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"INVESTMENT APPRAISAL PROCESS IN AGRICULTURAL PROJECTS AND ITS PROFITABILITY"

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MAGİSTR DİSSERTASİYA İŞİ

"INVESTMENT APPRAISAL PROCESS IN AGRICULTURAL PROJECTS AND ITS PROFITABILITY"

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Abstract

This research examines large-scale cereal production schemes (wheat, barley, and corn) in the Karabakh region in Azerbaijan, a key cereal production area, contributing around 15% of the country's yearly wheat production through highly scientific techniques of investment appraisal. The research uses the exponential smoothing state-space (ETS) method in combination with yield analysis for the prediction of future harvests and income streams. Afterward, the research uses the cost-benefit approach in calculating the benefit measures (NPV, IRR). At the beginning of this research, the findings show high economic feasibility, including, for example, cumulative schemes like land restoration and modernization of irrigation systems, where the Internal Rate of Return is around 13.8% and the Net Present Value is strongly positive at the 7%-10% discount rate. Improved irrigation technology (pivot, drip irrigation, etc.) increases the efficiency rate of irrigation and production, and the use of precision agriculture technologies (Variable Rate Input Application, Global Positioning System guidance, etc.) minimizes costs through optimized inputs. The presence of government assistance in the form of subsidies for machinery and irrigation, high-quality seeds, and insurance cover increases the project feasibility, since high-quality inputs have already considerably elevated the production of cereals in the non-irrigated lands.

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INTRODUCTION

Relevance and Development of the Topic. The global economy depends on agriculture as its essential foundation because it provides food security and maintains employment opportunities and family income stability. The World Bank reports that agricultural production with its supporting industries generates 4% of worldwide GDP while employing 26% of the global workforce according to 2024 data. The agricultural sector maintains its position as the foundation which protects worldwide food security. The UN Food and Agriculture Organization (FAO) predicts that agricultural production needs to increase by 70% to meet the food requirements of a projected 9-10 billion people in 2050. The increasing worldwide food requirements have made agriculture an essential element for achieving sustainable development and reducing poverty and maintaining international peace. Research evidence shows that agriculture supports the global economy through multiple channels because it delivers vital food products and basic materials while creating rural economic expansion and providing economic stability during recessions and generating substantial employment opportunities through sustainable development. Agriculture maintains its essential position in the worldwide economy because it drives economic growth while providing essential food security and supporting social welfare. From an academic perspective, numerous studies confirm the contribution of agriculture to economic development. For example, classical development theories (Johnston and Mellor) argue that agricultural surpluses and productivity growth are the initial stage of industrialization.

Object and Subject of the Research. The topic of the dissertation work is large agricultural projects conducted in the Karabakh region, particularly the grain sector, such as wheat, barley, and corn. The topic of the investigation is the evaluation of the economic efficiency and profitability of investments carried out during these agricultural projects. Therefore, the investigation considers investment efficiency, bearing in mind the effect caused by the new sowing methods, irrigation, and quality seeds used on the fertile ground lying in Karabakh.

Purpose and Objectives of Research In addition, agriculture plays a key role in trade as an export commodity for many countries -it accounts for a significant share of exports in many developing economies and is important for earning foreign exchange. At the same time, the sector faces challenges such as the impact of climate change, land degradation and price volatility on a global scale. These issues have given rise to a rich body of literature on sustainable agricultural practices, climate-smart farming and the sustainability of food systems. In short, the global role of agriculture is well recognized in academic discourse: it is the cornerstone of the economy of human civilization, vital for feeding the planet and supporting the livelihoods of a large part of humanity.

The agricultural sector in Azerbaijan maintained a 30% GDP share during its Soviet Union period according to Lerman Zvi Sedik David (2010). The Soviet Union's collapse in 1991 required Azerbaijan to establish an economy based on hydrocarbons because oil and gas production expanded from 16% of GDP in 1995 to 64% by 2023. The agricultural sector experienced a major decline in its GDP share which dropped from 25% in 1995 to less than 6% in 2023 (State Statistical Committee of the Republic of Azerbaijan, 2024). The nation holds upper-middle-income status according to international organizations because of its large hydrocarbon reserves. The state generates additional revenue from hydrocarbon expansion, but this growth creates two problems which threaten agricultural sector development through Dutch disease effects and structural issues.

Research Methods. It is expected that this study will provide grounds for setting up priority programs in this branch based on the economic profitability of investment in the ongoing and future years. The objectives are as follows:

- Calculation of costs of investment in agricultural projects, agricultural output, and, consequently, financial parameters, such as NPV (Net Present Value) and IRR (Internal Rate of Return)
- Forecast future crop production based on ETS (Error, Trend, Seasonality) and estimate income flows based on such forecasts.
- Discuss how state subsidies and other financial support initiatives affect the attractiveness of investing in a project.

The execution of these tasks makes it possible for the researcher to evaluate how projects can finance themselves in the future and whether they need funding from the state. At the beginning, the ETS model was used for forecasting future yields, while statistics on productivity in previous years were taken into consideration. This helped estimate the future changes in productivity in grain-sown territories, particularly in territories where irrigation methods are used. Afterwards, a cost-benefit analysis was carried out in order to assess investment characteristics of the project: the efficiency of invested finances, in terms of NPV and IRR, was calculated. In the process, the initial investment of the project (CAPEX), operational expenditure (labor, fertilizer costs, energy costs, and so forth), and potential income (from product sales) were calculated. In the process, the analysis of the investment cash flows included the free cash flows (Free Cash Flow) and the time till amortization (Payback Period). In this regard, the work utilized models directly providing a comparison between estimated expenditures during a certain time period and real productivity. The dissertation assessed investment characteristics, taking into consideration regional specifics: high fertility of newly liberated territories, potential improvement in irrigation infrastructure, and background information about government support. The dissertation quantitatively estimated, with precise numbers, the role of existing subsidy schemes (subsidies regarding machinery and insurance, high-performance seed distribution schemes, and so forth), influencing the financial characteristics of the investment. The results of the work application possess high practical value, as they can be used for estimating investment attractiveness with precise numbers on a certain territory and serving as a basis during planning processes both for government agencies and investors.

CHAPTER I: THE STRATEGİC ROLE OF AGRİCULTURE IN AZERBAIJAN`S ECONOMY

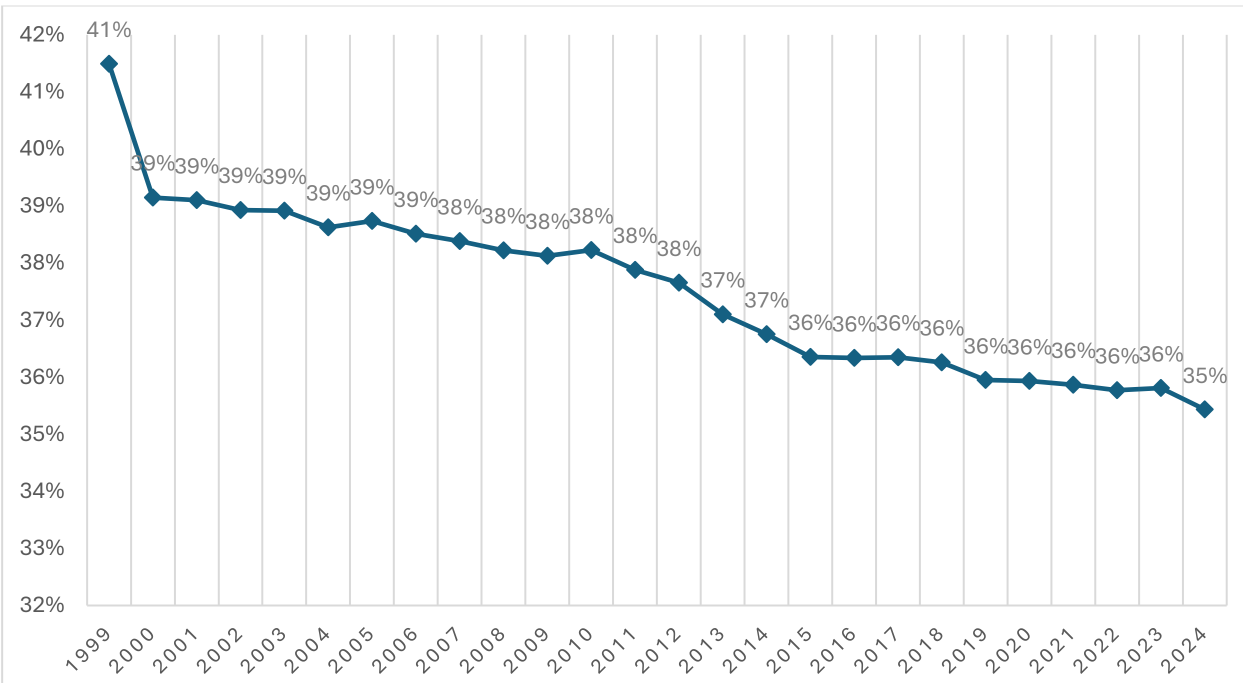
LITERATURE REVIEW

The global economy Agriculture continues to be the backbone of Azerbaijan and the Southern Caucasus region, but it is also characterized by limited water resources and a climate that has become more unpredictable than ever before. The country exploits around 30% of its total available water, while the remaining water is tapped from transboundary rivers, and this gives the country a per-capita renewable water availability of approximately 804 m³ in 2020, much lower than that of Georgia. Around 86% of the total domestic water is devoted to irrigation, but the irrigation system in the country is outdated. Flood and furrow irrigation methods are widely practiced in the country, resulting in high water losses and the generation of problems associated with drainage, waterlogging, and soil salinization. Due to the frequent occurrences of drought and undependable rainfall, agricultural productivity has dramatically decreased across the country. Azerbaijan has two possible agricultural developmental paths according to the literature: “the increase of grain production based on modern breeding and the introduction of modern irrigation technologies.” The country is gradually lessening its reliance on imports of grains through enhanced production domestically, with encouraging developments in wheat breeding in particular. Faiq Khudayev, director of the Research Institute of Crop Husbandry, said: "In Azerbaijan, approximately 60% of the country’s total 986,000 hectares of grain lands will be sown with locally bred wheat in the year 2025. The choice of high-quality seeds and the development of varieties suitable to the country’s soil and climate conditions are basic for the improvement of yields." The Institute has shifted its focus from traditional breeding methods that would take an average of 15 years to produce a new variety to fast breeding based on genetic studies and rapid hybridization methods, where up to six generations per year can be produced, shortening the breeding process to five to six years in total. The new breed of wheat is more resistant to drought and disease and is suitable to Azerbaijan’s semi-arid climate. The latest statistics show a growth of 0.9% in the output of grains in the first quarter of 2024 despite adverse climatic conditions, clearly hinting at the effectiveness of the locally bred wheat and enhanced farming practices to improve output levels in due course. Various studies, including Ojaghi et al. (2025), suggest that the conservation of wheat genetic diversity is the basis for ensuring the sustainability of grain production methods in the long run. Given the severity of water scarcity at the root of agricultural problems, the scholarly literature widely calls for the pressing need to modernize irrigation. Z. H. Aliev, in 'Problems of Water Deficit in the World and Azerbaijan (2020),' states that "just 4% of arable lands are irrigated through modern methods, while the remaining 96% are irrigated through the older methods, resulting in the increase in groundwater levels and soil salinization." Modern irrigation should improve agricultural water productivity from "0.73 kg/m³ in 2007 to 1 kg/m³ by 2025 and to 1.50 kg/m³ by 2050," according to Z. H. Aliev, by adopting modern irrigation and intelligent agrotechnology strategies. "From 2023 to 2025, the governmental incentives will increase modern irrigation to no less than 11% by developing more than 40,000 hectares and an additional 150,000 hectares." All this fits well with the estimate that "water losses will be reduced by up to 42% by 2027." These policy recommendations find empirical basis in the literature cited below. For instance, according to Aliyev (2023), low-duty irrigation in sloping lands practiced through drip and pulsed-sprinkler irrigation regimes helps sustain soil moisture at a level of 80 to 100% of the soil's capacity, thereby utilizing less water and decreasing runoff in comparison to surface irrigation methods. Huseynova (2023) states that a significant portion of irrigation water loss (one-third) is attributable to conveyance losses, while another quarter is lost at the farm level, thus hinting at the possibility of large irrigation efficiency gains through the implementation of micro-irrigation methods and efficient conveyance systems. Regional statistics available for Armenia suggest that the implementation of modern irrigation infrastructure has the potential to increase the efficiency levels of the irrigation system from the current average of 25% to a higher level of 75 to 80% and increase the rate of water productivity by a significant margin of 40%. Thus, the current literature suggests a two-track approach to making Azerbaijan climate-resililant: developing the country's grain sector through science-based breeding and (2) improving the efficiency of irrigated agriculture to save water in a manner that conserves the precious resource in Azerbaijan and the Caucasus region in general. At the same time, the two strategies are synergistic because climate-resistant wheat requires the implementation of efficient irrigation networks, while the application of "advance irrigation technology" will in no way guarantee food security in the absence of suitable wheat strains. Consequently, the current manuscript proceeds to emphasize the need to implement an integrated climate-resilient farming system.

1.1. Analysis of changes in the agricultural sector's market share over the years

The agricultural sector maintains its importance for Azerbaijan because it supports economic growth and provides employment to rural residents and ensures food availability. The agricultural sector uses 36% of its workforce in rural areas to produce 5-6% of the national GDP (Figure 1.1.1). The economic structure of rural areas depends heavily on farming because most people work in this sector which makes agriculture their main source of income and their protection against unemployment. Small increases in agricultural output will create major income growth for families which will help reduce poverty levels in these communities.

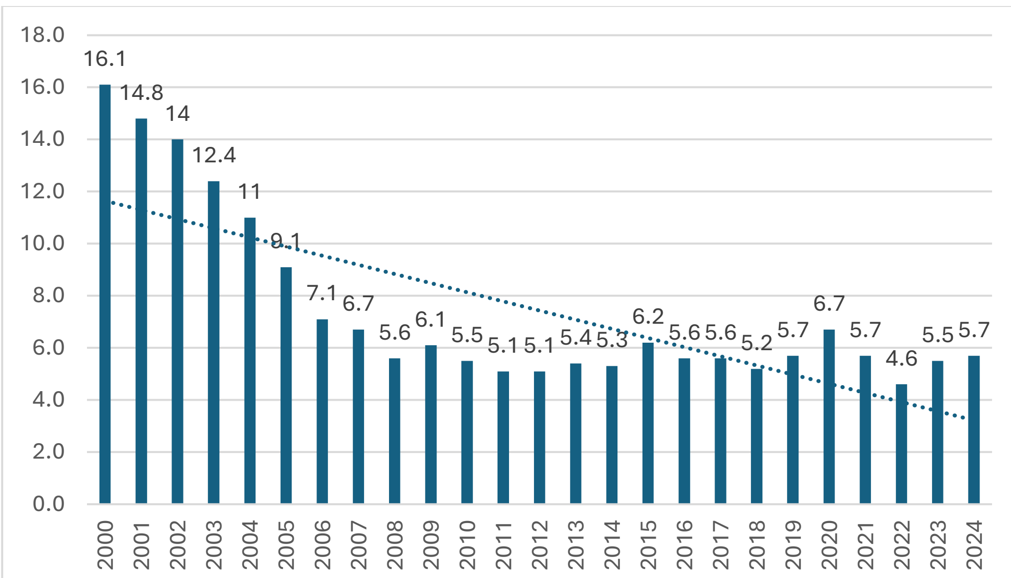
Figure 1.1.1. % Share of agriculture in the labor force, 1999-2024



Source: Stat.gov.az, https://www.stat.gov.az/source/labour/en/002_1-2en.xls

The official economic strategy of Azerbaijan now places greater importance on agriculture because it helps stabilize the volatile oil industry. The agricultural sector of GDP experienced a significant decline from 16% to 5.5% during the period from 2000 to 2010 because of fast oil sector growth. The agricultural sector experienced a small increase in its GDP share which rose from 5.5% to 6.2% during 2010–2015 because of growing interest in developing non-oil sectors. The current agricultural sector contribution to GDP stands at 5.7%. The national economy now views agriculture as its fundamental base because of recent economic developments. The sector depends on food production for self-sufficiency because the COVID-19 pandemic and worldwide supply chain disruptions proved that domestic food security is essential. The fiscal structure of Azerbaijan depends heavily on oil and gas revenues, yet agriculture plays a crucial role in achieving economic diversification and supporting rural employment and national food security. The government views sector development as a strategy to achieve sustainable growth with reduced hydrocarbon dependence and better resistance against worldwide economic disturbances.

