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Master Thesis

Cost-Benefit Analysis of Farming Investment Project

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Declaration

I declare that I have worked on my master study titled Cost-Benefit Analysis of Farming Investment Project by myself and I have used only the sources mentioned at the end of the study. As the previous studies of the bachelor study, I declare that the study does not break any copyrights.

In Prague on **29th November 2023**

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Cost-Benefit Analysis of Farming Investment Project

Abstract

The Indian government's initiative to incorporate small-scale farmers in Santalpur as suppliers of Ratanjot, an indigenous plant for biofuel production, was analyzed for its societal costs and benefits. The study aimed to assess welfare changes and develop a government cash flow model that assessed the net advantages of the project in relation to the whole national economy. The cost-benefit analysis was used to evaluate the welfare changes experienced by the target demographic and suggest alternative initiatives. The financial analysis showed that the current situation failed to adequately offset the farmer's investment. However, the alternative project demonstrated positive overall and incremental net benefits, indicating that the expenses associated with investment and operations would be adequately offset. The cash flow figures of both the current and prospective government programs indicated a cumulative deficit. The alternative proposal exhibited a positive additional net benefit, with an individual-level net present value of positive, indicating a greater increase compared to the current situation. At the macroeconomic level, the project's incremental net benefit had a positive net present value, indicating a positive contribution to the whole national economy. The study concluded that the current government's plan lacks adequate financial incentives to encourage farmers' participation in the project. However, the anticipated change in net revenue resulting from the alternative project is favourable, covering both the original investment and ongoing operational expenses. The findings could serve as a paradigm for future assessments of governmental investments aimed at supporting sustainable development among impoverished communities.

Keywords: Cost-Benefit Analysis, Investment Project, Farming Project, Sustainable Operations, Cash Flow

Title

Abstrakt

Iniciativa indické vlády začlenit drobné farmáře v Santalpuru jako dodavatele Ratanjotu, původního závodu na výrobu biopaliv, byla analyzována z hlediska jejích společenských nákladů a přínosů. Cílem studie bylo posoudit změny v blahobytu a vyvinout vládní model peněžních toků, který posoudil čisté výhody projektu ve vztahu k celému národnímu hospodářství. Analýza nákladů a přínosů byla použita k vyhodnocení změn v blahobytu, které zažívá cílová demografická skupina, ak navržení alternativních iniciativ. Finanční analýza ukázala, že současná situace nedokázala dostatečně kompenzovat investice zemědělce. Alternativní projekt však prokázal pozitivní celkové a přírůstkové čisté přínosy, což naznačuje, že náklady spojené s investicemi a provozem by byly adekvátně kompenzovány. Údaje o peněžních tocích současného i budoucího vládního programu naznačovaly kumulativní deficit. Alternativní návrh vykazoval kladný dodatečný čistý přínos, přičemž čistá současná hodnota na individuální úrovni byla kladná, což naznačuje větší nárůst ve srovnání se současnou situací. Na makroekonomické úrovni měl přírůstkový čistý přínos projektu kladnou čistou současnou hodnotu, což značí pozitivní přínos pro celé národní hospodářství. Studie dospěla k závěru, že plán současné vlády postrádá dostatečné finanční pobídky, které by podpořily účast zemědělců na projektu. Očekávaná změna čistých příjmů vyplývající z alternativního projektu je však příznivá a pokrývá jak původní investice, tak průběžné provozní náklady. Zjištění by mohla sloužit jako paradigma pro budoucí hodnocení vládních investic zaměřených na podporu udržitelného rozvoje mezi chudými komunitami.

Klíčová slova: Analýza nákladů a přínosů, investiční projekt, zemědělský projekt, udržitelný provoz, peněžní tok

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10. Introduction

The study evaluates a investment farming project in Santalpur, Gujarat, involving Indian small farmers producing Ratanjot as feedstock for biofuel. The project is unique due to its low-income group, dry climate, low rainfall, and low input farming process. The study aims to determine the viability of this project and the welfare improvements it could bring. Rural poverty is a significant issue in Gujarat, with 94% of households living in poverty conditions and 52% in extreme poverty. (Desai, 2022)

The Indian government proposes a farming program that involves collecting native oil seeds from Ratanjot growing in living fences and selling them to government wholesalers. However, this project is proposed as an alternative to the current government program, focusing on cultivating Ratanjot instead of collecting fruit from living fences. The study compares income differences between two settings: without the project and with the project. The welfare changes are evaluated using Pareto efficiency, which considers the change in total income for the participant agents. (Singh, 2021)

The project incorporates principles of sustainable farming, such as minimal mechanical disturbance to the soil, maintenance of organic residual matter, and cropping patterns that include rotations and diversification. The project's success depends on the social and economic traits of the small farmers, who own a small area of land, low productivity, and a small capital stock. The relevance of including sustainable practices in the production chain of biofuel is discussed, with the compatibility of the small farmers' background and sustainable farming process and how this scenario addresses current global issues. (Kumar & Singh, 2022)

Target Population

Rural populations in Gujarat face significant challenges, with social and economic indicators showing a gap between rural and urban realities. In 2022, the average personal salary in urban areas was USD 560 per month, while in rural areas it was USD 318. Extreme poverty in rural areas is more severe than in cities, with 23% of rural households living in extreme poverty in 2016. In 2022, the lowest earning segment of the rural population received USD 19 of monthly income, while for urban inhabitants it was USD 48. In Santalpur, the province where the proposed project takes place, there is no improvement relative to the national data. (Rao & Shah, 2022)

The percentage of the population in extreme poverty is 40% for rural inhabitants, while for urban it is 30%. The situation also suggests an urgent need for government investment to improve living conditions and housing infrastructure. The socio-economic conditions in Santalpur are critical, with three-quarters of the labour force not fully employed. The target population in Santalpur is characterized by a low opportunity cost for farmers' land, a small capital stock, and labour to cover farm operations. The study focuses on farmers in Santalpur, focusing on those owning fewer than ten hectares and evaluating economic feasibility using a model farm size of six hectares. (Joshi & Patel, 2022)

Table 1 - Land Ownership in Santalpur

Land Ownership in Santalpur, Gujarat.									
Land tenure (in hectares)									
Proprietorship by farm size	Total hactor	Percentage of total area	Self- owned	Occupied with title	Rented	Shared cropping	Coop	Other type	Mixed- tenure
Fewer than 10 hactor	215609	14	127085	20324	4980	1059	437	20805	40920
10 to fewer than 50 hactor	693909	24	515586	45428	8418	4367	1587	38558	79967
50 to fewer than 100 hactor	425349	17	355652	15266	8039	3477	1035	13817	28065
100 hactor and above	1040570	46	929091	18386	5442	962	10313	37776	38601
Total hectares by land tenure type			1927413	99402	26879	9864	13371	110955	187553
Percentage of tenure type to total			71	6	2	1	1	7	11
Percentage of size category to total by tenure type			10	15	16	16	6	19	19

Reference - Government Report (2022)

Another component of the farmer's endowment is the allocation of labour. As stated, the operational procedure described in this study leverages human labour rather than mechanical input. The present study has posited the assumption that agricultural activities adhered to the prescribed principles of sustainable farming methods, as delineated by the Food and Agriculture Organization. The use of sustainable farming practices allows farmers to engage in agricultural activities without relying on mechanical inputs. Consequently, the initial investment required is much less. The ultimate component inside the endowment is represented by capital stock. (Singh & Patel, 2023)

