriculture, advanced irrigation, state-of-the-art storage and efficient transportation networks for sustaining of their supply chain. To modernize Balochistan's supply chain, crucial policy steps include infrastructure development, technology adoption and direct market connections, investments in storage, packing and transportation infrastructure, coupled with promoting efficient irrigation and precision agriculture, can alleviate key challenges. Establishing direct links between growers and major markets would reduce reliance on intermediaries and ensure better returns. Water management initiatives, financial support through subsidies and education programs on best practices and modern technologies are vital for sustainable improvements. Enforcing quality standards, supporting research and development and fostering government-private sector collaborations would collectively contribute to transforming Balochistan's traditional apple supply chain into a dynamic, resilient, profitable and sustainable model.

Results from Regression Analysis of Grower's Net Returns

Linking factors of production response to net returns of grower’s help in targeted planning. In current analysis several coefficients were found positive and statistically significant as given in table 4.12. Age and experience were found positive and significant, which illustrate that with increase in age and experience by one year net returns increased by Rs. 1336 and Rs.2729 respectively. Similarly, selling of orchard at fruiting and flowering stage have reduced their net returns significantly. Irrigation water deficiency reduced net returns by Rs. 72,376/-. Conducive climatic condition coefficient is positive and significant which illustrate that conducive climatic conditions could increase net returns by Rs. 1,077,41. Infrastructure is positive and significant in association with net returns, it potentially increased net profit by Rs. 65,134/ in study area. Orchards located along major roads yield higher net profits per acre, with an increase of Rs. 69,241/- compared to others. Growers who sell their produce directly to markets receive a relatively high net return of Rs. 50,636/- per acre. These coefficients and their significance levels provide valuable insights into the factors that affect apple growers' net returns. The model allows for a better understanding of the impact of various variables on growers' income and can be useful for making informed decisions in apple cultivation and marketing. F-test associated P-value of 0.0000, indicate that the combined effect of all the explanatory variables in the model significantly explains the variation in apple growers' net returns. The R-squared (R^2) value of 0.74 means that variables considered in model explain 74 percent variation, while the remaining 26 % is due to unknown factors.

Table 4.12: Estimates of Regression Analysis

Net income			
Variables	**Coefficient**	**t-value**	**P-value**
Age	0.0134	1.86	0.065
Education	0.0062	-0.32	0.747
Household Size			
3-5	0.4991	1.45	0.15
6-9	0.3993	1.14	0.258
10<	-0.0397	-0.11	0.91
Experience	0.0273	2.2	0.03
Area under Orchard	-0.0079	-0.78	0.439
Sold level			
Sold at Fruiting stage	-0.532	-2.44	0.016
Sold at Flowering stage	-2.567	-5.8	0
Water inefficiency	-0.7237	-3.42	0.001
Climatic factors	1.0774	4.64	0
Infrastructure quality	0.6513	2.78	0.006
Distance to road	0.692	2.89	5
Marketing channel	0.5063	2.49	0.014
Constant	5.78	5.45	0
Adj R-Square 0.74,	F(14, 105) = 21.73,	Prob>F = 0.000	

Source: Field Survey, 2023

Conclusions

Apple production is an important source of livelihood to people of Balochistan. Findings showed that net returns in Pishin and Killa Saifullah were Rs. 5,67,850/ acre and Rs. 5,06,750/acre for the period under study. Orchards sale out at ripening and flowering stages reduced growers net profits by Rs.53,292 and Rs. 2,56,667 respectively. Field survey revealed that inputs suppliers, contractors, commission agents (both local and in main market) and transporters have key roles in apple supply chain. Local commission charges 4% of the total sale, while this increase to 10 % in major city markets. In production, transportation cost arrived 20 % of the overall cost of production. According to regression analysis, producer age, experience, orchard selling decision, marketing channel selection, water availability and proper climatic conditions, distance to the major road and infrastructure quality have a substantial impact on net returns. Adaptation strategies like drip irrigation system, solar tub wells and low interest credit could help to enhance net returns of apple growers. Reliance of growers on commission agents for sale and inputs as well as inefficient post-harvest losses in terms of packaging and shipment were highlighted the possible challenges that reduce fruit perishability and productivity gains across the chain. Existing supply chain in study area seems static and traditional without any innovative perspective. Auction facility in local market, access to information, direct link of growers to mage companies ,focus on improving farmers' technical abilities and environmental consciousness could contribute to impactful productivity gains across the chain.

Authors' Contribution

K. Zubair conducted survey and data feeding in excel. *A. Ali* did analysis and develop the initial drop. N. *Ara* worked out tables, formatting and figures. M. Rasheed technically reviewed the article. Idea of work on Apple fruit was developed by S. A. Shah. He also helped in recommendations setting of the article.

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