Figure 1.1.2 % Share of Agricultural sector in GDP, 2000-2024



Source: Stat.gov.az, https://www.stat.gov.az/source/agriculture/az/1.6.xls

During the previous decade, the agriculture sector in Azerbaijan has enjoyed consistent, though at times irregular, growth. During the first years following the country's independence, the sector experienced a drastic contraction due to the destruction of the network of Soviet-era collectives and input enterprises, which resulted in a difficult transition phase. However, from the early years of the previous decade until currently, there has been a gradual escalation of agricultural production due to land reform initiatives, government support strategies, and infrastructure development. In terms of real growth, agriculture has been increasing at about 3 to 4 percent within the previous decade, outstripping the growth rate of the overall population and adding value to the national food basket. As reflected **in Table 1.1.1** above, the Azerbaijan agriculture sector has recorded consistent growth within the previous decade despite being affected by several global shocks. The overall production value of the sector from the years 2015 until the year 2024 has grown from approximately 5.6 billion AZN to almost 13 billion AZN, registering a more than two-fold nominal growth. The growth from the years of 2015 until the end of the years of 2018 can be considered moderate due to the gradual enhancement of productivity levels as a result of accumulated technological advances and continuous government support to the sector's producers. The rather sharp escalation has been registered from the year of 2019 until the end of this decade due to stepped-up government investments in the countryside's infrastructure development and irrigation network enhancement initiatives coupled with sectorial support through relevant supportive government programs targeted at priority sectors of agriculture such as agriculture's grain crops sub-sector, horticultural crops sub-sector, as well as livestock production sub-sector. The comparatively sharp escalation from the levels of about 9.2 billion AZN registered within the previous year until almost the level of 13 billion AZN recorded within the years of 2024 reflects the sector's vitality and relative resilient performance against global shocks.

Table 1.1.1. Gross output of agriculture, actual prices, million manats, 2010-2024

Years	Agricultural enterprises	Plant-growing products	Livestock products	Private owners, family peasant farms and households	Plant-growing products	Livestock products	Total Output
2010	**193**	60	133	**3,685**	1,939	1,746	**3,878**
2011	**236**	82	154	**4,289**	2,258	2,032	**4,525**
2012	**319**	97	222	**4,525**	2,361	2,164	**4,845**
2013	**364**	121	243	**4,881**	2,509	2,372	**5,245**
2014	**405**	112	293	**4,821**	2,338	2,484	**5,226**
2015	**410**	133	278	**5,225**	2,629	2,597	**5,635**
2016	**449**	146	303	**5,183**	2,431	2,752	**5,632**
2017	**645**	239	407	**5,935**	2,781	3,154	**6,580**
2018	**661**	262	399	**6,349**	2,924	3,425	**7,010**
2019	**713**	321	392	**7,124**	3,430	3,693	**7,837**
2020	**835**	438	396	**7,594**	3,590	4,004	**8,429**
2021	**886**	467	419	**8,278**	4,044	4,234	**9,163**
2022	**1,094**	509	585	**9,890**	5,029	4,861	**10,984**
2023	**1,351**	694	657	**10,860**	5,240	5,619	**12,211**
2024	**1,489**	819	670	**11,507**	5,344	6,163	**12,995**

Throughout the years, the sector has been dominated by the contribution of private farms. During the first years of independence, the role of agricultural enterprises had been greater in number, but the role of private farms has grown substantially as land has been transferred from the state to the general public. By the 2000s and the preceding decade, it can be said that the contribution of the private farm sector to the agriculture sector has been above 80% to 90%. This can be attributed to the fact that the agriculture sector of Azerbaijan remains to be composed predominantly of family farms. The ability of the farm sector to remain firmly grounded and adjusted to the existing market situation can be assumed to be far greater than many state/collaborated agricultural enterprises of the pre-liberation period. The distribution of the value of overall growth demonstrates that the value of plant growth production has grown rather than livestock production of the agricultural enterprises of Azerbaijan as of 2024. However, the contrary has occurred in the case of the farm sector. This point makes it rather clear that since the beginning of the previous decade, the enterprises of the sector are increasingly engaged in the development of the plant growth sector of the sector. During the previous years of the previous decade, the development of the agriculture sector can be said to be at a mid-growth level of development at the rate of growth of progressive development through regular modernization of the sector and the gradual growth of their production levels of the sector, though the sector has been at less than its possible levels of development. The current level of development of the sector can be said to be at growth stage through the development of mechanized agriculture development of the sector along with the development of climate-smart agriculture, through the sector through development of value chain development of the agriculture sector of the previous decade at growth through which the sector aims at making contributions of the sector at far greater levels of development levels of the previous decade.

1.2. Overview of state policies aimed at fostering growth in agriculture and attracting investments

One of the main factors behind the recent growth of the agricultural sector in Azerbaijan is the government's overall support and investment incentive scheme. The government recognizes that the modernization of agriculture requires a substantial amount of capital resources in the form of machinery, irrigation systems, processing facilities, and storage facilities. To this end, overall policies supporting the growth of agriculture through both local and foreign direct investments have been developed and are closely linked to the government's national development objectives of economic diversification, improving the welfare of the countryside through improved livelihoods, and improving food security. One of the integral components of this policy package is the provision of supportive fiscal arrangements. Since 2014, the agriculture sector has been granted exemption from various taxes, namely the profit tax, land tax, value-added taxes applied to agricultural products, and property taxes. Although the exemption of taxes from agriculture was initially valid for only a period of ten years, the exemption of taxes remains in effect to date and has created a favorable environment for agricultural production in the country. This policy has significantly reduced the production costs of agriculture due to the exemptions from various taxes and has encouraged many people to join this sector since there are no financial risks involved when investing. As a result, the policy has greatly encouraged the growth of agriculture through the adoption of various modern technologies due to reduced costs of production. The Azerbaijan Minister of Agriculture states: "Agriculture in Azerbaijan is exempt from taxes. This has a huge benefit for investors. This policy has greatly reduced the costs of doing business in agriculture and aims at encouraging the reuse of the first earnings of agriculture to develop the sector through the introduction of various technologies”.

Besides the general exemption from taxes, the government also supports agricultural development through subsidized financial tools and direct support programs targeting both small-scale farm holders and large agricultural business investors. The Agricultural Credit and Development Agency, along with government-associated financial institutions, also makes available the sector of concessionary lending terms and interest rates that are considerably lower than the market average. This will remove the limitations of investment based on capital and enable the sector to adopt modern production methods that were previously beyond its reach.

Besides the above financial instruments, the government also has co-financed schemes to support the financial burden of capital costs. One of the crucial steps employed through a presidential decree involves the allocation of state finances to subsidize the procurement of up to 40 percent of the price of newly purchased agricultural equipment and machinery bought through the AgroService distribution network. This measure helps greatly in keeping the costs of mechanization low and promoting rapid advances of farm technological levels. Hence, it also makes contributions in the transition of agriculture from the traditional and manpower-consuming type to technologically advanced models of production. The different financial and non-financial support arrangements work together to improve the investing capacity at the farm level and contribute to national-level aspirations of increased productivity enhancement, value chain competitiveness enhancement, and the overall transformation of the agricultural sector of Azerbaijan according to the desired structural changes. In this case, when a farm wishes to mechanize through the procurement of equipment such as tractors and harvesters, the government provides financial aid through a form of reimbursement of almost half the expenses involved. In addition to this support and the general aim of encouraging farm productivity through insurances of agricultural production against various natural and man-made risks, the government also partially reimburses the costs of premiums of agricultural production insurances through coverage of the general costs of the insurances involving a contribution of up to 50 percent of the general costs involved. In addition to the provision of subsidies to aid input increases at the farm level through the provision of government finances of up to 70 percent of general costs of fertilizers, pesticides, and bio-humus components through various government subsidies, and also contribution of almost half of the costs involved in the various field activities through the provision of approximately 50 AZN of finances per hectare. The above reduces the costs of production and helps with improved productivity yields through the constant usage of quality production materials.[1]

Apart from financial support, the government has invested heavily in basic infrastructure to improve the environment of agribusiness. Irrigation schemes have been built or improved, hence increasing the irrigated land under agriculture. Advisory support, veterinary care, and wholesale markets are being improved to optimize agricultural production processes. In addition to this, the

[1] https://e-qanun.az/framework/57124

establishment of agro-industrial sites and logistics centers aims to attract private sector investments in the field of processing and storage through incentives such as exemptions from land and basic facility usage fee exemptions. The efforts mentioned above provide exciting investment opportunities in the agricultural sector of Azerbaijan through the backing of a package of government support schemes described below in **Table 1.2.1**.

Table 1.2.1. Key government support for encouraging investment in agriculture

Government Support Measure	Description
Tax exemption	Farmers/producers are exempt from profit tax, VAT, property tax, and land tax
Subsidized Loans	Low-costed loans provided via state agencies (low-interest, long-term) for agricultural projects, including farming and food processing ventures
Machinery Grants	State pays 40% of cost of agricultural machinery/equipment for farmers (through AgroService leasing/sales)
Raw Material Subsidies	Government covers 70% of fertilizer and pesticide costs for farmers; also provides subsidies for certified seed and sapling purchase, and fuel subsidies (50 AZN/ha for fuel)
Insurance Support	Pays 50% of agricultural insurance premiums to promote crop and livestock insurance uptake. Agrarian Insurance Fund helps farmers insure against weather and disease risks.
Preferential Import	Imports of agricultural machinery and irrigation equipment are exempt from customs duty and VAT, making capital imports cheaper. This lowers the cost for investors bringing in modern equipment.
Direct Subsidies for products	Targeted subsidies for certain products: e.g., bonus payments per kg of wheat, cotton, tobacco, or per ton of sugar beet delivered to processors

1.3. Capital Formation

In the agriculture sector, the growth of fixed capital primarily involves the role of capital investment. The financial capital derived from various sources has been invested in specific asset groups, such as machinery and equipment, buildings and structures, productive livestock, as well as the growth of perennial crops. The role of investment can be best described when its impact is considered in relation to the utilization and durability of fixed capital.

As in the case of other industries, the agricultural fixed capital stock depreciates overtime as it is used in the production process. This results in the fixed capital stock eventually reaching the end of its life and being scrapped. Depreciation can thus be described as the value of the fixed capital stock used during a particular period of time. As a result of capital investment over a particular period, the fixed capital stock rises by the difference between total investment and the value of depreciation.

An example of this difference from a statistical point of view would be the usage of the Gross Fixed Capital Formation (GFCF) indicator, which can be found in the national accounts of the post-Soviet states, including Azerbaijan, and the Net Fixed Capital Formation (NFCF), also known as the net capital stock (NCS). The consumption of fixed capital (CFC) signifies the difference between the above two.

Certain fixed assets used in agriculture, like productive livestock, retain their value in actual terms and hence do not require depreciation. In the System of National Accounts, as also in sectoral financial statements, Gross Fixed Capital Formation (GFCF) signifies the overall investment made in fixed assets during a particular period.

In agricultural economics, the value of net capital stock at the end of a period of time approximates the value of fixed assets less the value of depreciation. The System of National Accounts (SNA) formula for the value of net capital stock at time t is:

$$\mathbf{NCS_t = NCS_{t-1} + GFCF_t - CFC_t}$$

Where:

- NCS_t- Net Capital Stock at the end of period t
- NCS_{t-1}- Net Capital Stock at the end of the previous period

- $GFCF_t$- Gross Fixed Capital Formation during period *t*, considering the total value of new fixed capital investments
- CFC_t- Consumption of Fixed Capital (depreciation) during period *t*, reflecting the amount of fixed capital already depreciated

According to the formula, if investments in fixed capital over a year are greater than the depreciation of those assets, there is an increase in net capital stock. This rise can result not just from introducing new fixed assets, but also from replacing or improving assets already in use.

1.3.1. Investment levels within the agricultural sector

Examination of whether the flows of investment meet the basic development needs of various sectors of the economy, including agriculture, acquires significance. As a result, the evaluation of financial resources invested in agriculture becomes especially important. The said allocations can be estimated through relative indicators, which include the agricultural investment coefficient and the coefficient of investment allocation to agriculture.

The agricultural investment coefficient expresses the level of fixed investment within the agricultural sector over a particular period, usually a fiscal year, compared to the value added through agriculture during the same period. The agricultural investment coefficient can be calculated using the following formula:

AIC=Gross Fixed Capital Formation in Agriculture / Agricultural Value Added

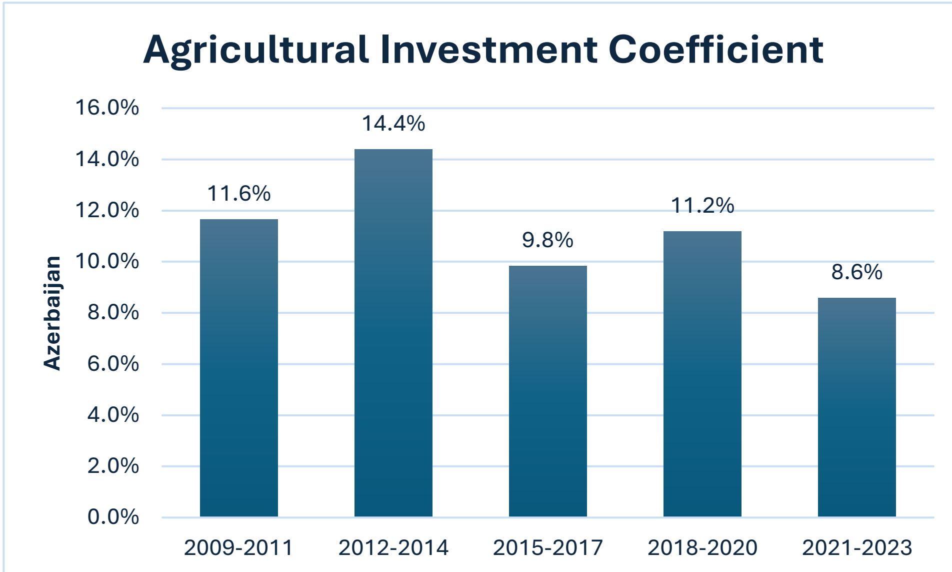
Where:

- **$GFCF_{agri}$** – total value of fixed capital investments invested in the agricultural sector during the period.
- **VA_{agri}** – value added generated by agriculture over the same period.

The agricultural investment coefficient indicates the percentage of the value of fixed capital allocated to agriculture in relation to the sector's value added. To gain a better insight into the funding of the sector, the investment allocation index is also used. This index calculates the ratio of agricultural investment to the total national investment in relation to the agricultural sector's percentage of Gross Domestic Product (GDP). This index also reveals how well the capital allocated to the agricultural sector relates to its significance in the economy. When the index is lower than one, it means that the agricultural sector receives less funding compared to its contribution towards the GDP. However, the index exceeds one if the agricultural sector gets more investment in relation to its contribution towards the national output.

Nevertheless, in recent years, fixed capital investment in the agricultural sector in Azerbaijan has been quite volatile. Over the period from 2005 to 2013, the agricultural investment coefficient was on the whole rising annually, signifying rising capital inflows during the period of economic growth. However, during periods of instability in the economy's macro-parameters, the coefficient fluctuated, producing a dramatic decline subsequently. Also, the agricultural sector showed some improvement in the period from 2017 through 2019. But the improvement was halted by the outbreak of the global coronavirus pandemic, causing capital accumulation in various industry sectors to decelerate. Generally, in the long term, agricultural investment volatility is closely related to the condition of the economy. Also, during periods of stability in Azerbaijan’s oil output prices in the international market, more capital is allocated to agricultural projects by the government. However, instability in the market produces negative outcomes in capital accumulation. Moreover, the agricultural system in Azerbaijan is structurally different in terms of land fragmentation for agricultural production on the one hand and the absence of collateral in capital accumulation on the other. Generally, **Figure 1.3.1** indicates that the agricultural sector faces the challenge of the stability needed for sustained capital accumulation in order to increase productivity.