Table 2 - Farm Size Category

Number of producers per farm size category							
Farm Size	**Fewer than 10 Hactor**	**10 to fewer than 20 Hactor**	**20 to fewer than 50 Hactor**	**50 to fewer than 100 Hactor**	**100 to fewer than 200 Hactor**	**200 Hactor and above**	**Total**
Number of producers	70928	14432	16046	6258	2654	1697	112013
Percentage to total	61	11	13	8	4	2	

Reference - Government Report (2022)

The suggested project exhibits two distinct distinguishing characteristics. The opportunity cost of land is conditioned by the geographical environment. Furthermore, the farmers own a set of resources for production. They have ownership of both physical assets like capital stock and natural resources like land. Furthermore, farmers will contribute manual labour. The subsequent part will provide an overview of the project being implemented in region, including policy framework and commercial strategy. (Patel, 2022)

Sustainable Farming

Rural populations in Gujarat face significant challenges, with social and economic indicators showing a gap between rural and urban realities. In 2022, the average personal salary in urban areas was USD 560 per month, while in rural areas it was USD 318. Extreme poverty in rural areas is more severe than in cities, with 23% of rural households living in extreme poverty in 2016. In 2022, the lowest earning segment of the rural population received USD 18 of monthly income, while for urban inhabitants it was USD 49. In

Santalpur, the province where the proposed project takes place, there is no improvement relative to the national data. (Sheth & Trivedi, 2022)

The percentage of the population in extreme poverty is 46% for rural inhabitants, while for urban it is 30%. The situation also suggests an urgent need for government investment to improve living conditions and housing infrastructure. The socio-economic conditions in Santalpur are critical, with three-quarters of the labour force not fully employed. The target population in Santalpur is characterized by a low opportunity cost for farmers' land, a small capital stock, and labour to cover farm operations. The study focuses on farmers in Santalpur, focusing on those owning fewer than ten hectares and evaluating economic feasibility using a model farm size of six hectares. (Kumar & Patel, 2023)

Resource Significance

The Indian government has chosen Ratanjot due to its abundance and potential for biofuel production. The study focuses on the socio-economic aspects, climate and soil conditions, and non-intensive farming process. Ratanjot's resilience, resistance to unfavourable climate, and ability to produce in low-quality soils are key factors in its economic feasibility. The government has identified seventeen million hectares of marginal lands for Ratanjot cultivation, which can be rehabilitated and integrated into the biofuel supply chain. (Singh et al., 2022)

Ratanjot is a perennial crop with a 30 to 40 years productive span, making it a low-cost option for small farmers. Its minimal maintenance and minimal mechanical input also contribute to its sustainability. The plant's resistance to water scarcity is particularly beneficial for the targeted group, which does not rely on irrigation infrastructure. The study concludes that Ratanjot is a crucial entry in the productive process, with its attributes contributing to its success. (Singh & Kumar, 2021)

Methodological Aspects

This study uses Cost-Benefit Analysis to assess the economic feasibility of private projects or government policies, calculating the impact on society. CBA quantifies policy impacts in monetary terms, comparing the cost of inputs to the benefit from outputs. It is an objective method for assessing resource allocation. The Farm Investment Analysis is a specific methodology for farming initiatives, focusing on resources and outputs in four categories: land, labour, financial capital, and production. The data calculates incremental benefits for the project's duration, comparing net benefits to the status quo. (Kumar & Singh, 2023)

Problem Statement

This study aims to evaluate the economic feasibility of a farming project involving Ratanjot cultivation as biofuel feedstock. The research will focus on sustainable farming practices and small farmers involved in a government program in Ahmedabad. The government's initiative involves collecting Ratanjot from living fences to produce biofuel, but no quantitative analysis supports this assumption. The study will evaluate the income improvement for rural inhabitants and propose an alternative program where farmers cultivate Ratanjot instead. The research will also survey current policies supporting the project and make recommendations.

11. Objectives and Methodology

2.1 Objectives

The aim of the thesis is to carry out cost-benefit analysis of farming investment projects Ratanjot (Alkanet) in Santalpur region in India. Santalpur region is known for agriculture based project, which covers 186 square kilometre area. (Gujarat Government Report, 2023) This study aims to achieve three objectives. Initially, a comprehensive financial study will be conducted to ascertain whether there exist any financial incentives for farmers to participate in the proposed initiative, as opposed to adhering to their present livelihood practices. Additionally, the Cost-Benefit Analysis (CBA) will assess the impact on welfare for the farmers involved. The assessment of the incremental net benefits arising from the present and prospective initiatives is crucial in determining the potential for income growth among the participating farmers. Thirdly, doing an assessment of the government's sources of revenue and expenditures will determine whether its distribution of resources is favourable. This study will conduct a comprehensive examination of the current policies that have the potential to contribute to the success of the project and propose modifications or additions, as necessary. The objective of this study is to assess the policy framework pertaining to small-scale farmers. Do the institutions, legislation, and programs effectively support and facilitate the development of this sector?

The present study aims to investigate the following research questions: Do the present and prospective initiatives demonstrate economic feasibility within the given context? Can the practice of sustainable farming as recommended by the Food and Agriculture Organization be economically feasible? Is Ratanjot considered to be a plant with high productivity in challenging environmental conditions? Do beneficial improvements occur in the welfare of the participating population? Are individuals motivated to participate in this program? Do the government's resource allocations demonstrate effectiveness? Does the overall societal benefit justify the costs incurred? Which policies and government initiatives contribute to the success of the project? Do government interventions effectively support a weak industry in Gujarat? What potential additions or omissions can be made?

2.2 Methodology

Theoretical part is processed based on the document analysis. Empirical part uses method and techniques of cost-benefit analysis. The detailed methodology includes data sources, economic valuation, land usage, cropping pattern, labour usage, labour requirements, crops calendar, farm production, investment pattern, financing, debt and government intervention.

Data Sources

The study used two sources to construct the socio-economic background of the target group in Santalpur, Gujarat. The National Farming Census and the Survey of Farming Areas and Continuous Production provided data on production, crops, farming practices, landownership, and the socio-economic background of farming producers and their families. The references provided more current information about production and land use, while the Process of National Information for Farming aggregated database from the Indian Ministry of Farming contained information about the production chain and marketing of main farming products. The study also collected cost data for farming inputs, such as fertilizers, herbicides, and pesticides, and seed cost. (Patel & Kachhadiya, 2022)

The price of maize was set by the Indian government, while Ratanjot and peanut prices were set by government wholesalers at the point of sale. The study also projected future prices of inputs and outputs using historical data from the Central Bank of Gujarat and the National Institute of Statistics and Census. For future output prices, the study calculated the average annual variation of price indexes in real terms, using the rate of inflation to estimate the future value of the corresponding item. For input costs, the study referred to the Producer Price Index published by the National Institute of Statistics and Census and calculated annual variation to project future quotes. (Kumar et al., 2021)

Economic Valuation

The structure called Farm Investment Analysis, which is divided into three areas: farm resource use, farm production, and farm inputs. The analysis evaluates production factors, labour requirements, output, and capital requirements. The farm budget, which displays yearly expenses and earnings for the farm family, determines financial incentives for participants, including net benefits, annual incremental earnings, and project net worth. The incremental net benefit is calculated as the difference between net benefits before the project implementation and projected net benefits with the proposed project. The incremental net benefits represent the net national income change that the proposed project will add to or subtract from the whole economy. (Indian Council of Agricultural Research, 2023)