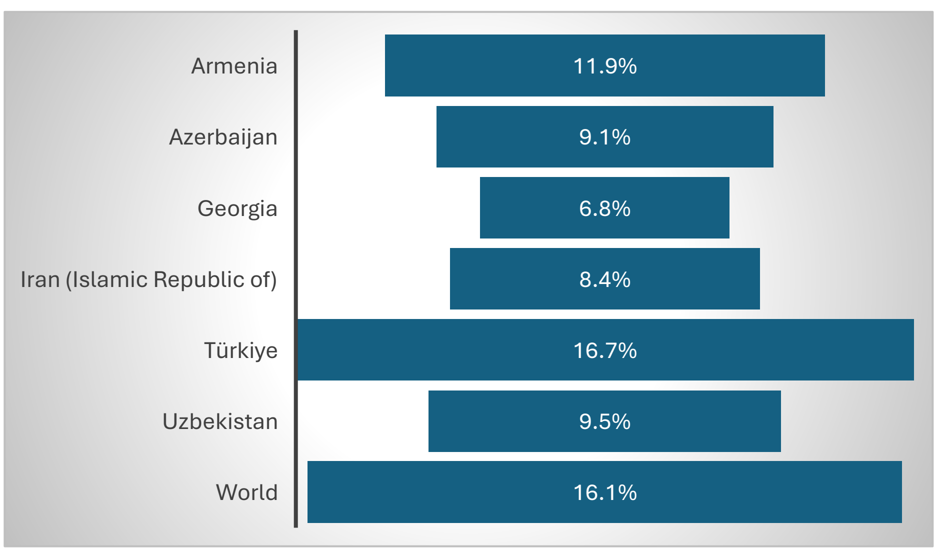
Figure 1.3.1. Agricultural Investment Coefficient in Azerbaijan, 2009-2023



Source: FAO, *https://www.fao.org/faostat/en/#data/CISP*

Overall, As can be seen from **Figure 1.3.2** under current circumstances, Azerbaijan's agricultural investment ratio remains much lower than that of most regional countries and is also below the global average.

Figure 1.3.2. Average Agricultural Investment Coefficient, 2019-2023



Source: FAO, *https://www.fao.org/faostat/en/#data/CISP*

The graph compares the contribution of agricultural GDP in various countries in the region. Azerbaijan's agricultural GDP contribution rate is 9.1%, classifying it in the middle group among the compared countries. This rate is higher than Georgia's (6.8%), implying that the agricultural sector in Azerbaijan is of higher importance in the economy. However, Azerbaijan's rate is lower than Armenia's (11.9%), Uzbekistan's (9.5%), and particularly in the case of Turkey (16.7%), all of which value their agricultural sector contributions higher. Azerbaijan's agricultural GDP contribution rate is relatively low compared to the global average of 16.1%. This suggests that, despite its importance, Azerbaijan's agricultural sector is not as crucial to the country's economy as it is in many fewer wealthy nations. However, Azerbaijan's rate is higher than some of the region's transition countries' agricultural GDP contribution rates. This demonstrates the agricultural sector's ongoing significance to rural communities' food production.

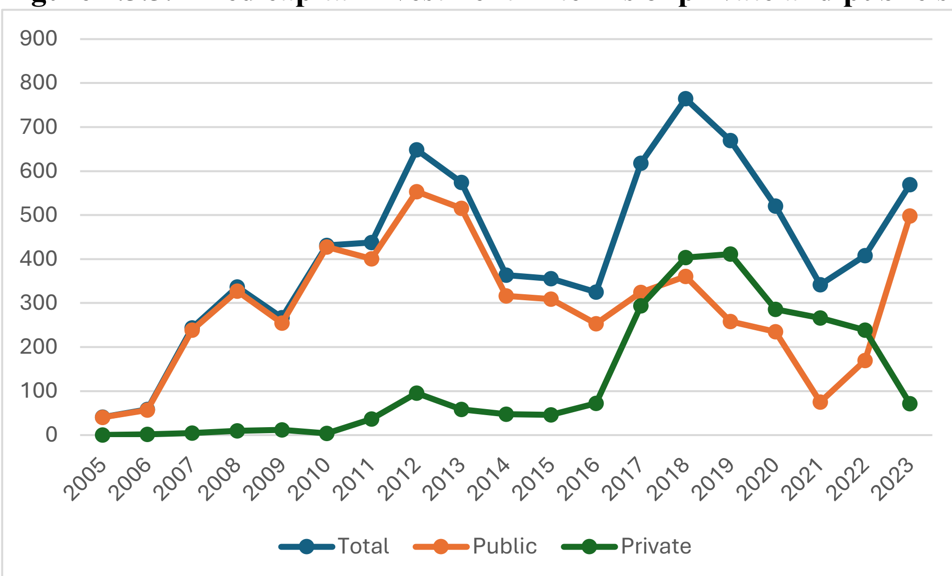
In summary, the country's agricultural sector occupies a central position in the nation's economic hierarchy. It significantly contributes to the well-being of the rural inhabitants. However, it does not significantly contribute to the GDP at the same levels as in agricultural-dependent countries.

1.3.2. Trends in fixed capital investment in terms of private and public sector.

After the advent of major land reforms in Azerbaijan, agricultural investments began to grow in the late 1990s and the early 2000s. These investments led to the reorganization of agricultural production. Additionally, the period was marked by the entry of new landowners. However, the level of investment remained low. Both the government and the new agricultural farmers faced financial constraints. Hence, the rate of capital during the period was modest. This indicated that the ability to improve the agricultural sector was still hindered by the lack of adequate financial resources.

Figure 1.3.3 showing the capital investments in the agricultural sector in Azerbaijan from 2005 to 2023 clearly indicates the fluctuating pattern of investments due to various reasons such as variations in government spending, investments from the private sector, among others. Initially, the increase in the total amount of investment was very significant in the mid-2000s, closely tracking the increase in the government's spending on the agricultural sector. This explains the dominance of the government in agricultural capital accumulation. However, the government spending was very high from 2007 to 2012. At the peak in 2012-2013, the spending declined sharply due to adjustments in spending according to the government's policies. At the initial stage, the spending by the private sector was very low. However, from 2016 onward, the spending began to increase significantly from 2017 to 2019. However, the spending in the private sector fluctuated. At the peak in 2012-2013 and 2017-2019, the spending in the agricultural sector was very significant. However, the spending in 2020-2021 was low due to the various uncertainties related to the outbreak of the coronavirus. However, from 2023, the government spending was very high. Hence, the recovery in the agricultural capital accumulation was very significant. Thus, the graph clearly indicates that the agricultural capital accumulation in Azerbaijan is mainly financed by the government. However, the spending by the private sector was still in the developmental stage. Additionally, the spending in the agricultural sector was very volatile.

Figure 1.3.3. Fixed capital investment in terms of private and public sector, 2005-2023



Source: Compiled based on data from the Statistics Committee

1.3.3. New Opportunities in Karabakh: Grain Production Potential and Investments

The regions of Karabakh and East Zangazur also represent some of the most promising regions for agricultural development in Azerbaijan. This is particularly true in the wake of the recent reclamation efforts initiated in 2020. Both regions provide access to abundant agricultural land that was left undeveloped for nearly thirty years. Grain production in the region of Karabakh also presents an outstanding opportunity. This is especially true given the region's favorable environment and the significant support from the government. There are many reasons why grains can grow very effectively in the reclaimed regions:

- **Optimal Soil and Climate Conditions**: Regions such as the Aghdam-Fuzuli plain in the Karabakh region contain wide plains. These regions are marked by the availability of very fertile 'chernozem' (black) soils ideal to produce grains. Geographically speaking, the region's moderate climate, along with sufficient levels of winter and spring rainfall, favors the plantation of winter wheat and spring barley. Large periods of land being left fallow might have contributed to the conservation of the land and its fertility. However, issues related to the clearing of mines and the restoration of the land are being faced. Recent assessments suggest the potential for high produce if advanced methods are adopted.
- **Hydrological Assets and Irrigation Capacity**: The occupied lands also have adequate water resources in the form of the Khachinchay & Sugovushan reservoirs, in addition to the Hakari and Araz rivers. However, during the period of occupation, the major part of the irrigation system was neglected. Azerbaijan is now working on rehabilitating the system. Reasserting government control over prominent reservoirs in the region of Karabakh would make it feasible to water vast agricultural lands. This would make it possible to modernize the irrigation system in the region by implementing advanced irrigation methods like sprinkler and drip irrigation systems. These improved methods could prove very useful in boosting corn and spring harvests.
- **Government Incentives and Infrastructure**: The government of Azerbaijan encourages agricultural investments in the region of Karabakh by implementing various government measures. Investment in the reclaimed regions is rewarded by the government through various attractive incentives. To illustrate, business entities that establish operations in the industrial-agricultural zones in the region of Karabakh benefit from exemption from profits

tax, property tax, as well as land tax for ten years from the registration approval. Additionally, business entities in the industrial-agricultural zones in the region of Karabakh also enjoy exemption from the payment of customs payments on imported equipment. Finally, business entities in the industrial-agricultural zones in the region of Karabakh also enjoy the opportunity to gain access to business loans on reduced rates. Additionally, significant funding by the government is directed towards the renovation of infrastructure, such as the reconstruction of road networks, energy, as well as irrigation systems. Furthermore, in the region of Aghdam, an Agro-Industrial Park is being developed. Additionally, the government provides all the free infrastructure services for the beneficiaries of the Agro-Industrial Park.

- **Untapped Land and Mechanization:** About 100,000 hectares of agricultural land in Karabakh and the surrounding liberated regions are suited for growing grains. Much of the land in the region is flat to mildly rolling, allowing for the use of agricultural machines like farm tractors and combine harvesters. Azerbaijan is in the process of conducting a land cadastre in the region. This helps in the efficient utilization of land plots. One of the reasons for the choice of the region for the setting up of agro-parks for grains could be the extent of land available in the region. Such projects are usually joint ventures by the government. Currently operating in the region is the agro-park named Dost. There are also agro-parks being constructed in the region.

The main aim of the research work is to assess the viability of investment in the grains sector, including the production of wheat, barley, and maize, in the newly recovered regions of Azerbaijan. This research explores the business viability of grains production in Karabakh. It assesses the costs involved in the production of grains in terms of land preparation costs, agricultural inputs, farm equipment costs, as well as the costs of farm manpower. These comparisons are made against the expected grains production levels in terms of yield rates per season. Additionally, it samples the effect the government stimulus package would play in terms of the contribution made in increasing the profitability of the whole production process. The reason behind the conduct of the research is anchored on the combination of many different parameters. These parameters relate to the ample usage of the land for the production process due to its fertility. Additionally, the research suggests the interventions made by the government in terms of support to the production process. Other parameters related to productivity levels in the agricultural field in terms of the production levels for grains.

By quantitative analysis, the research intends to assess if the grains industry in Karabakh attracts enough capital on its own without government subsidies in the future or if any sort of government support is going to be needed. Despite its future contributions in terms of jobs for the settled population, reduced usage of imported wheat in the market, and enhancement in food security in the region, the analysis intends to explicitly determine financial feasibility. Private capital on a large scale will flow in if the rate of return measures the anticipated risks. This analysis also uses local data on production statistics from sources like the Agrarian Research Center and the Food and Agriculture Organization. Initial analysis suggests good future outcomes. Domestic prices for wheat in Azerbaijan also experienced an increase during the previous years, like other international countries. Expected future improvements in the production yield in the region of Karabakh, because of the land never having been worked before along with better sources of irrigation, are expected to decrease the unit cost of production per unit. Further enhancement in the rate of profitability for the capital in the region of Karabakh, because of the government's relaxation in taxes for at least the next decade, acts like an added benefit.

To conclude, in the context of the discussion on the importance of international farm production on the one hand and the Azerbaijan context on the other, the current demand in the market for agricultural investments presents the opportunity within the Grain industry in the region of Karabakh. Moving forward, the proposed research wishes to explore the use of case studies in the determination of the profitability of the production of grains in the liberated land. Such research will provide clarity on the pivotal success factors in the process of the production of grains in the region of Karabakh. At the same time, it would validate the utilization of more resources in the Grain industry in the region of Karabakh.

CHAPTER II: EVALUATING INVESTMENT OPPORTUNITIES IN AGRICULTURAL PROJECTS

2.1. Overview

In the current chapter, a comprehensive analysis of the cost structure, revenues, subsidy schemes, and all other technical and economic parameters, which are of relevance for the feasibility of operating a large-scale grain farming venture using irrigation technology on a 2,500-hectare scale, will be carried out within the Karabakh region, specifically the territories of the Agdam districts. This analysis will form the basis for the evaluation of the economic feasibility of irrigation agriculture on a regional level. Financial and productivity calculations focus on the following six major crops: wheat, barley, and late-season corn grown as a second season crop following the harvest of wheat and barley, alfalfa, sugar beet, and soybean. Even if the choice of the various crop species is eventually driven by the respective choices of the concerned farming operators, the choice of the species for the purposes of the current thesis argumentation is of relevance. It is appropriately explained below: Wheat and barley form the primary base of the Azerbaijan feed-based nutrition system, acting as major raw material inputs for the flour and feed sectors. Corn, within the initial and tail phases of growth, provides feed for large-scale livestock feeding schemes, opening opportunities for farmers to undertake rotations that ensure efficient use of land. Alfalfa is a high-value forage crop that offers great potential for improving the nutritional status of the soil through the fixation of nitrogen. Sugar beet is considered for its significance within the sugar industry. Soybean, a new player in the Azerbaijan agriculture sector, provides opportunities for the development of protein-based feed, contributing to rotations that ensure soil sustainability.

Through the lens of these crops and the new irrigation systems, the objective of this chapter is to demonstrate the ways that technology improvements, like pivot irrigation systems, drip irrigation, and efficient water management, can transform productivity, efficiency of use, and the economic viability of large-scale farming entities in Karabakh. It will also highlight the ways that the instruments of government support, like subsidies, easy credit, and investment incentives, affect economic decision-making for the potential investor. This chapter, in its entirety, provides the methodological and economic basis for the evaluation of the feasibility and return on invested funds for the growing of irrigated crops on newly renovated areas for agriculture in Azerbaijan.

2.2. Financial evaluation of the costs and returns associated with establishing a grain farm.

2.2.1. Yield of crops

The productivity of crops planted in the selected Agdam area will vary depending on many different factors. The main data and nuances that will be used in productivity calculations will be the fertility of the soil cover, whether the planted crop is suitable for the soil structure, and the productivity data provided by the Statistics Committee.

Wheat and Barley.

As seen from **Table 2.2.1**, the average wheat productivity per hectare for Azerbaijan for the time 2015-2024 ranges around 30-33 centners per hectare, equivalent to 3.0-3.3 t/ha. In contrast, the average productivity for the Aghdam region was a slight improvement, increasing productivity from 32.4 centners per hectare to 41.6 centners per hectare. This suggests that the wheat productivity level for the Aghdam region has surpassed the average for the entire nation by around 6-8 centners per hectare. Variability of productivity over the last ten years is consistent with weather patterns, for example, the average wheat productivity for 2018 declined sharply by around 30.0 centners per hectare because of the drought, which was temporarily offset by a 7.6% increase for the year 2019, when the rainfall patterns picked up.

Climate Factors that Influence Yields. Precipitation is a decisive factor for wheat yield, given the semi-arid climate of Azerbaijan. Wheat is widely grown on rain-fed fields, and drought is the main limiting factor for wheat growth. This affects about one-third of the total wheat area in the country, thus resulting in reduced wheat yields. However, well-irrigated wheat areas during years of sufficient precipitation increase productivity. Studies show that there is a direct correlation between water supply and wheat yield[2]. This is estimated at about 10 kg of grain per 1 mm of water, regardless of whether it is rain or irrigation. This is supported by regional data, which shows that the national wheat yield dropped to around 29-30 centners per hectare during the drought of the 2017-2018 growing season, but it returned to above 32 centners per hectare when precipitation improved the following year. Temperature is the other variable used in the regression analysis[2]. Hot weather, especially when it occurs during the growing season, is known

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[1] https://icarda.org/media/blog/wheat-self-sufficiency-requires-sustainably-closing-yield-gap-cwana#:~:text=Our%20data%20%28Fig,water%20availability%20and%20productivity%20gains

to accelerate drought effects, thus lowering crop productivity. In this case, for instance, the summer of 2017 was recorded to be very hot, with the average June-August temperature of 26.6 °C, which is 1.9 °C higher than the average. It is presumed that this condition, therefore, accelerated drought effects on the growing plants. It is also worth noting that lower growing season temperatures or sufficient moisture that compensates for the presence of high temperatures are the keys to higher productivity. It is also found that the regression analysis between the climate and yields reveals that higher rainfall and lower growing season temperatures (averaged around 14-15 °C), which is the average, result in higher productivity, while drought that is accompanied by heatwaves results in lower productivity.