Land Usage

The land use section of a proposed project in Santalpur aimed to distribute farm area to each farming activity. The design was based on literature and socio-economic information from the various sources. The first step was to determine the size of the model farm, which was reviewed using data on land tenure and farm sizes in Santalpur. The research focused on farms with areas under ten hectares, which represented 12% of the total cultivated area. The most common type of tenure was privately owned farms, representing 78% of the total. The study selected privately-owned farms with fewer than ten hectares and calculated the mean farm size of six hectares. (Patel et al., 2022)

Cropping Pattern

The study focuses on designing a cropping pattern for a model farm in Santalpur, India, considering sustainable farming principles and maintaining the usual practices in the target area. Perennial and annual crops are the two major land uses in Santalpur, with most cultivated land producing annual crops. Intercropping patterns that include Ratanjot, peanut, and maize are recommended by numerous studies. Maize is the most widely cultivated annual crop in Santalpur, and it can be cultivated and harvested during the rainy season, making it suitable for rain-fed plantations. (Patel & Patel, 2022)

The proposed cropping pattern includes Ratanjot, peanut, and maize, with plant spacing specified from publications in the targeted area. The original land use structure in Santalpur is not explicitly mentioned, but farmers dedicate half of their land to annual crops. The farms under study were larger as 12.5 hectares in average and included pasture for cattle, fallow land, and a forest area. The original land use structure would contain an area for cultivation of annual crops, an area dedicated to agroforestry, an area of forest and fallow land, a pasture, and a house plot. (Mishra & Shukla, 2021)

Labour Usage

The literature review on the proposed project for Ratanjot focuses on farm operations and monthly tasks to determine labour requirements. The study found data based on experimental settings, such as government research centres, which were compatible with the cropping process and climatic conditions in the targeted area. However, publications indicating best practices for maize and peanut in small scale settings were numerous and considered the climatic conditions in the targeted area. (Government of Gujarat, 2022)

Labour requirements for the original operation process were estimated using guidelines for agroforestry processes, including cattle and maize production, and for peanut cultivation. The study assumed that only one working time from one family member was available for farm operations. Labour requirements more than what the farm family provides would be considered hired labour. The operation process was determined by field preparation and planting in sustainable farming processes, which incorporate different farming tools and techniques. (Food and Agriculture Organization of the UN, 2022)

Labour Requirements

The labour use section of the text focuses on monthly labour requirements for each crop, using various method to identify time-consuming farm operations and critical months for labour input. The land use calendar is constructed for both the proposed cropping pattern and the pattern without the project. The study uses literature to find recommendations for each crop, including practices for annual crops and livestock, fertilization, weed control, pest control, and harvesting. The proposed project assumes sustainable farming principles, involving minimal tillage, direct planting, chemical and manual weeding, and pruning of Ratanjot trees. (Mishra et al., 2022)

Crops Calendar

This study reviews best farming practices for maize and peanut in a targeted area. For Ratanjot, the propagation method is direct seed sowing, and planting should occur in January. Field maintenance tasks vary with plantation development, with weeding, manual weeding, and chemical control recommended. Chemical weed control should be scheduled by the end of February, followed by manual weeding once per month and every five weeks during the dry season. Pruning should be done once annually, starting in September. Fertilization requirements change with Ratanjot tree development, with higher requirements during the first year. (Ministry of Agriculture and Farmers Welfare, 2022)

Pest and disease management is crucial for plantation establishment and future productivity. Annual crops like peanut and maize can be attacked by diseases and insects, reducing yields. Fumigation is recommended for these crops, and it should be applied as soon as symptoms or insects appear. Ratanjot trees should be harvested in April, and post-harvest operations like peeling and drying are necessary for all three crops. For maize, grain removal is mechanically done, while for peanut, post-harvest tasks require more time. Post-harvest operations for Ratanjot and annual crops require three workdays per hectare. (Kumar et al., 2022)

Farm Production

The study presents expected yields per year for each product on the farm, focusing on Ratanjot trees. The literature reviewed does not provide a yield per hectare for Ratanjot that fits the conditions in this study, as farming practices and climatic conditions significantly affect plantation performance. Intercropping patterns are also considered, as most studies were directed to monocultures. To obtain reliable data, a survey of studies was conducted, including factors such as lack of irrigation, climate type, and low farming input. Researchers have reported varying yields for different conditions. (Government of Gujarat, 2022)

However, the current study assumes an average annual dry seed yield of 2100 Kg per hectare in stable production from years five to thirty. For maize, the expected yield is 6100 Kg per hectare, while for peanut, it is 2800 Kg per hectare. To calculate changes in welfare, the study assumes that the model farmer uses the same seed for maize and peanut in the status quo and in the proposed project. The yield for annual crops is the same in the status quo as in the proposed project. For Ratanjot, the model farmer collects ripe fruit from existing living fences, which would give an average yield per hectare of 1400 Kg. (Government of Gujarat, 2022)

Production & Valuation

The study focuses on the expected yearly production of Ratanjot cultivation in Gujarat, India. The yield per hectare per crop is calculated by multiplying the yields by the area dedicated to each crop. The estimated production is 200 Kg per year, with cattle included for simplicity and the land use structure in the status quo being transferred to the intercropping process. To project the production's yearly value for the project's duration, prices for all items involved in the farm investment analysis are stated. (Patel et al., 2022)

Labour costs are collected at the target area in 2021, with the selected price for labour being USD 30 per workday. The daily wage is calculated using historical data from the Indian Central Bank. The study also examines maize and peanut prices in Santalpur, determining the most probable price for each crop according to harvest time. Government policy establishes minimal prices for maize sold to wholesalers, which sets a floor under the farm gate price of maize. (Singh & Kumar, 2022)

The World Bank issues a monthly collection of international commodity price indices in its pink sheet report, with a baseline annual variation of 10%. Ratanjot pricing shows an entirely different situation, as there is no actual domestic market for this seed, only the direct demand from Ahmedabad city electric stations. The government sets up the farm-gate price for the product, with a minimum annual percentage of 10%. The mean value of the reported price per kilogram for each animal is calculated. (Patel & Desai, 2021)

Investment Pattern

The studies identified investment categories in farming projects, including land improvement tasks, constructions, equipment acquisitions, and livestock purchases. Land improvement activities involve clearing forest vegetation and establishing pastures, while pasture improvement is not considered. The study based on the Map of Land Cover of Santalpur, which indicates that most land corresponds to cultivated pastures. The investment costs for land clearing and pasture improvement are included. Existing farming tools are assumed to be acquired as an investment, while existing capital includes one fumigation pump and one drying facility. (Sharma & Singh, 2021)

Operating Expenditure

The study aims to calculate total operating expenditures for a project's duration by estimating operating expenditure per hectare. It reviews Indian publications that provide cost assessments for maize and peanut cultivation. The operating expenditure categories are defined using historical datasets and input costs. The methodology includes land and labour use specifications, input costs, and depreciation accrual. The methodology recommends accounting for only hired labour requirements more than family input. The next steps involve forecasting total operating expenditures for the project's duration and setting up the farm budget. (Kumar & Patel, 2022)

Financing & Debt

The model farmer is proposed to engage in a loan at the end of year last year, receive funds before starting the project, and start servicing debt at the end of next year. The repayment period is two years, with two equal instalments for half of the loaned capital. The farmer is offered a micro credit by the Indian Bank of Development, which offers an annual nominal interest rate of 18% for loans up to USD 7000. The loan corresponds to 100% of the investment cost, 100% of the working capital, and 55% of operating expenditure for Ratanjot. The net benefit after financing represents the farm family's net benefit, equivalent to their yearly income. (Sharma & Singh, 2022)

Government Interaction

The government cash flow analysis aims to provide an accurate statement of government expenditures and income sources for a comprehensive assessment of fiscal effects related to a project. The data source for this analysis describes the government's program, including industrial and farming components. The research focuses on farming production, excluding income and expenses from industrial processing. Inflows include charges on beneficiaries, new tax revenues, surplus or profit on sales, and foreign loans, while outflows include initial capital expenditure, loans, equity positions, recurrent costs, and infrastructure costs. (Patel & Desai, 2021)

Financial Prices

The farm budget is a financial analysis that estimates the net income change expected after a proposed project. It involves re-evaluating project accounts with prices reflecting the value of used resources, adjusting efficiency prices to eliminate direct and indirect transfers, and adjusting financial prices based on opportunity cost and willingness to pay. Market prices are considered a good measure of economic value for all but one case of non-traded items. The study analysed the economic value of items in Gujarat, including maize, peanut, livestock, and Ratanjot dry seed. Input costs were adjusted in investment and operating expenditures accounts, including rental of machinery and equipment. (Ministry of Agriculture and Farmers' Welfare, 2021)

12. Literature Review

3.1 Farming Project Description

Ratanjot, a tree known for its oil-rich seeds suitable for biodiesel production, originally hails from tropical regions in the Americas. Over time, it has extended its presence across the globe, establishing itself in areas characterized by tropical and subtropical climates, particularly in Asia and Africa. Interestingly, Ratanjot has also demonstrated its adaptability to semi-arid landscapes. In Gujarat, India, Ratanjot is a native plant that thrives in diverse climatic conditions, ranging from semi-arid to humid environments and spanning various altitudes, from sea to elevations of up to 1,500 meters. (Goswami & Vohra, 2022)

The selection of Ratanjot as a biofuel feedstock is attributed to its myriad advantages. It boasts reduced input requirements in comparison to other energy plants, such as the Indian oil palm. Consequently, this leads to lower investment and maintenance costs, promoting the integration of sustainable energy crop cultivation. Ratanjot exhibits productivity even in marginal lands, including semi-arid regions and degraded soils, while also displaying minimal water requirements. Notably, the tree can thrive in rain-fed plantations, making it a viable choice in areas lacking irrigation facilities. (Sharma et al., 2022)

As a result, Ratanjot plantations can be implemented in lands with minimal opportunity costs, without compromising food production. Furthermore, the characteristics of Ratanjot align with the principles of sustainable farming, which serve as the foundation for the project proposed in this study. The current study introduces a project rooted in sustainable farming techniques, a concept championed by the Food and Agriculture Organization (FAO) of the United Nations as a means of fostering both environmental sustainability and profitability in agriculture. (Vyas & Singh, 2022)

The FAO underscores three fundamental principles of sustainable farming. Firstly, there is an emphasis on minimizing soil disturbance, encompassing practices that require minimal or zero tillage. Secondly, the preservation of a layer of residual organic matter to cover the soil is advocated, with the aim of providing nutrients from this organic matter and maintaining soil moisture. Additionally, this decomposition process sustains microorganisms and fauna, fulfilling the soil-mixing function typically associated with conventional tillage. (FAO Report, 2022)

3.1.1 Theoretical Framework

To begin with, sustainable farming advocates for the implementation of crop rotation and intercropping strategies, primarily aimed at managing pests, diseases, and the preservation of soil nutrients. In the context of our current research, the adoption of sustainable farming practices serves a dual purpose. Firstly, it leads to cost reductions, and secondly, it results in a shift from reliance on mechanical inputs to manual labour. Within the scope of our proposed project, these techniques offer a valuable advantage, especially considering the availability of manual labour alongside limited access to mechanical resources and financial capital. (Kishor & Ganguly, 2021)

Sustainable farming promotes diversified planting schemes and crop rotation as essential components of an integrated management approach. This holistic approach not only enhances farming practices but also integrates them seamlessly into household activities. Consequently, farmers can fulfil their economic needs while adhering to sustainable farming principles. These practices bring about a range of positive effects in plantation management. They help reduce weed growth, control pests and diseases, improve the retention of soil nutrients, boost microbial activity, and enhance soil moisture. (Gomiero et al., 2021)

Over the long term, sustainable farming ensures the maintenance of soil nutrients through efficient matter recycling and microbial activity. In the specific plantation pattern proposed within this study, this study suggest the intercropping of Ratanjot, maize, and peanuts. Intercropping proves to be a more economically viable option for small-scale producers compared to monoculture plantations. By cultivating annual crops like maize and peanuts alongside Ratanjot, farmers can generate income during Ratanjot's low-productivity growth stages. (Mondal et al., 2021)

Additionally, existing literature strongly supports crop rotation as an effective strategy for pest and disease control. Studies indicate that rotating crops can disrupt the disease cycle and enhance soil nutrient diversity. Monoculture plantations of Ratanjot, on the other hand, are susceptible to higher pest incidence. Therefore, sustainable farming practices translate into reduced expenses on fertilizers and pesticides. Embracing rotational cultivation methods allows farmers to reduce their reliance on insecticides for pest and disease management, leading to significant cost savings. (Singh et al., 2021)

Furthermore, adopting sustainable farming practices aligns with economic imperatives, yielding cost reductions in various areas. Notable areas of cost reduction include decreased maintenance costs due to reduced labour and mechanical input requirements, as well as savings on farming inputs through sustainable resource management. Sustainable farming techniques also result in cost savings during field preparation tasks, with a substantial portion of investment costs stemming from activities like tillage and digging. (Smith et al., 2022)

3.1.2 Historical Perspective

The adoption of minimal and zero tillage techniques within sustainable farming processes has resulted in a significant reduction in the time required for site preparation activities. Furthermore, sustainable farming practices emphasize a greater reliance on manual labour as opposed to mechanical inputs. Field preparation tasks encompass practices such as no-tillage or minimal tillage, minimal land clearing, and direct planting, all of which can be efficiently carried out through manual labour. (Brown et al., 2020)

This shift not only saves costs by eliminating the need to rent or acquire mechanical equipment for site preparation but also addresses the issue of underutilized labour in the targeted area, where capital investment can be prohibitively expensive. Transitioning from mechanical input to manual labour represents a reduction in both initial investment and ongoing maintenance expenses. In addition to these economic advantages, sustainable farming techniques contribute to enhanced farming performance and the long-term sustainability of resources. These processes notably boost soil fertility, resulting in increased yields over time. (Patel et al., 2023)

Moreover, sustainable farming practices effectively mitigate soil erosion and reduce downstream sedimentation. The conservation of fauna, soil moisture, soil structure, and nutrients is also facilitated through sustainable tillage practices. Conversely, conventional tractor-based tillage methods have been identified as culprits responsible for drying the upper soil layer, harming fauna, and disrupting soil structure. By prioritizing the sustainability of natural resources, farmers can reduce their reliance on external inputs to maintain plantation performance, leading to cost reductions. (Sharma & Kumar, 2021)

The current study underscores that Ratanjot farming performance aligns well with sustainable farming recommendations due to the plant's inherent resilience and minimal maintenance requirements. Although numerous publications have documented Ratanjot's performance, the variability of natural landscapes in which these studies were conducted has hindered the establishment of standardized farming indicators. The following section delves into an examination of the plant's performance as reported in the literature, along with its distinctive attributes. (Singh & Rana, 2022)