Impact of Modern Irrigation on Yield. The implementation of a modern irrigation system for 2,500 ha of land in the village of Aghdam will positively affect the wheat yield. In that village, the wheat harvest used to come only from rainfed agriculture, also known as "dəmyə əkinçiliyi." By using irrigation, it will make it possible to provide water when it is needed the most. According to the World Bank, the average increase of wheat yield for Azerbaijan farmers that used improved on-farm irrigation systems exceeded 20% [3]. For wheat farming within the Kura-Araz Lowland, where the village of Aghdam lies, the average rainfall is approximated at 406 mm, with irrigation contributing to about 84 mm. Increased irrigation will provide the necessary water for the plant, especially during droughts, when it used not to. This is because the total water requirement for the plant is about 500-600 mm, and this requirement will have been satisfied. Practically, irrigation will help offset reduced yields for irrigation areas that receive lower rainfall annually. Studies among regions of similar climates have shown that the increment of irrigation water by 100 mm will increase wheat yields by about 1 t/ha when other optimal circumstances are provided. Even supplemental irrigation of 28-166 mm after the dry season was shown to raise wheat yields by 2-3 t/ha when timely planting and variety selection are made. Consequently, it is expected that a large increment of wheat yields will result if the initial 2,500 ha irrigation materializes. Nevertheless, it should not be overlooked that soil fertility might become the next limiting progress. The soil of the irrigation area was made better only by the return of the residues (straw) of the previous harvests with only minimal fertilizer use. However, soil fertility will not play the decisive role when water is plentiful. The use of water will then depend on the

[3] https://www.worldbank.org/en/results/2019/10/10/azerbaijan-managing-irrigation-systems-through-water-user-associations#:~:text=Jabbar%20Asadov%20is%20a%20farmer,a%20result%20of%20the%20improvements

availability of several nutrients (nitrogen, phosphorus, among others) for the full use of the potential of irrigation for yielding. However, irrigation, even without optimizing fertilizer use, will help bring the average wheat irrigation areas of Aghdam closer to their biological optimum. To give a perspective, new wheat varieties were introduced in Azerbaijan, and they attained as high as 55 centners per hectare or 5.5 t/ha when provided optimal cultivation. This veritably suggests that if irrigation will take on new irrigation systems, it is also possible that average wheat irrigation areas will break the barrier of 50 centners per hectare of average annual actual yields up through new irrigation systems. In other words, irrigation areas will offset the bad effects of lower rainfall. Of note, other inputs will also become important. Overall, other inputs that make wheat reaches optimal growth will also become important.

Smart Sowing and Precision Fertilization Technologies. Irrigation, along with other related activities, such as optimal planting and fertilizer application, also significantly contribute to increased productivity. Under the umbrella of precision agriculture, it has been shown that optimal practices are carried out on a per square meter basis using global positioning systems, sensors, Variable Rate Fertilizer Application (VRT), and other information technology. According to worldwide assessments, the implementation of such technology has a distinct role in increasing productivity. To give a perspective, it has been determined that precision farming techniques are able to increase overall productivity by as much as 30%, in addition to decreasing water use by 20% and fertilizer use by 15%, as per a 2021 evaluation by Food and Agriculture Organization (FAO), [4]which means that smart technologies are able to increase yields by as much as a third from a similar area. The application of innovations in planting and fertilizing has also been shown with concrete examples. A meta-analysis conducted by Chinese scholars, involving 79 studies, revealed that adopting wide-row precision planting technology resulted in a 9.9% increase in yields of winter wheat over conventional planting. This is due to optimized factors like soil preparation, planting depth, and row spacing, because of which around 10% more wheat can be produced per hectare. Furthermore, experience in advanced nations has shown that adopting precise fertilizing and spray technology ensures that no excess as well as deficient fertilizer reaches the plant, hence not only using fertilizer effectively but also increasing yields. Adopting smart fertilizing technology, for

[4] https://www.coherentmarketinsights.com/industry-reports/precision-farming-market#:~:text=As%20the%20world%27s%20population%20continues,%28FAO%2C%202021

example, has been revealed to increase yields by 20% with simultaneous reductions in water and fertilizer use of around 40%.

Impact on Forecasts and Expected Growth Rates. From the above empirical facts, it can be argued that the adoption and implementation of modern pivot irrigation and precision sowing and fertilizing methods have great potential for improving productivity above what would be achieved by conventional methods. To operate within this perspective, a linear regression model based on historical productivity measures, as measured within traditional approaches, can be adapted and shifted upwards based on the adoption and implementation of modern technologies to achieve precision. Based on percentages shown within global experiences, it would be feasible to assume that modern irrigation technologies and related ‘smart’ agrotechnical solutions greatly improve output forecasts. According to international statistics, pivot irrigation systems, which optimize water feeding for plants, save water and improve outputs up to twice as much as before at once. At the same time, based on exact sowing and fertilizing solutions, it becomes possible to increase production by 20-30% within delimited production territories. Assuming that our forthcoming linear regression model will define a basic scenario based on traditional knowledge, this new reality requires an upgrade on the projection course provided by our model. First, there will be an adjustment on forecast indicators representing an average 25% boosted contribution of modern technologies, based on international scientific and practical facts. It becomes evident that modern irrigation and agrotechnical solutions will enable significantly higher outputs within forthcoming years compared to today’s production rates.

Calculation Method. Calculations will start with making forecasting for next 10 years based on data from previous 25 years. There are 3 methods to make forecasting: *linear regression, ETS, and ARIMA*. The calculations were made using the ETS method. The main reasons for this are listed below:

ETS Model (Error, Trend, Seasonal) - The ETS model represents a class of exponential smoothing methods. Error, Trend, and Seasonality are components. The ETS model, which describes a method for representing and decomposing a univariate or multivariate stream of data into three components: error, trend, and seasonality, is widely recognized as an interpretable and flexible model. It was formalized by Hyndman et al. in 2008. The ETS model represents time series observations Y_t using the following decomposition:

$$Y_t = l_{t-1} + b_{t-1} + s_{t-m} + \varepsilon_t$$

Where:

l_{t-1} **:** Level component

b_{t-1}**:** Trend component

s_{t-m}**:** Seasonal component (If applicable)

ε_t**:** Error term at time *t*

m: Seasonality length

Each component (E, T, S) can be specified as:

- Additive (A): constant magnitude over time,

- Multiplicative (M): Varies proportionally with level,

- None (N): The component is not included.

As a result, there are various ETS model combinations supported by ETS, including ETS(A, A, N), ETS (M, A, N), and ETS (A, M, A).

Advantages of ETS Modeling:

- Flexibility: ETS models fit datasets with or without trend and seasonality and allow a maximum of 30 different model types.

- Recency Weighted Smoothing: Exponential smoothing gives more importance to recent values and thus increases sensitivity to recent changes in the data.

- Effective performance with limited data: ETS performs effectively even with limited data, especially when trend effects are more prominent compared to cyclical components.

- Interpretability and transparency: Unlike some models based on machine learning algorithms, ETS components are interpretable and help explain the underlying dynamics.

Applications in Agricultural Yield Forecasting. Agricultural ETS models are commonly used in agriculture forecasting involving annual or seasonal series with trend or small cyclic components.

Examples of crop production datasets, such as wheat or barley production per year, will have trend components due to improvements in farming methods and changes in weather; ETS models can handle these (Makridakis et al., 2020). Within arid and semi-arid regions, such

as Azerbaijan, ETS models will be capable of accounting for the increases due to infrastructural developments like irrigation and better crop seeds. The Python code used for the calculation is as shown in **Figure 2.2.1**.

Table 2.2.1. Actual average wheat and barley yield in Azerbaijan and Agdam, t/ha, 2015-2024

	Wheat			Barley		
Years	Azerbaijan Republic	Agdam Region	Difference %	Azerbaijan Republic	Agdam Region	Difference %
2015	3.15	3.19	2%	2.95	2.98	1%
2016	3.06	3.27	4%	2.69	3.0	12%
2017	2.98	3.87	27%	2.56	3.18	24%
2018	3	3.76	25%	2.79	3.44	23%
2019	3.21	3.9	20%	2.97	3.55	20%
2020	3.18	4.07	28%	2.96	3.64	23%
2021	3.28	4.09	24%	3.07	3.67	20%
2022	3.13	4.11	29%	2.88	3.75	30%
2023	3.3	4.19	24%	2.99	3.9	30%
2024	3.1	4.23	37%	2.93	3.84	31%

Source: Stat.gov.az, https://www.stat.gov.az/source/agriculture/az/2.187.xls

Figure 2.2.1. Python ETS Forecast Calculation (Additive Trend, No Seasonality)

```
from statsmodels.tsa.holtwinters import ExponentialSmoothing

# Step 1: Take historical yield
yield_series = agdam_df["Yield_t_ha"]

# Step 2: Build ETS Model  — additive trend, no seasonality
ets_model = ExponentialSmoothing(yield_series, trend="add", seasonal=None)
ets_fit = ets_model.fit()

# Step 3: Figure out forecast period
forecast_values = ets_fit.forecast(10)  # Forecast for 10 years

# Step 4: Convert results to DataFrame format
forecast_years = list(range(2025, 2035))
forecast_df = pd.DataFrame({
    "Year": forecast_years,
    "Forecast_Yield_t_ha": forecast_values
})
```

Adjusting the obtained productivity results with the effects of modern irrigation technologies and "smart" sowing and fertilization technologies on productivity, the results obtained are reflected in **Table 4**:

Table 2.2.2. Average forecasted wheat yield in Agdam, t/ha, 2025-2026

	Wheat		**Barley**	
Years	**Forecast_Yield_t/ha**	**Adjusted Yield, t/ha**	**Forecast_Yield_t/ha**	**Adjusted Yield, t/ha**
2025	4.38	5.48	3.76	4.70
2026	4.49	5.61	3.81	4.77
2027	4.59	5.74	3.86	4.83
2028	4.69	5.86	3.91	4.89
2029	4.79	5.99	3.96	4.95
2030	4.9	6.12	4.01	5.01
2031	5	6.25	4.06	5.07
2032	5.1	6.37	4.11	5.13
2033	5.2	6.5	4.16	5.19
2034	5.3	6.63	4.20	5.26
2035	5.4	6.75	4.25	5.32

Assumptions. The projections are made based on average climatic conditions every year (no worse-than-worst drought or heatwave on top of existing variability, since irrigation will mitigate the effects of rainfall shortfalls). They also consider improvements in agriculture technology in the irrigated areas, perhaps additional fertilizer uses or better seeds, in the order of improvements that can reasonably be expected within the next ten years. Such improvements will not come about by technological revolution but will result from the better climate. Yields could level off around 48-50 c/ha (since growth cannot exceed nutrient-supplied growth rates, even when irrigation is provided). However, using high-yielding varieties along with judicious fertilizer use, the results could go beyond the estimates, since studies show that it is possible to get 6.5-7.0 tons per hectare.

Comparison with real "Pivot" data. In this part, a comparative analysis will be presented in relation to empirically observed production figures, which have been derived from the author's personal working experience, in addition to the wider production trends based on regional and national levels in Azerbaijan. In recent years, pilot projects with a focus on 'pivot irrigation systems and improved fertilization methods have been initiated in the Samukh and Tovuz regions. Such local projects have recorded higher production trends compared to regional and national production levels. **As presented in Table 5**, in Samukh district, wheat production in Pivot irrigations since 2017 has an average production level of 4.31 t/ha during 2017-2023, which is higher than the regional average of 3.71 t/ha by 15%. In Samukh, based on the national average, wheat production in pivot irrigations is higher by 35%. Furthermore, in the Tovuz district, wheat production via pivot irrigation is higher than regional and national averages by 19% and 39%, respectively. Thus, barley plantings were also carried out in both regions using the pivot irrigation method during 2019-2023, and the results exceeded the regional averages by 58% and the national average by 86%, which is an example of how pivot irrigation and proper fertilization and technical maintenance increase productivity. Moreover, Table 2.2.3 above highlights interesting dynamics in barley production in Samukh in the early years of research. A reduction in production occurred from 2019 to 2021. However, based on professional research observations by the researcher, this situation reversed in 2022 with an enhanced approach in carrying out technical maintenance and fertilization work. Therefore, a nearly two-fold increase in production occurred. From a research perspective, a more conservative approach has been taken in adjusting these real data for productivity results. As an alternative to real increases, a 25% increase in the results of previous periods has been considered, although in Samukh district, for example, over a 7-year period, the productivity indicator at the end of the period showed a 46% increase compared to the beginning.

Table 2.2.3. Comparison of actual barley and wheat yield results with averages, 2017-2023

Years	Region	Crop	Harvested area, ha	Actual quantity,T	Actual yield,T	Average yield in region,	Average yield in Azerbaijan,	% in region	% in Azerbaijan
2017	Samukh	Wheat	2,696	7,549	2.80	2.62	3.05	7%	-8%
2018	Samukh	Wheat	2,614	11,765	4.50	3.53	3.01	28%	50%
2019	Samukh	Wheat	2,275	6,839	3.01	3.26	3.24	-8%	-7%
2020	Samukh	Wheat	2,423	12,638	5.22	4.32	3.17	21%	65%
2021	Samukh	Wheat	2,089	9,011	4.31	3.8	3.29	14%	31%
2022	Samukh	Wheat	2,416	12,268	5.08	4.23	3.19	20%	59%
2023	Samukh	Wheat	2,015	10,590	5.26	4.23	3.38	24%	55%
2019	Samukh	Barley	148	720	4.86	3.46	2.97	41%	64%
2020	Samukh	Barley	221	1,054	4.77	3.6	2.96	32%	61%
2021	Samukh	Barley	222	1,044	4.71	3.67	3.07	28%	53%

2022	Samukh	Barley	222	1,673	7.55	3.72	2.88	103%	162%
2023	Samukh	Barley	495	1,947	3.93	3.61	2.99	9%	32%
2017	Tovuz	Wheat	6,938	13,183	1.90	3.23	3.05	-41%	-38%
2018	Tovuz	Wheat	4,180	18,808	4.50	3.24	3.01	39%	50%
2019	Tovuz	Wheat	4,799	17,755	3.70	3.3	3.24	12%	14%
2020	Tovuz	Wheat	4,705	25,900	5.50	3.83	3.17	44%	74%
2021	Tovuz	Wheat	4,522	23,656	5.23	3.71	3.29	41%	59%
2022	Tovuz	Wheat	5,177	26,759	5.17	4.37	3.19	18%	62%
2023	Tovuz	Wheat	5,215	26,883	5.16	4.19	3.38	23%	53%
2019	Tovuz	Barley	377	1,715	4.55	2.73	2.97	67%	53%
2020	Tovuz	Barley	409	2,523	6.18	3.95	2.96	56%	109%
2021	Tovuz	Barley	466	2,908	6.24	3.79	3.07	65%	103%
2022	Tovuz	Barley	613	4,018	6.55	3.8	2.88	72%	128%
2023	Tovuz	Barley	540	3,235	5.99	2.93	2.99	104%	100%

Late Corn. It is planned to plant corn as a second crop to wheat and barley fields. This decision has both agronomic and economic aspects. So, Corn is an important grain and forage crop. This plant has a wide range of applications and high productivity. Canned products such as flour, starch, grits, ethyl alcohol, oil, and others are obtained from corn kernels. Paper, linoleum, activated carbon, synthetic resin, and other products can be obtained from the stalks, leaves, and petioles. The high content of feed units and digestible protein in corn kernels allows its use as valuable forage, and transplanting is considered an important method for increasing forage production. At present, in global agriculture, all kinds of resources and the implementation of cost-effective technologies are allocated to this purpose. The key elements of these technologies include minimal and zero-tillage techniques, also known as No-Till. Considering the fact that a strong root system is formed in a corn plant, during re-sowing, the field must be covered immediately after harvest to a depth of 8-12 cm, and organic and mineral fertilizers must be applied to the field at a rate determined in accordance with the results of soil analysis and tilled to a depth of 25-28 cm. The top layer of the soil must be loosened with a trowel or rotor tines. This will make the soil soft, granular, even, remove weeds, and will provide an even depth of seed burial. The application of soil herbicides for weeds must be applied and mixed in the fields 2-3 days before sowing. Cultivation, thinning, and re-filling operations must be performed 2-3 times during re-sowing of the corn. The first cultivation operation among the rows must be performed at a depth of 8-10 cm, the second operation at a depth of 6-8 cm, and the third operation at a depth of 5-6 cm.