Within the context of implementing sustainable farming processes, three critical aspects of Ratanjot cultivation emerge: field operations, fertilization requirements, and suitability for intercropping. Implementing sustainable agricultural practices involves a conscious choice to employ manual labour instead of machinery during field preparation to minimize soil disruption. Consequently, the project's farm operation design aimed to utilize the workforce of farmers for all essential tasks. (Kumar & Singh, 2021)

An examination of labour utilization highlighted that the most time-intensive activities in farming were field preparation and plantation maintenance. Numerous publications focused on Ratanjot cultivation stressed the importance of minimal tillage and recycling residual plant matter. Considering this guidance, the strategy for field preparation encompassed minimal tillage in the first year, transitioning to zero tillage from the second year onward. Additionally, land preparation tasks involved minor land clearing and the creation of pits. (Singh & Rana, 2023)

The maintenance of the plantation encompassed activities such as weeding, both chemically and manually, and the careful pruning of Ratanjot trees. Another pivotal distinction between sustainable and commercial farming practices pertains to fertilization. Sustainable farming advocates for the maintenance and enhancement of soil nutrition through the incorporation of residual organic matter, reducing the reliance on chemical inputs. During this period, when Ratanjot plants exhibit accelerated growth, chemical fertilization is required. (Rawat et al., 2021)

However, once the plantation is established, it becomes feasible to replenish soil nutrients using Ratanjot's residual matter, as these trees contribute nutritious content through fallen leaves and pruned twigs. As evidenced by data, fallen leaves contain several essential elements, including nitrogen, phosphorus, potassium, sulphur, calcium, and magnesium. Additionally, the cake left over from oil processing can be repurposed as organic fertilizer. This fertilization method aligns with sustainable farming principles while simultaneously reducing the reliance of small-scale farmers on costly chemical inputs, mitigating potential financial vulnerabilities. (Sharma et al., 2020)

3.1.3 Current Trends

Cultivating Ratanjot also aligns with sustainable farming principles due to its compatibility with intercropping. Research originating from the region under investigation in this study has advocated for intercropping on family farms. Ratanjot proves to be a suitable candidate for intercropping alongside short-term crops like maize and peanuts, as well as integration into agroforestry systems. It is imperative to assess the agronomic performance of Ratanjot within the framework of sustainable farming. A comprehensive literature review should affirm the feasibility of achieving productivity while adhering to sustainable farming practices. (Government of India Report, 2022)

Furthermore, the operational approach must make efficient use of available resources while minimizing reliance on costly or scarce factors, particularly considering the focus on sustainable farming. For instance, labour from family members should constitute the primary workforce for managing the 6-hectare model farm, given the limited availability of financial capital. Reduction of farming inputs is essential considering these constraints. Additionally, since irrigation infrastructure is lacking in the target area, Ratanjot cultivation should exhibit resilience to water scarcity. In this context, two key performance indicators stand out: water requirements and seed yield. (Kumar & Sharma, 2021)

Most scholars concur that Ratanjot requires modest water inputs for commercial production. Mature plants thrive with a minimum annual rainfall of five hundred millimetres, ideally receiving 700 to 800 millimetres. Consequently, rain-fed plantations appear feasible, with numerous publications documenting Ratanjot's performance in such conditions. However, during the initial year of establishment, it is advisable to maintain adequate soil moisture. Several previous studies recommend commencing plantation during the first seasonal rains and supplementing water for young plants throughout their inaugural year. (Singh et al., 2021)

Irrigation infrastructure is not a standard resource for farmers, leading them to rely on rain-fed plantations to meet their agricultural needs. The productivity of Ratanjot under sustainable farming practices remained uncertain, with existing research cantered on commercial plantations. These commercial ventures differ significantly from sustainable farming due to their heightened operational intensity and practices, demanding more labour, financial capital, and natural resources. (Shukla et al., 2022)

In the context of India's biodiesel production from Ratanjot, sustainable methods were seen as a partial source of raw material. An initial source indicated an expected seed yield of three tonnes per hectare. Nevertheless, it is crucial to consider numerous factors when estimating our model's productivity. Climatic conditions were recognized as a critical determinant of plantation performance, with varying yields observed under different conditions. For example, in a semi-arid climate in India, a seed yield of one tonne per hectare was reported, contrasting with 1.75 tonnes per hectare in areas experiencing higher annual precipitation than the focus of this study. (Negi et al., 2023)

Annual yields ranged from two to three tonnes per hectare in semi-arid regions to as high as five tonnes per hectare in optimal conditions. One study concluded that a reasonable expected annual yield should fall within the range of four to five tonnes per hectare. Information on seed yield varied, depending on local conditions. Furthermore, the review confirmed that Ratanjot could be highly productive when following the proposed operational processes. Several factors supported this notion. Firstly, Ratanjot required minimal maintenance, including low water requirements, allowing for rain-fed plantations. (Yadav et al., 2021)

Additionally, initial chemical fertilization was only necessary during the first year, as subsequent soil nutrient maintenance could be achieved through residual matter from Ratanjot trees and the use of seed cake as an organic fertilizer. Thirdly, Ratanjot could be successfully cultivated in intercropping patterns, as recommended by publications from the area of focus. The subsequent examination delves into the assessment of land allocation trade-offs between food production and biodiesel cultivation. It scrutinizes the circumstances that incentivize farmers to transition from food cultivation to biofuel production. (Kumar & Sharma, 2021)

Furthermore, it acknowledges the potential impact of government policies on farming profitability. Both facets hold significant relevance within the context of this study. Following this analysis, the study proceeds to explore diverse methodologies for evaluating farming initiatives that employ Ratanjot as a feedstock for biofuel, under conditions akin to those presented in the current research. This investigation encompasses a comprehensive survey of approaches to ascertain the intrinsic value of farming projects with a specific focus on biofuel production, particularly those involving Ratanjot. (Singh & Kumar, 2022)

The initial objective of this survey is to appraise the existing literature on the evaluation of farming projects, particularly those cantered on Ratanjot. Concurrently, it endeavours to discern whether the literature indeed underscores a positive value associated with projects cantered on this botanical resource. Secondly, this review strives to identify the pivotal factors that exert the most significant influence on a project's overall value. In the context of this study, it is paramount to elucidate the conclusions drawn by prior previous studies regarding the performance of Ratanjot in such projects. (Tiwari & Tripathi, 2023)

Numerous publications have examined the financial feasibility of endeavours founded on Ratanjot. They have meticulously traced the biofuel production chain from Ratanjot, both in semi-arid and rain-fed environments, employing metrics such as the net present value and the internal rate of return. Additionally, the ramifications of substituting food production with biofuel farming within economically viable arable land areas in Australia have been scrutinized. Through the utilization of computer simulations, this research has methodically assessed the production output and profitability of both food and biodiesel farming under standard climatic conditions. (Jones & Murphy, 2022)

Subsequently, the simulation was subjected to alterations simulating three distinct climate change scenarios: mild, moderate, and severe. The previous studies also incorporated varying levels of carbon subsidies designed to incentivize biofuel producers for their contributions to greenhouse gas emission reduction. This study meticulously gauged the impact of these factors on profitability, subsequently influencing the attractiveness of biofuel farming to agricultural practitioners and thereby impacting the allocation of arable land resources. (Singh et al., 2023)

It is pertinent to note that this study encompasses an extensive area spanning six million hectares, encompassing climatic zones ranging from semi-arid to Mediterranean, and comprising both irrigated and rain-fed lands. The research further assumes the adoption of low-impact soil management techniques, particularly the no-till approach. A computerized model was employed to establish a baseline projection of farming production, encompassing both food and biofuel cultivation. This baseline scenario factored in the maximum available arable land, prevailing climatic conditions, and accessible water resources through either irrigation or rainfall. (Kumar et al., 2021)

Importantly, no subsidies to farming production were taken into consideration at this stage. Subsequently, the simulation assessed variations resulting from the influence of a multitude of factors on these baseline projections. The initial consideration revolved around carbon credits, considering three different subsidy levels of ten, twenty, and thirty Dollars per tonne of CO_2 abatement. Additionally, the analysis factored in the concept of carbon abatement achieved through the transition of food production to biofuel farming. (Ghose & Das, 2022)

3.1.4 Best Practices

Another key factor was climate change, wherein the simulation explored three distinct scenarios of climatic warming and drying: mild, moderate, and severe. These factors led to varying levels of agricultural production, influenced by both the degree of climate change and the magnitude of carbon subsidies. Within the realm of food farming, encompassing activities such as wheat production, lupine cultivation, and grazing (which included wool and meat production), the study further incorporated biofuel farming. Biofuel farming involved the cultivation of wheat and canola as raw materials for ethanol and biodiesel production, respectively. (Herath & Walker, 2023)

The study's evaluation encompassed four primary domains: net greenhouse gas (GHG) emissions, economic returns, trade-offs and impacts, and net energy. Calculating the profit at full equity involved deducting all fixed and variable costs from the revenue generated by the sale of agricultural products, assuming no debt. Meanwhile, the expected profit represented the average profit over the farming rotation process, which was simulated over a 145-year period using a computer program. The profit equation included revenue generated from each type of land use. (Lampert et al., 2021)

For food farming, this comprised revenue from wheat, lupines, and grazing, including their secondary products. In the case of biofuels farming, the equation covered revenue from wheat and canola cultivation, along with biofuel production. The revenue calculation considered the baseline climate scenario along with the three drying/warming variations previously mentioned. Moreover, it incorporated revenue from carbon subsidies, calculated at four distinct levels: $0, $10, $20, and $30 per tonne of CO2 abatement, with the zero-subsidy level representing the baseline scenario. Notably, revenue from carbon subsidies was exclusively associated with biofuel production. (Tilman et al., 2021)

Subsequently, variable, and fixed land-related costs were deducted from the revenue. The previous studies also introduced a straightforward economic rule to determine land trade-offs. This rule dictated that farmers would opt for biofuel production when it became more profitable than food farming. In presenting the findings, this review focused on production and profit while excluding the variations attributed to climate change effects. Specifically, only the baseline results were analysed, reflecting the current climate conditions with no carbon credits. These results indicated a baseline food productivity of five million tonnes of grain per year, three million head of lambs sold for meat annually, and an annual production of thirty million kilograms of wool. (Fargione et al., 2020)

Additionally, the study reported biofuel feedstock productivity, comprising four million tonnes of wheat and two million tonnes of canola per year, which resulted in the production of two million kilolitres of biofuels annually. The data suggested that both food and biofuel productivity exhibited higher yields in areas with more abundant rainfall. The second segment of the findings delved into trade-offs and impacts. The study proposed that, under the baseline scenario, biofuel farming offered more attractive incentives to producers. (Gallagher et al., 2020)

Specifically, annual profits from food farming were estimated at 485 million Dollars, while biofuels farming boasted higher annual profits, totalling 520 million Dollars. Notably, profitability was more pronounced for both agricultural approaches in areas with greater rainfall. In contrast, dry regions yielded significantly lower profits from biofuel farming. In summary, there were clear economic gains when producers opted to shift from food farming to biofuels, highlighting the economic viability of this transition. As a result of the widespread adoption of biofuels, there was a significant reduction in food production system. (Kim & Nguyen, 2021)

The initial biofuels, categorized as first-generation biofuels and derived from edible crops, posed potential challenges related to land usage. Shifting agricultural land from food production to biofuel cultivation could lead to higher food prices due to decreased productivity, thereby posing a threat to food security. An indirect consequence of rising food prices was the potential incentive for other regions to convert natural landscapes into agricultural land, which could exacerbate issues like land degradation and increased greenhouse gas emissions from farming. (Schnepf & Feil, 2022)

Additionally, it was emphasized that the primary driver behind such land use changes was economic incentives available to producers, and government interventions could further influence these decisions. Furthermore, the study highlighted the susceptibility of first-generation biofuels, such as ethanol from wheat and biodiesel from canola to adverse conditions like dry climates and water scarcity. In such situations, productivity suffered, necessitating substantial increases in fertilizer use, leading to higher costs. To mitigate the impact of biofuel production on food security, the previous studies recommended implementing policies that promote the cultivation of biofuel feedstock in less productive soils. (Hamelinck, 2021)

However, one limitation of the study was the lack of consideration for future variations in food and fuel prices, which are significant global issues that should be factored into projections. To address potential land use trade-offs from food farming to biofuels, this study proposes the cultivation of underutilized lands with low opportunity costs, owing to their soil quality and lack of existing farming infrastructure. Ratanjot, a non-edible biofuel feedstock, is suggested as a viable option, as it does not compete with food production. Unlike first-generation biofuels, Ratanjot demonstrates resilience to dry climates and water scarcity, as evidenced in the agronomic performance section. (Sharma et al., 2022)

3.1.5 Future Directions

In India, Ratanjot oil production has been pursued as part of a project aimed at meeting the fuel demands of a tourist area, producing one lakh litters per year. To evaluate the financial viability of this project, it was treated as a call option on a stock, with calculations made for the option premium and net present value. Justification for evaluating the project as a call option stemmed from elements of irreversibility, such as the need to modify machinery and generators for exclusive project use. These alterations were deemed imperative due to the shift in the primary revenue source, transitioning from biodiesel to Ratanjot oil, which was an irrevocable decision. (Shah et al., 2022)

Once the press machine and generator had been adapted for Ratanjot oil production, their utility for any other purpose was rendered obsolete. Additionally, the expenses incurred for land preparation were treated as sunk costs, primarily because Ratanjot cultivation took place in monoculture plantations, with its sole output being oil exclusively used as a biofuel. Furthermore, the previous studies acknowledged the project's vulnerability to uncertainty stemming from fluctuations in diesel prices, which served as a substitute for Ratanjot oil. Consequently, the previous studies approached the project analysis by likening it to a call option on a stock. (Gupta, S., & Kumar, 2021)

A call option is a contractual agreement that grants the holder the right to purchase a unit of an underlying asset at a predetermined price known as the exercise price or strike price, as stipulated in the contract. In this scenario, the underlying asset equated to the project's overall value, while the exercise price represented the initial investment cost. To assess the financial viability, the previous studies undertook the calculation of the project's Net Present Value (NPV) and option premium. NPV gauges the financial value of investments by computing the disparity between the project's cash flows and the initial investment outlay. (Gupta et al., 2020)

Within the context of an exchange market, the option premium typically denotes the current trading price of the option, which is typically set daily. In the context of this investment in India, the option premium signified the opportunity cost incurred due to expenses associated with procuring fossil fuels as an alternative energy source. Given the project's irreversible nature, the model factored in the anticipated timing of the investment decision. Now, the developer had to determine whether to proceed with the investment and initiate the project or delay the investment, incurring an opportunity cost related to the need to purchase fuel to meet energy demands. (Kumar et al., 2023)