Calculation Method. Because of the constrained nature of available government statistics with respect to late corn (as a second crop) yield in the Agricultural Statistics of Azerbaijan, this research work utilizes_solely on the expertise of the researcher in their professional field to predict future production in the next decade. As shown **in Table 2.2.4** below, variability in the level of production of late corn in terms of yield shows a level of variability, but with no major fluctuation. The average production level over this period is therefore approximately 4.05 t/ha. Hence, taking into consideration these elements in projecting future production levels, a good estimate in this research work to project production level in the first year of forecasting, namely 2025, will be 3.5 t/ha, which is a level taking into consideration the lower bound of early-year production levels in empirical research work. With a linear regression mathematical model established using a Python programming tool, future production levels in this next 10-year period have a projected potential capacity ranging from 3.5 to 4.66 t/ha.

Table 2.2.4. Actual yields of late corn in Samukh and Tovuz, 2017-2022

Years	Region	Area Harvested, Ha	Actual Quantity, T	Yield, T/Ha
2017	Samux	1,766	5,298	3.00
2018	Samux	2,663	12,915	4.85
2019	Samux	2,033	7,500	3.69
2020	Samux	2,311	10,537	4.60
2021	Samux	2,069	4,671	2.26
2022	Samux	1,680	6,867	4.09
2017	Tovuz	2,946	11,107	3.77
2018	Tovuz	2,713	10,715	3.95
2019	Tovuz	2,033	7,500	3.69

2020	Tovuz	5,260	28,943	5.50
2021	Tovuz	4,208	21,021	5.00
2022	Tovuz	3,405	14,267	4.19

Other Crops. These 3 crops are considered as the main crop area and the main calculations were made on these crops. The other 3 crops are planned to be planted more for crop rotation and enrichment of the soil cover with a fertile humus layer obtained from plant residues. Thus, sugar beet, soybean and alfalfa are high-protein crops, when the plant residues remaining after harvesting are mixed with the soil during the tillage stage, the minerals collected in the residues will be mixed with the soil and ultimately form a more productive and fertile soil layer for the main crops in the next plantings. A standard agronomic approach has been put forward for the yield forecasts of these crops. Thus, the yield results obtained with traditional technical maintenance rules will be taken into account for the next 10-year period with a stable and slightly positive increase in all years. Planting these crops in small plots will minimize the risks of yield loss that may arise from them. The results are also strengthened and justified by the author's professional experience and outputs obtained as a result of agronomic consultations.

2.2.2. Standards for Grain Losses in Wheat, Barley, and Maize

Losses of cereal crops during post-harvest phases have occurred at different levels, such as in the field or pre-harvest stage, during harvest (mechanical harvest losses), storage losses, and transport losses. Such losses have direct effects on actual production and hence are very important in cereal production and management. Globally, standards and guidelines in the form of ISO standards and/or standards known as GOST, which represent Eurasian and Former Soviet Union standards, have established a level of provision and guidelines on how such losses can be reduced. In the subsequent sections, we shall highlight loss levels in wheat, barley, and maize (the second crop) during different stages, how ISO/GOST standards have established such losses, and guidelines by these standards to reduce losses.

ISO standards focus on agricultural machinery performance standards and food quality standards, but they do not address "loss percentage" in a universally accepted manner. ISO standards do provide methods for measuring losses, including performance requirements, but they do so in a particular manner. ISO standards encompass ISO 6689 (Harvesting equipment – Combine Harvesters) and other standards that assess tests in which combine harvesters are tested based on a relevant level of losses. In general, a machine's processing capacity is tested based on an allowable level of fixed losses, such as an allowable level of 1.5% grain loss at a separator or threshing mechanism. ISO standards stipulate that: "combine performance will not exceed a 1.5% grain loss based on weight during threshing and separation. Differences in capacity can be established with an allowable level of losses," which provides scope for machine engineering to improve upon the performance standards established by ISO. Notably, ISO standards address methods for measuring losses, such as the processes of gathering losses in order to establish standards for measuring losses behind a combine. Regarding the quality standards for grains, ISO standards (as well as other standards like EN ISO 24333:2010) signify that in post-harvest handling, quality will not be affected, which indirectly relates to losses (as outlined in standards such as limits of admixture, damaged grains that can be considered "loss" in quality). The most direct definition of loss in ISO standards pertains to machine performance. For instance, ISO test methods are equivalent to national standards such as GOST 28301-2015, which is a CIS standard for testing a combination. The standard has been harmonized with ISO 5687 and ISO 8210, where the standard defines combining capacity using the 1.5% loss.

GOST Standards specific numerical requirements for losses of grains at each step are established through GOST standards, and analogous national legislation in post-Soviet countries.

Harvesting Losses: Typically, total losses of grain after a combine passage should not exceed 2% for upright crops and 3% for lodged crops. Further breakdown in losses will include header losses (cutting apparatus) not to exceed 0.5% for upright crops (or 1.5% with poor lodging) and losses in threshing/separating devices not to exceed 1.5%. As indicated, these are allowable limits; otherwise, a need to adjust settings/operational parameters arises. As a matter of fact, operating manuals of combination harvesters have a recommended maximum loss percentage to be achieved by the operator. A critical threshold established in standard GOST 28301-2015 for testing grain combine harvesters fixing testing standards specifies among others a 1.5% total loss level as a point of direct comparison where nominal performances operate under such limits. A total loss threshold of 2% is thus a critical standard for optimized harvest operations both in international standards and in national standards.

Storage Losses: The concept of "natural loss in storage" is, in fact, comprehensively described in GOST and a series of state standards, which establish permissible storage losses as a percentage the of total weight of each type of grain over a definite time span. For instance, in accordance with a directive of the Russian Ministry of Agriculture based on standards of GOST, storage losses of wheat, barley, and other cereals in a silo elevator shall not be less than 0.045% in 3 months, not less than 0.055% in 6 months, and not in excess of 0.09a 5% over storage time of 12 months under normal storage conditions. Such minimal requirements correspond to losses based on evaporation of moisture and biological respiration of the volume of stored grain, which can be considered losses in sound grain. Differences in storage conditions, such as storage on a warehouse floor in bags, provide slightly other requirements; however, in all cases, these requirements are stated in tenths of a percentage. Authoritative storage requirements specify a higher permissible storage loss for maize grain, which shows a higher moisture content. In this case, storage losses for maize are not allowed to be lower than 0.075% in 3 months and 0.115% in 6 months in a silo storage facility, with an increase in a proportional manner in a 12-month duration. However, these requirements make it easy to distinguish storage losses due to natural reasons from losses considering spoilage or pilferage. Worth noting in this matter is that new standards between 2024 and 2025 show a minor update in specifying a maximum storage loss not to exceed 1%.

Transport losses: Transport losses are also subject to requirements such as ГОСТ or other national standards on grain transport. For the Russian/EAEU standards on rail transport of bulk grain, state transport losses do not exceed 0.03% for distances up to 1,000 km, 0.04% for 1,000–2,000 km, and 0.06% beyond 2,000 km. The limits indicated in these standards, which were corroborated in a 2021 standard show minimal losses can be attained if transport is carried out in a sealed container. Standards for transport losses in road transport are set; for instance, transport loss is set at 0.07% for bulk-container transport with open-bed transport and a transport loss not more than 0.05% for transport in bags and containers. The uniformity in transport loss limits of 0.01% to 0. That 1% demonstrates that losses above this level are not accepted. ISO and GOST standards have specific guidance on allowed losses of grain. ISO standards focus on machine performance requirements, such as a threshing loss of 1.5% in combines, where a lower loss is not achievable considering feasibility and economic considerations, where a goal of zero loss is ideal but not feasible. On another note, losses in harvest, storage, or transport are allowed at a rate not exceeding 2%, 0.1%, and 0.05%, respectively.

2.2.3. Land allocation and Crop Rotation

Crop rotation is one of the fundamental agricultural practices used in maintaining soil fertility and agricultural production. Crop rotation involves varying crop species over different seasons and years, thus ensuring a break in the continuity of nutrient removal from the soil. Crop rotation ensures a balance in nutrient removal and addition, unlike crop monoculture, which leads to nutrient deficiency in soils[5]. Crop rotation promotes better soil structure, protects soils from erosion, and prevents pests and diseases that continue to accumulate in soils under continuous culture. In some of the drier regions of Azerbaijan, crop rotation remains an important practice in maintaining soils under intensive agricultural production. Through crop rotation practices, where crops are frequently changed based on species, root systems, and planting patterns, this practice prevents the buildup of pathogens in soils and weeds, thus increasing the organic matter content in soils. Of key significance, therefore, is ensuring conservation and rotational complexity for enhanced benefits in soils, including increased retention of surface residues, which in this case improves soil porosity and macroporosity. Additionally, runoff and increased water infiltration into soils are reduced.

Specific Interactions between Rotation Crops.

Legumes in this rotation sequence have a very important function in terms of their role in biological nitrogen fixation and improving soil structure. Alfalfa is known for its nitrogen fixation function, where a dense stand can potentially contribute 350-800 pounds of nitrogen fixed per acre per year, or approximately 390-900 kg/ha per year. Alfalfa-fixed nitrogen is largely sequestered in the massive root and crown biomass, such that when an alfalfa crop is removed, an immense amount of nitrogen can be returned to the system with the decomposing roots. As a result, a very important nitrogen credit can sometimes be given to this crop sequence in terms of not requiring additional nitrogen fertilization during the first year following an alfalfa crop, based on pot experiments where wheat crops were not given any nitrogen following an alfalfa crop.

Additionally, another legume crop in rotation is soybean, which also has the capability of fixing atmospheric nitrogen up to 180 kg/ha. Although a major proportion of this nitrogen is taken with the crop at harvest time, an estimated 25-40 kg/ha can apparently be left in the soil. Hence, winter wheat or corn following soybean can benefit from this residual nitrogen. Apart from providing

[5] https://www.fao.org/4/a0100e/a0100e02.htm#TopOfPage

nutrient inputs, other advantages offered by legumes are related to soils. Alfalfa, a legume, with a deep taproot system capable of penetrating depths of a few meters into compacted layers of soil, promotes better drainage and provides a network of pathways for subsequent crops. Being a perennial crop, with a life span in rotation of 2-3 years, another benefit is associated with weed control and addition of organic matter. Regional agronomic recommendations distinctly promote leys containing alfalfa for this purpose. Thus, in Southern Russia and the Trans-Caucasus, including Azerbaijan, a typical rotation might include two years of alfalfa and subsequent crops of winter wheat and a row crop, such as corn or sugar beet. Here, rotation takes advantage of the soil-improving qualities of alfalfa as a prelude to wheat’s high nutritional requirements. It is essential to note, however, that crop production tends to increase with a rotation of cereals after legumes rather than simply after other cereals. Long-term studies in a comparable climate have shown an increase in wheat production of 40% when follow-crops include soybeans or other broad-leaf crops rather than continuous wheat, mainly due to a combination of both nitrogen and non-nitrogen advantages in terms of improved soil structure and water-holding capacity, along with reduced pressure from diseases following crop legumes.

Sugar beet. Sugar beet can be considered a broad-leaved crop with a rooting habit that makes it an ideal crop in crop rotation systems. Sugar beet adds diversity to crop rotation by providing a non-host environment for diseases such as Fusarium, which preferentially attack wheat and barley crops. Furthermore, sugar beet acts as a "cleansing crop" because it reduces crop carry-over when it is planted in crop rotation systems. Moreover, sugar beet grows to a depth of over one meter in search of nutrients from deep in the soil. As a result, sugar beet’s deep-rooting characteristic can counteract subsoil compaction, in addition to improving aeration and water infiltration, and creating channels for subsequent crops to grow. Moreover, sugar beet can scavenge nutrients from deep in the soil because of its deep-rooting capabilities, which can reach nutrients in the deep layers of soils that other crops with shallow rooting systems cannot access. Sugar beet can scavenge nutrients such as nitrate because of its deep-rooting characteristic, which can access nutrients from deep in soils when other crops have stopped growing due to nutrient deficiency. Additionally, sugar beet can improve soil microbiology since sugar beet can secrete sugars into the soils using its root systems. Therefore, sugar beet adds biodiversity to soil because of its contribution to soils during its growing stage.

Cereal crops (wheat and barley): The cereal part of the rotation benefits from being grown in a rotation rather than a continuous manner because they contribute a lot to soil biomass (more information in another section) and have different resource-use requirements. Winter wheat and either winter or spring barley share common vulnerabilities to pests and diseases; thus, planting them in each rotation area is not recommended in a continuous manner but rather rotated with other crops. Such rotation is recommended because continuous wheat and/or barley crop rotation are known to worsen diseases such as root diseases and fungal diseases. For example, a serious fungal disease known as "Fusarium head blight" attacks small-grained crops such as wheat and barley, which become more pathogenic when these grow immediately after another type of grain crop or immediately after corn; thus, planting wheat and barley immediately after another type of grain crop or immediately after corn is not advisable according to wheat and barley plant specialists. Rotating wheat and barley with broad-leaf and legume crops will, therefore, keep pathogenic attacks to a minimum. Additionally, wheat and barley make good use of existing residual soils when they follow leguminous crops such as "alfalfa/soybean" and "organic matter-rich crops" such as "beetroot," where they make good use of existing nitrogen and nutrients without necessarily requiring additional fertilizer inputs, resulting in increased crop proteins and production. To summarize, these crops have moderately deep and fibrous roots, with a depth of up to 1.5 m planted in well-prepared soils with barley being shallower, which when planted during "winters into late spring/early summer months," make good use of rainfall during this time. Rotating these crops with those with different rooting systems and water requirements will thus make good use of available water in soils. An agriculture scientist says planting crops in rotation using those with different rooting systems is an important way of utilizing existing water in soils. For instance, planting a summer crop with deep rooting systems such as "corn" immediately after a crop with short rooting systems such as "wheat" will make good use of available water left in soils by wheat, an amount which "wheat" is not in a position to access because of wheat's shallower rooting systems; thus, a crop with deep rooting systems such as wheat will make good use of water left in soils after an intensive water-demanding crop such "corn" with very heavy irrigation requirements is planted because "wheat" can access water left in soils but not "wheat" because "wheat" is planted in a situation where it heavily relies on irrigation in order to set adequate crop production targets. Net, wheat and barley serve important functions in a rotation, and their performance will be aided by being planted after crops such as fertility-building crops and pest breakers.

Late corn as second crop. The tradition of planting a late crop of corn following the harvest of winter grains dates to when irrigation systems were put into practice in this region of intensive agriculture. After planting wheat and barley in early summer (June), a sufficient time span is left for a second crop of corn for silence or grain production before fall. The two major requirements for a successful double-cropping system in Aghdam are sufficient growing days and sufficient water supply. With an abundance of summer warmth and light and irrigation by a pivotal system, both requirements have been met. A crop of corn, being a high-nitrogen-demanding crop with a relatively long maturation time, can be accomplished using short-season hybrid varieties with an approximately 85- to 95-day maturity time if planted immediately after wheat harvest. Watering is critical for this late-maturing corn because, without sufficient water, high temperatures in July and August would significantly impact production. In a pivot irrigation system, late-maturation corn can be adequately irrigated; this supporting evidence from an Arkansas double-crop experiment states, "Irrigation is a key to good yields for late-planted corn." The sequence of planting shows synergisms in this combination: Winter wheat acts as a cover crop and protects the soil during spring, and when harvested, this left-over crop can be used as a mulch for corn planting. Further, corn can be planted without tillage into this crop residue, which prevents runoff losses of water in summer convective systems. Stubble mulch and accurate irrigation systems work in tandem to promote a microclimate in which corn seedlings thrive in a hot and dry environment. In terms of nutrients, corn planted after wheat can assimilate any nutrients (particularly nitrogen) left unused by the crop of wheat planted before it. Furthermore, if wheat is planted after a legume crop, it can indirectly benefit from the nutritional contribution of nitrogen fixed by legumes. The viability and benefits of this crop rotation were proven by a large local farm: for example, a local Azerbaijan farm named Agro Dairy explained that the implementation of 'pivot irrigation and better agricultural practices allowed for double cropping, resulting in record wheat production.' Such evidence shows that with good management, the wheat-corn rotation can improve crop output per hectare considerably. While double-cropping requires specialized fertility and pest control management considerations (i.e., observing and managing corn borers and other pests, potentially using pest-resistant varieties or timely application of insecticides/fungicides depending on the season of planting), the rotation in and of itself addresses several potential concerns. Corn does not share the major diseases of either wheat or barley, thus breaking those disease cycles; but failing to plant corn following a corn crop depresses pressure from corn rootworm and foliar diseases. Overall, late-season corn planting meets this rotation requirement as a high-use activity during summer fallow, facilitated by irrigation, and adds additional residues and root tunnels to the soils for future rotation cycles.

Importance of Crop Residues in the Formation of Soil Organic Matter and Texture. Rotational crops such as cereals, legumes, and root crops provide a constant turnover of different crop residues, which is crucial in maintaining organic matter in soils.

The straw residues of crops such as wheat, barley, and corn stover have a high carbon content, resulting in a slow rate of decomposition, hence a significant contribution to an increase in soil organic matter. The addition of straw to soil increases their macroporosity, decreases bulk density, and promotes water infiltration and root penetration. In an arid climate, such as in Karabakh, straw can help reduce evaporation and erosion of soil. Empirical research shows a positive influence of straw addition on increasing soil organic matter content by up to 25% in soils (MDPI, 2023).

The decomposition rate of legume residues (alfalfa and soybean) is higher due to a lower C:N ratio and higher nitrogen content. Alfalfa, which has a deep-rooting habit and grows perennial biomass, is an important constituent of stable organic matter in the case of decomposed materials. Although soybean residues are considered lighter in mass, they provide organic nitrogen to improve nutrient availability in soils. The rotation of legumes and cereals can help in coordinating nutrient decomposition and promote accelerated humus formation (JEENG, 2024).

The sugar beet residues, in the form of nutrient-rich crop tops left in the field, act as green manure. They can decompose easily, leaving behind nutrients the in form of organic carbon and nitrogen in the soil, hence increasing fertility for the next crops to grow. Beet crops have deep-rooted systems with the ability to reduce soil compaction and boost microbial and fungal life in the field (British Sugar, 2025). The presence of a constant residue cover on all-year crops, summer legumes, and root crops sustains an active food web in the soil. The strategy conforms to FAO guidelines to recycle organic matter in a system to a maximum degree. The increase in content in the soil will bring enhanced functions such as water absorption capacity and erosion protection.

Economic Impact. The implementation of a crop rotation diversification strategy in a pivot irrigation system with precision fertilization application provides Fang with other important economic benefits, aside from improving crop performance. First, increased land productivity per unit area is a direct benefit in this rotation application since crops such as late corn can make use of the additional time afforded by irrigation and realize two harvests in one year. Such increased intensification can lead to a marked boost in total production a year in a 2,500-hectare farm. In this case, whereas before the total production may have stood at approximately 5-6 tons per hectare in a year for wheat production, this heightened production can now make an additional 8-10 tons per hectare in a year in corn production, in addition to other crop production such as silage. In this manner, such a rotational system can nearly double land productivity. In practical terms, such a benefit can be seen in the case of large agro-businesses in Azerbaijan, which have noted in Agro Dairy other large agro-businesses in this country where the implementation of pivot irrigation systems and other agro-technologies saw an additional crop produced in addition to a record wheat production; hence a new level in country-wide productiveness. Secondly, with higher production using the same resources, this system can improve bottom-line performance.

Further, diversification in commodity production brings variety in earnings. It makes sense in this case financially because it reduces risk and can therefore help in maintaining stable income despite volatility in market and climatic changes. One commodity can suffer setbacks in terms of lower prices and climatic changes, but another commodity can help in maintaining net profit incidence. Of course, this is in line with a major consideration in agricultural economics—the benefit of crop diversification impacting working hours in terms of crop harvest. Given an agricultural setting with a total of 2,500 hectares, crop and labor diversification in this case will be optimized in such a way that small crops will be harvested in early summer, corn and soy will be harvested in autumn, alfalfa will be harvested in multiple seasons, and beet will be harvested in late autumn.

The rotation itself, with legumes and deep-rooted crops, adds to cost savings. The nitrogen fixed by legumes lessens the need for synthetic nitrogen fertilizers in succeeding in crops. In terms of cost savings, this is a large benefit in that nitrogen fertilizer is a large cost in growing grain crops. With nitrogen fertilizer usage reduced by 30% to 50% when following an alfalfa crop or a soybean crop, this gives cost savings to the farming operation and simultaneously may raise crop output in wheat. On 2,500 hectares, with a given part of this area planted to legumes each year and other parts planted to crops which benefit from legumes in terms of nitrogen, savings in fertilizer usage can be indicated in large quantities every year. With high fertilizer prices each year, these savings improve income under very different circumstances. Cycles in pesticide and fungicide usage may decrease in expense in connection with rotation. For example, if planting wheat after corn or wheat in a given rotation, expenditures on fungicides are avoided each year, and losses in wheat output can be avoided; in addition, an infected crop can degrade with the production of mycotoxins in lower grades. Other expenditures in this connection would be in weed control. With rotation, different methods of weed control can be used to improve prospects against weeds becoming dominant or fungicides becoming used in increasing quantities because of resistance. A third dimension relates to long-term agricultural productivity on these soils and their financial significance. Rotation under irrigation can sustain high levels of production without reducing soil quality over time. Consequently, a savings function in soil organic matter, which can be considered a fertilizer savings program for the farmer, is available in this system and will provide returns in terms of nutrient availability and available water. Alternatively, continuous agriculture without rotation leads to reduced production and a need for correctional activities such as follows, heavy fertilizer application, or other amendments for poor soils, all of which cost money. Land degradation in Azerbaijan and in the whole Caucasus area, remains a problem—according to assessment, approximately 60% of usable agricultural land is degraded, which affects productivity and sustainability. This is attributed to poor agricultural practices and a lack of rotation, which can affect food self-sufficiency and agricultural economy. As a mitigation strategy, recommendations have emphasized the need for proper agricultural practices such as rotating crop ion to improve soils. The role of rotation in reconstructing soils primarily through organic matter addition and control of erosion protects this capital and, in a decade, can be a factor in requiring investment in rehabilitation. Additionally, this will make such lands less vulnerable to climatic shocks such as inaccessibility during rain or dried-up lands in case of rainfall. Also protected are production losses in bad years, which can present a cost benefit not always accounted for in an ideal rotation. Additionally, this crop rotation model meets agricultural development aims both in the country and internationally, making it feasible to access support in terms of incentives or better markets. Azerbaijan aims for agricultural advancements to achieve innovation and sustainability, with a farm using efficient irrigation systems, precise fertilization, and crop rotation being a manifestation of such an objective. This can be eligible to access support programs by the government in terms of support for irrigation systems or agricultural machinery, subsidies for strategic crops such as wheat or sugar beet, among others. Being part of a carbon credit program or a sustainability standard can present additional financial opportunities through carbon credits or additional revenue from sustainable crops, among others. In summary, therefore, the integrated rotation of wheat, barley, corn, alfalfa, sugar beet, and soybean crops, made possible by the support of pivot irrigation and precision fertilization, provides a symbiotic rotation pattern which can be interpreted as being both sound from an agricultural perspective and an equally important portent in terms of bottom-line financial gains. A plethora of available literature bears testimony to such a rotation pattern being beneficial in a variety of ways, including the sustainability of healthy soils and prudent resource utilization. The short-term gains in terms of increased production within this farmland can thus be readily achieved with double cropping and optimized use of inputs, not to mention maintaining a healthy resource base in terms of soil conservation and biodiversity in the long term.

2.2.4. Subsidies

The basis for subsidies in agriculture in Azerbaijan is based on Order No. 759, which was signed by President Ilham Aliyev on June 27, 2019. The level of subsidies is established on an annual basis based on the results of previous years by the Agrarian Subsidy Council. The subsidies are allocated in three main categories: Crops, Sowing, and Seeds. The level of subsidies is established in conformity with food security in terms of crops and agricultural products to be grown, as well as crop production expenditures in relation to such crops. Other rules governing land use, such as main and re-sowing, irrigation using advanced technology and non-irrigated lands, liberated territories, and other regions, have a major impact on the level of subsidies.

The role of government in providing subsidies is very important in making the agricultural sector self-sustainable and profitable. Large agricultural firms and companies operating in a country maximize their spending, and in most cases, there is income based on subsidies.

The decisions of relevant state bodies on the effectiveness of the subsidy policy are not unified. Thus, in reviewing the draft law "On the 2025 State Budget," for example, the Chamber of Accounts noted that "despite the continued subsidizing of the agricultural sector, no positive dynamics in terms of the share of agricultural added value in GDP have been observed over the years. In relative terms, compared to 2017, in 2023, subsidies allocated for crops increased by 2.2 times, subsidies per hectare increased by 2.4 times, and crop output per unit of subsidy reduced by 12.2%." Based on their practical experience, the authors state: "The present subsidy policy aims to increase the volume of farmland rather than output. According to annual rules for subsidies, subsidies for cultivation are in fact rather unstable and higher compared to crop subsidies. In these circumstances, several complexities may arise. Thus, enterprises in agriculture will prefer increasing farmland rather than increasing output. Therefore, they will order seeds sufficient in quantity with a view to fulfilling mandatory seeding requirements to seed with mandatory quantities in declared final areas without sufficient agro-technical treatment with a view to minimizing irrigation expenditures and without carrying out fertilization. Therefore, entrepreneurs will minimize expenditures for sowing per hectare, and since expenditures for sowing subsidies will exceed expenditures for sowing in some cases, they will have no grounds to maximize output increment; they will sometimes suspend harvests. Hence, a negative differential between subsidizing and actual crop output can arise in these circumstances. In this case, it would appear sound to increase crop subsidies in relation to sowing subsidies and to refine requirements when allocating subsidies for sowing. Analyzing different global responses to such similarities in policies will show interesting examples, including Chinese subsidies meant to foster their automotive sector. Chinese authorities have used subsidies to promote investments in hybrid and electric cars with the hope of shaping this sector and improving exports. A critical mistake in policymaking occurred when authorities used these subsidies based on production output rather than sales or exports. This disconnect spurred the massive production of electric and hybrid cars, which were of poor quality and had insufficient spares, under different brands. Consequently, millions of such cars, which were not market-worthy, were produced but did not end up in markets. Here, the government enhanced specifications of cars produced and rearranged subsidies based on exports and sales instead of production output. Eventually, this strategy led to the achievement of desired policy results, which shows the significance of using subsidies based on strategic targets.

The level of subsidies used for this research is set in accordance with the subsidy coefficients published by the Agricultural Subsidy Council on September 1, 2025. To clarify, in the case of sowing subsidies: 400 AZN per hectare is fixed for wheat and barley in regions with liberated lands using modern irrigation systems; 50 AZN per hectare for re-planting corn; and 160 AZN per hectare for alfalfa. Furthermore, in the case of crop subsidies: 19 AZN and 120 AZN per ton for sugar beet and soybean, respectively; 50 AZN in regions using modern irrigation systems for corn; and 100 AZN per ton in regions using modern irrigation systems for wheat. A detail to be noted is in regards to wheat production, where instead of taking into consideration a common wheat production coefficient, a coefficient referring to wheat produced by people with obligations to fulfill wheat production on farms with modern irrigation systems, delivered to the State Reserves Agency of the Republic of Azerbaijan and flour mills in accordance with an agreement concluded with the Ministry of Agriculture of the Republic of Azerbaijan shall be used. Then, a zero coefficient in all other cases. Therefore, calculations can be carried out taking into consideration the delivery of all produced goods to ADEA. The calculations will consider the crop and planting subsidy amounts separately. Thus, the planting subsidy will be added to the production value according to the area to be planted, and the crop will be added to the production value according to the forecasted yield.

2.2.5. Expected Price of the Crops

In this part, an estimation with respect to a possible selling price for the products will be conducted. The information used in this part will include data from actual sales in 2023, the Agricultural Outlook 2025-2034 published by the Food and Agriculture Organization and OECD, and information on trends in relevant databases. It is essential to note that the actual market price of a product during a specified time is influenced by market conditions; period in this case, a crucial factor in market pricing is the nature and quality of a product of interest to primary market buyers. Agricultural products do not have a standard nature and are thus classified into different product categories depending on parameters such as glossy appearance, dusty nature, protein level, and moisture content, among others. Due to the difficulty in estimating beforehand the nature and level of the product being produced, a prudent estimate will thus be carried out in this part with the aim of arriving at an average estimate.

Wheat Price. As we noted in the subsidy calculations, the entire product obtained from wheat will be sold to the State Reserves Agency and the selling price is formed by the state: 400 AZN per ton.

Barley Price. Moreover, the barley production and wholesale price in Azerbaijan has shown a marked fluctuation in recent years. During 2022, the field price of barley stood at approximately 0.4 AZN/kg or 400 AZN/ton, which decreased to 0.3 AZN/kg in 2023, thus showing a depreciation of nearly 25% in a span of one year. The main cause of this decrease in price can be attributed to total supply and demand capabilities, despite lower production expectations due to a drought in some parts of the country during this time. In retrospect, post the manat devaluation, the average farmer price of barley dropped markedly in 2016 to nearly 119 USD or approximately 190 AZN/ton, which recovered incrementally over the years. As observed in 2022, an increase in demand due to a global surge in food prices increased barley prices in Azerbaijan to nearly 0.4 AZN/kg.

Forecasting Prices for the Period 2025–2035: A moderate increase in barley prices in respect to inflation and demand in the market is expected in the coming decade. Forecasts from international bodies show that, in the mid-2030s, the global export price of feed barley is expected to reach an average of 225 USD/ton. Given the current exchange rate, this will be very close to 380-400 AZN/ton, which is expected to approach the 2022 level in Azerbaijan. In this sense, a small increase in nominal barley prices in the coming years is expected, but not much in terms of real prices. While regional geopolitical events, such as those between Russia and Ukraine, with important grain exporters, can temporarily affect barley prices, in a medium horizon forecast, a stable market amidst a slow but increasing trend in the level of inflation each year can be observed in regional markets. Hence, based on this forecast, in 2025-2035, an average barley price in tons in Azerbaijan will settle in a 300-400 AZN band, with an increasing trend towards the end of this decade.

Maize Price. In Azerbaijan, corn is produced both locally and imported, with a fluctuating price based on international trends. According to FAO data, in early 2010, the price of corn increased to 376 USD/ton in 2014, which is equivalent to AZN 300 based on an exchange rate in 2014. Following the subsequent devaluation of the manat in late 2015, the price of corn in 2016 dramatically reduced to 159 USD/ton, translating to AZN 250-260 based on a different exchange rate used in 2016. Gradually, prices went up; thus, despite a trough in 2019 with a low price of approximately 147 USD/ton, which is equal to AZN 250, prices in 2020 increased due to congestion in the global wheat market to 235 USD/ton or AZN 400. In 2022, with occurrences in the Russia-Ukraine war, global corn prices increased, which in turn increased Azerbaijani local corn farmer prices to approximately 264.7 USD/ton, which is AZN 450. Top travel sites show a reduced price in 2023 compared to a peak in 2022 since an average price in 2023 reduced to 241 USD/ton with an approximately AZN 410 conversion rate.

Forecasting Prices for the Period 2025–2035: Commodity Demand and/or Production Trends Forecasts show that corn prices will have relative stability on the global market over the course of the next decade with a gradual increase. According to the OECD-FAO Agricultural Outlook, the world export price of maize (grain maize) is projected to reach around 252 USD/ton by 2034, which is approximately AZN 430/ton at current exchange rates—below 2022 peak prices but higher than in 2023. As a matter of fact, it can be assumed that today's high maize prices will moderate in the short term and increase step by step towards current nominal prices in the mid/late 2030s. During this time, production will have increased globally, especially in the Americas, and meet demand, thus keeping prices under control. However, a combination of increased demand to support population growth and other sectors in demand for animal feed, along with country-wide inflation, will lead to a nominal price increase in the future. Regional perspectives, such as opportunities for imports in terms of Russia-Ukraine imports in addition to market dynamics in Turkey, will influence maize prices in Azerbaijan on domestic markets. Overall, according to official international forecasts, a ton of corn will cost in the range of 400-450 AZN from 2025-2035 with a gradual increase towards the end of this forecast term.