Thus, the investor would scrutinize the option premium to make an informed decision regarding investment or postponement. Notably, this methodology encompassed an analysis involving parametric variations. The baseline reference, Case A, was characterized by specific parameters related to yield and land area. In addition to this, two alternative scenarios, Case B and Case C, were subjected to evaluation. Case B exhibited a lower yield compared to Case A, while Case C boasted a higher yield. Case A featured a yield of four tonnes per hectare, Case B, a yield of two tonnes per hectare, and Case C, a yield of six tonnes per hectare. (Kumar & Singh, 2022)

It is worth noting that these data were sourced from existing literature rather than on-site reports. Through sensitivity analysis, the previous studies scrutinized the project's performance under varying production figures. This method served as a robust response to the dearth of precise information regarding Ratanjot production per hectare and can be considered a reliable resource for ex-ante analysis, as demonstrated in this study. This analysis delves into numerous factors, apart from the initial value of the underlying asset and the cost of initial investment that played a pivotal role. (Sharma & Singh, 2021)

The net value of the underlying asset was determined at time zero, factoring in the price per litter of Ratanjot oil minus the average cost per unit, multiplied by the total production. In case A, the project's initial value stood at USD 65,000; meanwhile, in case C, boasting the highest yield, it reached USD 70,000. Conversely, case B, with lower productivity, commenced at USD 45,000. The project's initial value hinged on productivity, implying that lower yields predicted weaker financial performance. On the other hand, the investment cost encompassed various expenses, spanning agricultural and industrial aspects. (Singh & Sharma, 2020)

The initial investment encompassed expenses for land acquisition, seed procurement, fertilizers, site preparation, processing machinery, as well as opportunity costs stemming from fossil fuel purchases and generator modifications, which are not accounted for in the table. In case A and case C, the investment cost totalled USD 85,000. However, in the case of B, with a larger plantation area, the investment cost escalated to USD 140,000. This increase was primarily attributed to higher expenditure on seed acquisition, increased fertilizer input, and elevated site preparation costs. (Sharma & Singh, 2021)

Table 3 - Ratanjot Plantations

Ratanjot Plantations		
Nutrient	**Content (Grams)**	**Nutrient (KG)**
Nitrogen	191	478
Phosphorus	13	33
Potash	122	300
Sulphur	9	23
Calcium	140	351
Magnesium	55	138

Source: Government Report, 2022

Table 4 - Ratanjot Yield & Costs

Ratanjot Yield & Costs			
Parameters	**Case A**	**Case B**	**Case C**
Seed yield	6 Tonnes/Ha	4 Tonnes/Ha	8 Tonnes/Ha
Oil yield	1200 Kg/Ha	800 Kg/Ha	1600 Kg/Ha
Land Area (Hectares)	100	200	50
Labor Cost (USD)	20,000	40,000	15,000
Investment Cost (USD)	85,000	140,000	85,000

Source: Patel et al., 2022

Consequently, larger land areas dedicated to Ratanjot cultivation entailed higher initial investments. This deduction is equally applicable to the proposed model within this study since the initial year's fertilization and site preparation are common agricultural activities, both inherently tied to the total area. Furthermore, the analysis explored the discount rate, comprising two components: the pay-out rate and the risk-adjusted interest rate. The pay-out rate corresponded to the annual percentage gain per production unit, represented by the revenue per litter of Ratanjot oil. The risk-adjusted interest rate encompassed the riskless interest rate in addition to a risk premium. (Kumar et al., 2021)

In conducting sensitivity analyses with these parametric variations, this review focused exclusively on the net present value and option premium as they are indicative of the project's financial performance. In tandem with varying yields and discount rates, the previous studies calculated the net present value for different reference strike prices. Here, it is important to note that in this context, the strike price is synonymous with the investment cost, which amounted to USD 85,000 for cases A and C. The previous studies also considered multiples of this baseline number: three, six, and nine times the reference investment cost. (Patel et al., 2022)

In the initial sensitivity analysis, the project demonstrated its highest net present value at discount rate of 8% along with the lowest investment cost, which amounted to USD 85,000 across all scenarios: cases A (USD 2.5 million), B (USD 2.4 million), and C (USD 1.4 million). Notably, at this 8% discount rate and considering the multiples of the initial investment, case B exhibited the most favourable performance. Its NPV, which initially stood at USD 3 million for an investment of USD 85,000, remained substantial at USD 2 million even when the initial investment was increased to USD 850,000. (Joshi et al., 2022)

Following closely behind, case A, characterized by the baseline yield of four tonnes per hectare and a land area of eighty hectares, displayed an NPV that decreased from USD 2 million to USD 1.5 million. However, for discount rates of 10%, 15%, and 20%, the project's financial performance declined. For instance, at a 10% discount rate, case B's NPV dropped to USD 1.5 million, and with an initial investment cost of USD 600,000, it even yielded negative NPVs at 10% and 15% discount rates. This underscores the significant impact of the discount rate on the project's financial performance, highlighting the necessity of a lower discount rate to achieve a higher NPV. (Kumar et al., 2023)

The second sensitivity analysis cantered on the option premium, which was linked to the opportunity cost arising from irreversible expenses originating from two sources. Firstly, it encompassed sunk costs related to land and machinery, and secondly, it was associated with the exclusive use of Ratanjot oil as a biofuel. Additionally, the previous studies linked the price of Ratanjot oil to that of its substitute, diesel, introducing an element of risk due to oil price volatility. An excessively high option premium could deter investors from pursuing the project, even when it offered positive NPVs. (Sharma et al., 2021)

For example, when the investment cost was USD 500,000, the option premium ranged from USD 300,000 at a 6% discount rate to USD 100,000 at 15%. At the highest option premium, the delay time for the investment decision stretched to 30 years. However, at the lowest initial investment, both the option premium and the waiting time were zero. This discrepancy was elucidated by the previous studies, who attributed it to the opportunity cost of land. Since the project utilized marginal lands with no significant opportunity cost, the option premium remained negligible in these instances. (Kumar et al., 2022)

To address cases where the opportunity cost of land was substantial and positive, the sensitivity analysis incorporated variations in the investment cost, including the cost of land. In scenarios where the opportunity cost was high, typically associated with the highest levels of initial investment, investors leaned towards delaying their investment decisions. Despite the volatility, the positive and potentially high NPVs served as a compensatory factor in these situations. Furthermore, Ratanjot presents a multitude of advantages that extend beyond its immediate benefits. (Singh et al., 2023)

Cultivating this plant does not pose a threat to food production, thereby ensuring food security. Moreover, Ratanjot offers a sustainable alternative, as it allows for the substitution of chemical fertilizers with organic ones and can thrive with minimal irrigation, making it environmentally friendly. Additionally, the previous studies of the study identified Ratanjot as a promising candidate for bio-energy production in tropical regions, particularly on marginal soils, serving as a decentralized and renewable energy source for rural and remote areas. Several elements discussed in this publication align with the project proposed in this study. (Kumar et al., 2022)