Soybean Price. With the small volume of local production, the local market in Azerbaijan is rather dependent on the prices of imported soybean products. Recently, imports have mainly fulfilled Azerbaijani demand in terms of soya beans; in 2023, imports amounted to 12.8 thousand tons of soya beans costing 8.35 million USD. Hence, an estimated average price of imported soya beans can be stated to be approximately 653 USD per ton (approximately 1,100 AZN per ton, considering the current exchange rate). The price of soya beans in the global market significantly rose in 2021-2022 to record-breaking highs (approximately 16-17 USD per bushel in 2022 on the Chicago Board of Trade, which is approximately 600-650 per ton). However, this global peak impacted Azerbaijani imports of soya beans and thus affected a peak in Azerbaijani soya bean product prices in 2022. Then, in 2023 and 2024, prices somewhat reduced with increased global production. As of late 2025, international soya bean prices were recorded to be approximately 10.78 USD per bushel, which corresponds to an average of 395-400 USD per ton. Therefore, since their peak in 2022, global soya bean prices have dropped by an approximate 35-40% in 2023-2025 years. In Azerbaijan, in accordance with global tendencies, market prices on wholesale imports of soya beans reduced after 2022, showing a moderate decline in 2024.

Price Forecast for the Period 2025–2035: Forecasts do not show strong variations in prices of soybean products during the upcoming decade, expecting market stability and gradual growth. The medium-term forecast of the OECD-FAO projects a small increase in nominal oilseed prices (including soybeans); nevertheless, in real terms, such prices are expected to remain stable or show a minor decrease. This forecast is based on an expected increase in global soybean production sufficient to cover demand and realize efficiency increases during a decade. In the 2024/25 crop year, global soybean production will reach a record volume (over 400 million tons) with a 7% increase in total production. A less intensive demand for protein-containing animal feed, especially in China, which reduces the share of soybean animal feed in animal diets, will slow demand growth for soybeans. Under such circumstances, the world price of soybeans will stabilize in the order of 500 USD per ton (approximately 850 AZN per ton) in early 2030s, and with a nominal increase based on an index of inflation rate, respectively. Therefore, in this case, until 2035, the wholesale price of soybeans in Azerbaijan will most likely continue in a range of 1,000 AZN/ton in 2025-2035 with a possible gradual increase in the second half of this decade towards the end of this decade, bordering on a price level of 1,100-1,200 AZN/ton. Although this forecast remains rather conservative, analysis of official international institutions (FAO, OECD, and World Bank) shows that prices for soybeans will remain stable in real terms with a small nominal increase. Worth noting that regional political events (regional feeding of Ukraine with soya) and global information concerning demand of soya oil under the global biofuel politics remain a risk factor.

Sugar beet Prices. In Azerbaijan, sugar beet procurement is mainly carried out by the Imishli Sugar Plant from local farmers, with a purchase price set via enterprise-level agreements. Recently, this procurement price has been progressively increased to boost motivational levels among the farming community. For instance, in 2022, sugar beets with a sugar content of 12% were purchased at a price of 65 manats, with an additional 81 manats paid for those containing 16% sugar. As for the possibility of a boost in subsidies, for the year 2023, an additional 4 AZN have been added to all sugar content categories. Therefore, during the 2023/2024 crop years, sugar beet purchase will cost 69 AZN per ton for sugar content of 12%, 72 AZN for sugar content of 13%, 77 AZN for sugar content of 14%, 81 AZN for sugar content of 15%, and 85 AZN per ton for sugar content of optimum 16%. An increase in purchase price per ton was achieved due to a collective agreement between Azersun Holding and the Ministry of Agriculture, resulting in an average sugar price increase of approximately 6-7% over the previous year. Worth noting in this context is an increase in state subsidies per ton of sugar-beet delivery from 12 AZN to 18 AZN in 2023, which boosts farmer revenue.

Price Forecast for the Period 2025–2035: In this regard, when considering the purchase prices of beets in Azerbaijan during the years 2018-2021, they were comparatively lower; in other words, they were fixed in the range of 55-60 AZN per ton for beets with 12% sugar content. However, due to an increase in fertilizer and fuel prices, along with other sugar market factors, they have increased over time. The official bodies recalculate the purchase price of beets every year based on different parameters, such as inflation and production costs. Hence, if these tendencies continue in future years, a small increase in the purchase prices of beets will be observed in the next years.

Meanwhile, with respect to the 2024 marketing year, the basic price for one ton of beets with 12% sugar content has already increased to 69 manats. With an anticipated continuous increase of 4-5 AZN each year, a ton of beets with 16% sugar can reach 100 AZN around 2030s, which aims to keep sugar production in Azerbaijan profitable and make beet farming attractive for local farmers. With a stable sugar market in the regional countries, basically two parameters will influence the purchase price of beets in Azerbaijan: namely, the country's subsidy policy towards beets and demand from Azersun/Imishli sugar plant. Meanwhile, currently, sugar prices are high, and prices of beets as a basic product are increasing. A conservative estimate in this case will state a gradual increase in a country-wide beet price from 85 AZN per ton to 100-110 AZN in 2025-2035. As for official explanations concerning these rises, they premise an increase in production in a country-wide manner due to an index of production cost, including fuel, fertilizer, and labor, as well as an index of a sugar price hike in an increased demand on a wholesale market. Meanwhile, an enlargement of a country-wide beet purchase price for 2025 is already fixed with an expected sugar content above 69 manat/ton, proving a trend towards a continuous hike. Therefore, in the next decade, an increase in the country-wide price of beets will decrease step by step in accordance with official directives and demand in a sugar market with credible limits in terms of a country-wide price rise each year.

Alfalfa price forecast, 2025-2035. The price of Alfalfa hay is mainly affected by local market situations, such as the progress of animal growth in the country, demand for Alfalfa, the total area of Alfalfa farmland, and local climatic conditions. Considering that the current base price in 2025 is established at 20 AZN for each centner, it can be expected that this level will incrementally increase with time according to the growing demand and cost of living. For instance, taking into consideration a 5% average demand and cost-of-living increment each year, the price for one centner of Alfalfa may reach approximately 25-30 AZN in 2030, which is equivalent to $250-$300 per ton. This estimate corresponds to the price allegedly received by local farmers in 2023. Although government forecasts do not carry much information concerning direct alfalfa prices, a strong feed market is a high priority for the government. It is assumed that the area for growing alfalfa will increase into the 2030s, and production capacity can subsequently be increased with better irrigation systems. Of course, this will make it possible to soften sudden price increases with increased quantities of hay. However, price pressure will continue to be positive since the strategy for developing the livestock sector to raise meat and milk production will drive up demand for alfalfa. Therefore, it appears reasonable to make a forecast concerning a gradual increase in prices of alfalfa hay in Azerbaijan in 2025-2035, leveling off in the latter years with a price of approximately 200-250 AZN per ton, or with an average price of 6-7 manats per bale, which corresponds to an anti-inflationary continuation of the current price level of 3.5-5 manats.

The forecast is based on probabilities of growth, which have emerged from official valuations for insurance and overall trends in the economy. Importantly, years with unusual climatic conditions (i.e., years with serious drought) are expected to see a higher price level for alfalfa above the forecasted level, with productive years showing a short-term slump in prices. The forecast aims at an index-linked increase in alfalfa prices.

2.2.6. Cost of Goods Sold Calculation

There are many factors to consider in order to determine the price of the product. These include seeds, fertilizer, pesticides, and herbicides, irrigation expenses, repair and maintenance of equipment, and fuel expenses, salaries of employees, rental charges for lands, insurance charges, and many other finer details. In view of the sustainability of agro businesses, the state also offers a discount on the expenses involved in producing the produce. These may include 70% of the expenses involved in the utilization of fertilizer, pesticides, and biohumus, which are industrially produced. Despite the subsidies granted by the state, owing to the poor soil quality that supports mass production and the lack of water resources in the country, the produce expenses are still high in Azerbaijan.

The result for production cost calculations was derived using real data for the year 2022 and a 3% escalation in costs annually. Production costs are derived from variable and fixed costs, as well as overhead expenses. Since authentic data on production costs related to farm products is not readily available, data derived from personal experience formed the basis for this work. Production cost prices are shown in **Table 2.2.5.**

Table 2.2.5. Production costs per crop, 2024-2035

Crop	*2025*	*2026*	*2027*	*2028*	*2029*	*2030*	*2031*	*2032*	*2033*	*2034*	*2035*
Wheat	1,492	1,537	1,583	1,631	1,679	1,730	1,782	1,835	1,890	1,947	2,005
Barley	1,151	1,186	1,221	1,258	1,295	1,334	1,374	1,416	1,458	1,502	1,547
Late Corn	1,328	1,368	1,409	1,451	1,495	1,540	1,586	1,633	1,682	1,733	1,785
Alfalfa	2,161	2,226	2,293	2,361	2,432	2,505	2,580	2,658	2,737	2,820	2,904
Sugar beet	2,528	2,604	2,682	2,762	2,845	2,931	3,019	3,109	3,202	3,298	3,397
Soybean	1,852	1,908	1,965	2,024	2,084	2,147	2,211	2,278	2,346	2,416	2,489

2.2.7. CAPEX Costs

Capital expenditures (CAPEX) are referred to as capitalizable costs. In relation to the research study, CAPEX will include the acquisition and installation of the Pivot Irrigation system, pipelines, and electricity cables, the building of the pumping stations, and the construction of the office building and reservoir.

Concessions. This subsection details the concessional financial support extended by the state for the purchase of CAPEX. The concessions are allowed for different parts of the equipment and irrigation systems that will be procured from AgroLeasing OJSC. In this regard, 40% of the cost of agricultural equipment and Pivot Irrigation systems will receive financial support from public funds. Additionally, 40% of the material expenses regarding irrigation pipes, electrical wires, and pumping stations for 70%, 50%, and 80% of the total expenses of those materials, respectively, will also receive financial support from the state's funding sources. Based on research carried out for this study and consultation with local experts, the total cost of investment for the agricultural machinery that is to be used for pivot irrigation system installation and precision agriculture-related equipment will be 37,900,000 AZN. The total cost of subsidies and discounts that will qualify for CAPEX purchase will be 10,176,000 AZN, and this will result in a net incremental investment of 27,724,000 AZN. Of this net cost, 5,100,000 AZN will come to the company through a leasing loan for machinery purchase, and the rest will come as equity contributions from shareholders. The CAPEX details are indicated **in Figures 2.2.2 and 2.2.3** below.

Figure 2.2.2. CAPEX Allocation considering subsidy amount

Planting Capex 1

CAPEX	EUR	AZN	Base Amount (AZN'000)	SUBSIDY Amount	Incl. Subsidy (AZN'000)	
Pipelines	4,000,000	8,000,000	8,000	2,240	5,760	70% of the price could be considered as material. There will be subsidy to the material.
Electricity	2,500,000	5,000,000	5,000	1,000	4,000	50% of the price could be considered as material. There will be subsidy to the material.
Pivots	3,500,000	7,000,000	7,000	2,800	4,200	
Pump Groups	1,150,000	2,300,000	2,300	736	1,564	80% of the price could be considered as material. There will be subsidy to the material.
Total Irrigation	**11,150,000**	**22,300,000**	**22,300**	**6,776**	**15,524**	
Roads	300,000	600,000	600	-	600	
Facilities/Other	1,250,000	2,500,000	2,500	-	2,500	
Reservoirs and Channels	2,000,000	4,000,000	4,000	-	4,000	
Total Other	**3,550,000**	**7,100,000**	**7,100**		**7,100**	
Machinery	4,250,000	8,500,000	8,500	3,400	5,100	
	-		-	-	-	
Total Machinery	**4,250,000**	**8,500,000**	**8,500**	**3,400**	**5,100**	
Total CAPEX Smart Farming	**14,700,000**	**37,900,000**	**37,900**	**10,176**	**27,724**	

Figure 2.2.3. Allocation related to investment financing

	Base	Subsidy	100%
total excl mac	29,400,000	6,776,000	22,624,000
Machinery	8,500,000	3,400,000	5,100,000
	37,900,000	10,176,000	**27,724,000**
			27,724

	Loan AZN'M		Interest Rat	Share	WACC
Leasing machinery	5,100	interest	8%	18%	1.5%
Shareholder funds	22,624			82%	4.9%
Total Investment	**27,724**				**6.4%**

CHAPTER 3: RESEARCH FINDING AND DISCUSSION

3.1. Overview

In this section, a 10-year final investment assessment will be carried out based on the information obtained in Chapter 2. The main financial tools targeted for determination will be NPV, IRR and Payback Period figures. In addition, a sensitivity analysis will be carried out for investment assessment.

3.2. Summary of the research outcomes

3.2.1. Preparation for Profit & Loss statement

Total Production Value.

To determine the Production Value, the key variables involved are yield, cropped area, and sales value per ton for each crop. The annual value of the Production Value is derived by multiplying these key variables. These values are then refined to make allowances for the following factors:

- In the case of grain loss, the total output of wheat and barley is reduced by 2%, whereas the amount for corn is 3%.
- Income generated from product subsidies is added to the Total Production Value.

The adjusted Production Value figures for years 2026-2035 appear **in Table 3.2.1**.

Table 3.2.1. Adjusted Production Value, 2026-2035

Years	Amount, in AZN
2026	9,610,104
2027	10,284,898
2028	10,853,204
2029	11,080,404
2030	11,265,705
2031	11,507,129
2032	11,860,921

2033	12,110,692
2034	12,418,288
2035	12,712,512

EBITDA.

EBITDA stands for Earnings before interest, taxes, depreciation, and amortization. It is an indicator of how much a company has earned through its core business activity. The calculation of EBITDA does not include costs such as interest and taxes. The adjusted production value, subsidies for planting and total crop farm cost figures are used to calculate the EBITDA of the project. Thus, the result we get when crop farm costs are subtracted from the total production value and subsidy revenues is equal to EBITDA. At the same time, EBITDA Margin is calculated based on the available data. The calculation of the EBITDA margin is a profitability analysis that shows the share of every dollar of revenue that a company generates in profit from its core business activities prior to the payment of interest expenses, taxes, and expenses related to depreciation and amortization. The calculation of the EBITDA margin is given by the formula:

(EBITDA / Total Revenue) × 100%

If we look at the EBITDA Margin indicators shown **in Table 3.2.2,** we can see that the ratio changed between 46-51% during the period, which is a high result

Table 3.2.2. EBITDA and EBITDA Margin results, 2026-2035

Years	*EBITDA, in AZN*	*EBITDA Margin, %*
2026	4,041,858	49%
2027	4,521,014	51%
2028	4,887,814	52%
2029	4,814,860	51%
2030	4,784,039	50%
2031	4,802,858	49%
2032	4,927,367	49%
2033	4,940,977	48%
2034	5,005,327	47%
2035	5,049,007	46%

CAPEX Cash Outflow.

In this section, the area experts will calculate and analyze the CAPEX investment pattern in terms of projects distributed throughout the time span. In any case, forecasting the cash outflow is very difficult without considering any changes or new emerging data within the project period, as this data may change at any time. The CAPEX cash outflow for this project will take the following form for better professional implementation: An initial investment of 3,000,000 AZN will be made for preliminary planning and irrigation system installation within the area prior to the sowing season to create a basis for the new project. In the first sowing year, there will be a CAPEX investment of 23,724,000 AZN for completing the construction process. In the following year, there will be an additional investment of 1,000,000 AZN that could help eliminate any construction defects or for optimization purposes. This will wrap up the whole investment process. It needs to be noted that the above requirements have been modified to incorporate CAPEX subsidies.

3.3. Free Cash Flow, Payback Period and IRR.

Free Cash Flow (FCF) measures the amount of cash generated by a firm after subtracting expenses related to its operating activities and sustaining and augmenting fixed assets such as properties and facilities. It measures the amount of cash left to the discretion of management to decide whether to distribute to shareholders as dividends, to repay debt, to buy back stocks, and to make acquisitions.

Internal Rate of Return (IRR) is the discount rate which makes investment`s Net Present Value (NPV) zero, indicating its profitability by finding the rate where cash inflow equals to cash outflow. The formula indicates following:

$$0 = NPV = \sum_{t=1}^{T} \frac{C_t}{(1 + IRR)^t} - C_0$$

Where:

C_t=Net cash inflow during the period t

C_0=Total initial investment costs

IRR=The internal rate of return

t=The number of times periods

The key connection between IRR and Discount Rate is that if Project IRR is higher than the discount rate, it`s worth to invest project. However, IRR<Discount Rate means that it disperses the value of project, it should be ignored to invest the Project. The free cash flow generated throughout the project is shown **in Table 3.3.1** and, considering the initial investment, the IRR figure is calculated as 13.6% for a 10-year period. Considering that the discount rate is determined as 7% in the latest discount rate statement of the Central Bank of the Republic of Azerbaijan dated 24.07.2025, it can be said that the IRR exceeds the discount rate and the project is a project worth investing in. **Payback Period** refers to the amount of time it takes for an investment to recover its initial cost from the net cash inflow it generates. In other words, it shows how many years (or months) it will take for a project to "pay for itself." Free cash flow calculations determined the payback period to be **5.97**, or approximately 6 years. This period is considered acceptable for agricultural investments.

Table 3.3.1. Free Cash Flow by years, 2026-2035

Years	Free Cash Flow, in AZN
2025 (Initial Investment)	(3,000,000)
2026	(19,682,142)
2027	3,521,015
2028	4,887,814
2029	4,814,860
2030	4,784,040
2031	4,802,859
2032	4,927,368
2033	4,940,978
2034	5,005,327
2035	5,049,007

3.4. Calculation of Net Present Value (NPV).

Net Present Value (NPV) is a financial metric used to evaluate whether an investment or project is profitable over time. It compares the value of expected future cash flows (money the project will generate) to the initial investment, while also considering the time value of money (the idea that money today is worth more than the same amount in the future).vIn simple terms:

NPV tells us how much profit (in today's money) we'll make from an investment after covering all its costs.

- If NPV > 0 → the project is profitable.
- If NPV < 0 → the project may result in a loss.
- If NPV = 0 → the project breaks even.

Formula is:

$$\text{NPV} = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - C_0$$

Where:

CF_t= Net cash flow at year t

r= Discount rate (reflects risk or cost of capital)

t= Year number (1, 2, 3...)

n= Total number of years (project lifetime)

C_0= Initial investment cost (paid in year 0)

The discount rate adopted to calculate the NPV of the project is 7% (the latest announced interest rate by the Central Bank). However, to calculate the financial sensitivity of the project, we recalculate the NPV by taking the discount rate in the range of 7-11%.

NPV results can be seen in **the Table 3.4.1**:

Table 3.4.1. NPV figures according to discount rates, 2026-2035

NPV FIGURES, IN AZN	DISCOUNT RATE, %
7,188,750	7%
5,883,326	8%
4,667,396	9%
3,562,455	10%
2,530,817	11%

Conclusions and Recommendations

The outcome of the empirical analysis confirms the profitability of the appraised grain projects in all scenarios. The quantitative criteria, including NPV and IRR, in all scenarios are positive. The IRR of 13.8% is significantly higher than the assumed discount rate of 7%, ensuring the grain projects are NPV positive, and the results are satisfactory even with an increased discount rate. These results confirm that with proper management, grain farming in Karabakh will remain an economically profitable venture.

The key factor influencing the above result is the application of better inputs and technology. Improved irrigation technology, such as pivot and drip irrigation systems, has already shown significant crop increase through better water management. High-tech farming that uses GPS-enabled agricultural machinery, variable application rates for seeding and fertilizers, and real-time observation will optimize the allocation and prevention of wastage. High agro-technical efficiency with proper application of good seeds, balanced fertilizers at the appropriate time and amount, sound pest management practices, and effective field management is critical for the attainment of the above potential returns. Government assistance is also critical and includes subsidy programs for agricultural machinery and irrigation (for example, a 40% subsidy for machinery), and improved seed programs that have already been quantified for significant crop increase even for non-irrigated land.

In addition to the economic benefits of increased revenues, such investments also provide comprehensive socioeconomic benefits. As estimated, this program will create around 15,000 to 18,000 seasonal and 2,000 to 3,000 permanent rural employment opportunities, while increasing average incomes among households by 8% to 12% per annum. Since these investments will boost domestic grain production, this directly affects Azerbaijan's goal of achieving food security for its rural communities.

Conclusion: To capitalize on the findings outlined below, it is recommended that:

- Develop and expand modern irrigation systems, such as pivot and drip irrigation, and other efficient methods in the Karabakh region by utilizing government-sponsored subsidies to promote their adoption. Improved irrigation systems are key to resilient yield production.

- Utilize precision agriculture technologies (such as GPS-guided farm equipment, remote sensing, variable rate application) to increase productivity and decrease input costs. Training programs and incentives should accelerate adoption.

- High agro-technical standards: Focus on ensuring timely agronomic practices (crop selection, fertilization, pest control, etc.) in order to fully realize the gains from technology investments.

- Targeted government assistance must be maintained and adapted to succeed in projects like machinery, irrigation, seed, and insurance subsidies that have proven to increase productivity in farming.

- Align such projects with national strategies for agriculture and rural development to achieve food security (target SDG goal 2). The profitability and societal return presented as benefits of such projects make them an attractive area for public-private partnerships (PPPs).

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APPENDIX

Appendix A1 – Production Value Calculation

		Year1	Year2	Year3	Year4	Year5	Year6	Year7	Year8	Year9	Year10
	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Wheat	-	**3,366,000**	**3,444,000**	**3,516,000**	**4,193,000**	**4,284,000**	**4,375,000**	**4,459,000**	**4,550,000**	**4,641,000**	**4,725,000**
Area		*1,500*	*1,500*	*1,500*	*1,750*	*1,750*	*1,750*	*1,750*	*1,750*	*1,750*	*1,750*
Yield		*5.6*	*5.7*	*5.9*	*6.0*	*6.1*	*6.3*	*6.4*	*6.5*	*6.6*	*6.8*
Price per ton		*400*	*400*	*400*	*400*	*400*	*400*	*400*	*400*	*400*	*400*
Barley	-	**1,144,800**	**1,188,180**	**1,232,280**	**623,700**	**631,260**	**651,596**	**672,494**	**693,966**	**717,393**	**740,087**
Area		*600*	*600*	*600*	*300*	*300*	*300*	*300*	*300*	*300*	*300*
Yield		*4.8*	*4.8*	*4.9*	*5.0*	*5.0*	*5.1*	*5.1*	*5.2*	*5.3*	*5.3*
Price per ton		*400*	*410*	*420*	*420*	*420*	*428*	*437*	*446*	*455*	*464*
Late Corn	-	**2,976,750**	**3,444,000**	**3,825,885**	**3,760,315**	**3,785,838**	**3,887,587**	**4,045,000**	**4,152,984**	**4,263,671**	**4,377,123**
Area		*2,100*	*2,100*	*2,100*	*2,050*	*2,050*	*2,050*	*2,050*	*2,050*	*2,050*	*2,050*
Yield		*3.5*	*4.0*	*4.4*	*4.4*	*4.5*	*4.5*	*4.6*	*4.6*	*4.6*	*4.7*
Price per ton		*405*	*410*	*415*	*415*	*415*	*423*	*432*	*440*	*449*	*458*
Alfa alfa	-	**57,000**	**60,000**	**63,000**	**126,000**	**126,000**	**128,520**	**174,787**	**178,283**	**181,849**	**231,857**
Area		*50*	*50*	*50*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Yield		*6.0*	*6.0*	*6.0*	*6.0*	*6.0*	*6.0*	*8.0*	*8.0*	*8.0*	*10.0*
Price per ton		*190*	*200*	*210*	*210*	*210*	*214*	*218*	*223*	*227*	*232*
Sugar Beet	-	**369,600**	**380,800**	**389,200**	**389,200**	**417,000**	**417,000**	**417,000**	**417,000**	**458,700**	**458,700**
Area		*200*	*200*	*200*	*200*	*200*	*200*	*200*	*200*	*200*	*200*
Yield		*28.0*	*28.0*	*28.0*	*28.0*	*30.0*	*30.0*	*30.0*	*30.0*	*33.0*	*33.0*
Price per ton		*66*	*68*	*70*	*70*	*70*	*70*	*70*	*70*	*70*	*70*
SoyBean	-	**345,000**	**345,000**	**345,000**	**345,000**	**345,000**	**345,000**	**360,000**	**360,000**	**360,000**	**360,000**
Area		*150*	*150*	*150*	*150*	*150*	*150*	*150*	*150*	*150*	*150*
Yield		*2.0*	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*
Price per ton		*1,150*	*1,150*	*1,150*	*1,150*	*1,150*	*1,150*	*1,200*	*1,200*	*1,200*	*1,200*
TOTAL PRODUCTION VALUE	-	**8,259,150**	**8,861,980**	**9,371,365**	**9,437,215**	**9,589,098**	**9,804,704**	**10,128,281**	**10,352,234**	**10,622,612**	**10,892,767**
ADJUSTED PRODUCTION VALUE (Based Crop Subsidies)		**9,610,104**	**10,284,898**	**10,853,204**	**11,080,404**	**11,265,705**	**11,507,129**	**11,860,921**	**12,110,692**	**12,418,288**	**12,712,512**

Appendix A2 – Free Cash Flow Calculation

ADJUSTED PRODUCTION VALUE (Based Crop Subsidies)		**9,610,104**	**10,284,898**	**10,853,204**	**11,080,404**	**11,265,705**	**11,507,129**	**11,860,921**	**12,110,692**	**12,418,288**	**12,712,512**
SUBSIDIES for Planting	-	**953,000**	**953,000**	**953,000**	**938,500**	**938,500**	**938,500**	**938,500**	**938,500**	**938,500**	**938,500**
Wheat	-	2,305,405	2,374,567	2,445,804	2,939,041	3,027,212	3,118,029	3,211,570	3,307,917	3,407,154	3,509,369
Barley	-	711,318	732,658	754,637	388,638	400,297	412,306	424,675	437,416	450,538	464,054
Late Corn	-	2,872,464	2,958,638	3,047,397	3,064,085	3,156,008	3,250,688	3,348,209	3,448,655	3,552,115	3,658,678
Alfa alfa	-	111,292	114,630	118,069	243,222	250,519	258,035	265,776	273,749	281,961	290,420
Sugar Beet	-	520,768	536,391	552,483	569,057	586,129	603,713	621,824	640,479	659,693	679,484
TOTAL CROP FARM COSTS	-	**6,521,246**	**6,716,884**	**6,918,390**	**7,204,044**	**7,420,165**	**7,642,770**	**7,872,054**	**8,108,215**	**8,351,462**	**8,602,005**
EBITDA	-	**4,041,858**	**4,521,014**	**4,887,814**	**4,814,860**	**4,784,039**	**4,802,858**	**4,927,367**	**4,940,977**	**5,005,327**	**5,049,007**
EBITDA Margin		*49%*	*51%*	*52%*	*51%*	*50%*	*49%*	*49%*	*48%*	*47%*	*46%*
CAPEX cash outflow	(3,000,000)	(23,724,000)	(1,000,000)								
Free Cash Flow	**(3,000,000)**	**(19,682,142)**	**3,521,015**	**4,887,814**	**4,814,860**	**4,784,040**	**4,802,859**	**4,927,368**	**4,940,978**	**5,005,327**	**5,049,007**
Cumulative Cash Flow		*(22,682,142)*	*(19,161,127)*	*(14,273,313)*	*(9,458,453)*	*(4,674,413)*	*128,446*	*5,055,814*	*9,996,791*	*15,002,119*	*20,051,126*
IRR	*13.8%*										
Payback Period from 2022 (ops)	*5.97*	-	-	-	-	-	*0.97*	*0.03*	*1.02*	*2.00*	*2.97*
		2026	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Free Cash Flow	**(3,000,000)**	**(19,682,142)**	**3,521,015**	**4,887,814**	**4,814,860**	**4,784,040**	**4,802,859**	**4,927,368**	**4,940,978**	**5,005,327**	**5,049,007**
Leasing		4,435,840	1,108,960								
Interest Leasing repayment	8%	(215,713)	(385,964)	(321,170)	(250,998)	(175,002)	(92,698)	(13,372)	(0)	(0)	(0)
Principal Leasing repayment		(367,597)	(780,656)	(845,450)	(915,621)	(991,618)	(1,073,921)	(569,938)	0	0	0
Total loan and interest	0	3,852,530	(57,660)	(1,166,620)	(1,166,620)	(1,166,620)	(1,166,620)	(583,310)	-	-	-
FCF after loan repayment *	**(3,000,000)**	**(15,829,612)**	**3,463,355**	**3,721,195**	**3,648,240**	**3,617,420**	**3,636,239**	**4,344,058**	**4,940,978**	**5,005,327**	**5,049,007**

Appendix A3 – Net Present Value Calculation

			Year1	*Year2*	*Year3*	*Year4*	*Year5*	*Year6*	*Year7*	*Year8*	*Year9*	*Year10*	
		2025	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	
	Shareholder Funds		**22,624,000**										
	Year		-	1	2	3	4	5	6	7	8	9	**NPV**
7%	PV		(22,682,142)	3,290,668	4,269,206	3,930,360	3,649,721	3,424,372	3,283,313	3,076,992	2,913,146	2,746,326	**$7,188,750.25**
	Cumulative Cash Flow PV		*(22,682,142)*	*(19,391,474)*	*(15,122,268)*	*(11,191,908)*	*(7,542,187)*	*(4,117,815)*	*(834,501)*	*2,242,491*	*5,155,637*	*7,901,963*	
	Payback Period from 2022 (ops) PV	*6.27*	-	-	-	-	-	-	-	0.3	0.8	1.9	
8%	PV		(22,682,142)	3,260,199	4,190,513	3,822,191	3,516,412	3,268,745	3,105,078	2,883,013	2,704,223	2,525,761	**$5,883,325.90**
	Cumulative Cash Flow PV		*(22,682,142)*	*(19,421,943)*	*(15,231,430)*	*(11,409,239)*	*(7,892,827)*	*(4,624,082)*	*(1,519,004)*	*1,364,009*	*4,068,231*	*6,593,992*	
	Payback Period from 2022 (ops) PV	*6.53*	-	-	-	-	-	-	-	0.5	0.5	1.6	
9%	PV		(22,682,142)	3,230,289	4,113,975	3,717,955	3,389,134	3,121,529	2,938,028	2,702,884	2,512,005	2,324,703	**$4,677,395.88**
	Cumulative Cash Flow PV		*(22,682,142)*	*(19,451,853)*	*(15,337,878)*	*(11,619,922)*	*(8,230,788)*	*(5,109,259)*	*(2,171,231)*	*531,653*	*3,043,658*	*5,368,362*	
	Payback Period from 2022 (ops) PV	*6.80*	-	-	-	-	-	-	-	0.8	0.2	1.31	
10%	PV		(22,682,142)	3,200,922	4,039,516	3,617,476	3,267,563	2,982,198	2,781,371	2,535,503	2,335,022	2,141,272	**$3,562,455.24**
	Cumulative Cash Flow PV		*(22,682,142)*	*(19,481,219)*	*(15,441,703)*	*(11,824,228)*	*(8,556,664)*	*(5,574,467)*	*(2,793,096)*	*(257,593)*	*2,077,429*	*4,218,701*	
	Payback Period from 2022 (ops) PV	*7.11*	-	-	-	-	-	-	-	-	0.1	0.97	
11%	PV		(22,682,142)	3,172,085	3,967,060	3,520,584	3,151,395	2,850,263	2,634,372	2,379,863	2,171,944	1,973,782	**$2,530,817.29**
	Cumulative Cash Flow PV		*(22,682,142)*	*(19,510,057)*	*(15,542,997)*	*(12,022,413)*	*(8,871,018)*	*(6,020,755)*	*(3,386,382)*	*(1,006,519)*	*1,165,425*	*3,139,207*	
	Payback Period from 2022 (ops) PV	*7.46*	-	-	-	-	-	-	-	-	0.5	0.59	

Appendix A4 – Leasing Cost Calculation

Annual Interest Rate	8%
Loan term (months)	72
Grace Period (months)	0
Investment	27,724,000
Share of Bank financing	**20%**

	0	1	2	3	4	5	6	7	8	9	10	Total
New bank Loan	5,544,800	5,177,203	4,396,547	3,551,098	2,635,477	1,643,859	569,938	-	0	0	0	
Total Debt Service	583,310	1,166,620	1,166,620	1,166,620	1,166,620	1,166,620	583,310	-	-	-	-	
Interest	215,713	385,964	321,170	250,998	175,002	92,698	13,372	0	0	0	0	
Principal	367,597	780,656	845,450	915,621	991,618	1,073,921	569,938	(0)	(0)	(0)	(0)	
Bank Loan Balance	5,177,203	4,396,547	3,551,098	2,635,477	1,643,859	569,938	-	0	0	0	0	