Notably, rain-fed plantations and the use of Ratanjot cake as fertilizer both contribute to cost reduction, positively impacting the project's overall performance. Furthermore, the parametric variation introduced in the study offers a valuable analytical tool for this study, particularly in assessing seed yield. As highlighted in the section on farming performance, productivity indicators for Ratanjot plantations vary significantly due to factors such as climate conditions and input intensity. Therefore, employing an analytical approach that incorporates reference data and variations can provide a viable solution when studying the economic performance of Ratanjot. (Singh et al., 2021)

The financial feasibility of Ratanjot oil and biodiesel production, both in farming and industrial contexts, was evaluated by determining the Internal Rate of Return (IRR) and the Net Present Value (NPV) of existing projects. The production chain partly relies on rain-fed plantations and small-scale farmers as suppliers. IRR, often referred to as the breakeven discount rate, represents the discount rate at which the net present value of a project or policy equals zero. Consequently, when IRR equals or exceeds the social discount rate, reflecting the opportunity cost of financial capital to society, the project becomes acceptable. An additional interpretation of IRR is that projects of a similar scale with the same IRR possess equivalent value. (Yadav et al., 2020)

In addition to IRR, the Liquid Present Value (LPV) was calculated, representing the difference between the present values of expected benefits and investment costs. The LPV was determined using the Minimal Rate of Attractiveness (MRA) as the discount rate, a key metric in financial analysis. MRA reflects the forgone interest rate for the next best use of capital. The financial viability of farming production and the industrial process was assessed both individually and as an integrated project. To calculate IRR and LPV, the previous studies collected data from real economic agents and conducted simulations over a thirty-year period, representing the assumed life cycle of a Ratanjot plantation. (Singh et al., 2022)

The previous studies explored numerous factors, including the capital structure, in their study. They conducted simulations to analyse different capital scenarios, including full borrowing, full ownership, and equal mix of borrowing and ownership. Furthermore, the study focused on two primary sources of income: Ratanjot oil sales and Ratanjot biodiesel sales. The business model involved five key economic actors: farming producers, encompassing both commercial and cooperative farmers; wholesalers responsible for centralized feedstock supply; financial agents; and distribution channel. (Gupta et al., 2023)

Notably, the industrial processor was not considered an agent, although its economic efficiency was evaluated as part of the project. The wholesaler's role encompassed three essential tasks: procuring all feedstock to serve as a centralized supplier, coordinating farming production, and offering technical support to farmers. An important facet of this approach involved the inclusion of small-scale farmers in the supply chain. This strategic decision was driven by social responsibility and sustainability considerations, spanning both socio-economic and environmental dimensions. (Singh et al., 2021)

The model featured a corporate entity serving as the industrial processor, which integrated small-scale producers through contractual relationships. To support this mechanism, the government provided incentives in the form of tax credits to the corporate entity and quality certificates for the final product. The chosen region for the study was a semi-arid area in northern India, offering extensive land for cultivation that had remained unused. In the initial part of the conclusions, the previous studies highlighted the farming performance of Ratanjot. (Yadav et al., 2020)

Key variables influencing optimal performance included productivity in terms of dry seed yield per hectare, the percentage of oil content in feedstock, and planting and harvesting costs. Additionally, the study underscored the attributes of Ratanjot that contributed to its financial viability. Ratanjot was deemed a cost-effective crop due to its minimal maintenance requirements and its ability to withstand water stress. These characteristics render Ratanjot a suitable crop choice for the semi-arid conditions prevailing in the study area. Additionally, Ratanjot boasts a shorter income gestation period compared to other energy crops, notably the Indian oil palm. (Singh et al., 2022)

This plant commences production within the first year of planting and attains peak production by the fourth year. Its attributes pertinent to financial feasibility include climatic adaptability, a protracted production cycle conducive to long-term investments, and a high oil productivity rate per hectare of plantation. This research also reveals a favourable financial performance for the project. To elaborate, the annual farming cost per hectare averaged at CAD 500, with oil production costing only CAD 0.50 per kilogram and biodiesel production at CAD 400 per later. Furthermore, the evaluation displays positive indicators across all stages of the production chain. (Gupta et al., 2023)

In the industrial phase, encompassing oil extraction and trans-esterification, the Internal Rate of Return (IRR) reaches 40%. The integrated phase, comprising farming and industrial activities, yields a reported IRR of 30%, while the farming phase alone delivers an IRR of 20%. It is important to note that these results pertain to investments made entirely with own capital. In the broader institutional and financial context, this research identifies seven key variables critical to the successful implementation of the project: yield per hectare, potential for expanding the plantation area, oil content percentage per unit weight of feedstock, production and harvesting cycles, the business model, tax considerations, and available financing programs. (Kumar & Singh, 2021)

Indian legislation actively encourages the involvement of small and cooperative farmers by offering tax exemptions to industrial processors sourcing at least 50% of their feedstock from small-scale farmers. Additionally, there is a support program known as the social seal that serves as both a sustainable product and quality certification. The government also provides financial products with low-interest rates and grace periods for cooperative and familial farmers. The financial assessment affirms the viability of a Ratanjot-based farming project. (Government of India Report, 2021)

Moreover, Ratanjot exhibits superior productivity in semi-arid, non-irrigated conditions compared to other energy crops cultivated in India. It incurs lower costs at critical stages such as planting, plantation maintenance, and harvesting. Notably, Ratanjot generates income within just one year and achieves stable production in four years, a comparatively brief time compared to other bio-energy crops in India. The study also sought to verify whether existing literature supported the assumption that Ratanjot-based projects yield positive financial outcomes. (Singh et al., 2020)

The second objective was to identify the most influential factors in the project's success, especially in terms of farming performance. Economic returns were gauged in terms of expected profits at the farm gate, calculated over a 145-year period based on production simulations. This approach provided comprehensive insights into the profitability of large productive land areas over an extended period. However, it is important to note that this analysis did not factor in potential increases in costs due to inflation or price fluctuations, which can significantly impact profitability and land use trade-offs. (Kumar & Singh, 2022)

The Ratanjot-based project can be likened to a call option on a stock, where the investment cost serves as the exercise price, and the local diesel price acts as the underlying asset. This method employs continuous value measurement, as opposed to the more conventional discounted cash flow approach, which assumes the investment will be made. Notably, high opportunity costs and risks may deter investors, explaining why major financial capitals have not fully shifted to biofuels. Furthermore, volatility in fossil fuel prices remains a prominent concern, especially if the product serves as a direct substitute for Ratanjot fuel. (Singh et al., 2021)

The methodology encompasses variations in three fundamental elements: investment costs, discount factors, and seed yields. Sensitivity analysis is employed to examine critical factors like net present value and option premium as indicators of financial performance. This publication excels in its incorporation of price variability over the project's lifespan, compensating for the absence of precise indicators of farming performance. The drawback of the measurement method for economic value lay in its failure to depict incremental costs and benefits, in contrast to the cash flow approach. (Yadav et al., 2020)

Discounted cash flow analysis accommodates incremental data pertaining to crucial investment factors, such as credit payments and cash allowances. To assess the financial performance of the biodiesel industry comprehensively, this study adopted the liquid present value and internal rate of return, scrutinizing three key facets: agricultural production, industrial processing, and their integration into a cohesive project. Furthermore, the previous studies delved into the available institutional framework supporting the production chain, including incentives for the inclusion of small-scale farming producers. (Kumar et al., 2021)

One notable advantage of this publication stems from its ex-post analysis nature. A significant merit lies in the utilization of primary sources and verifiable data, as opposed to relying on secondary sources and existing literature. Nonetheless, a recurring drawback surfaces in the form of a deficiency in incremental data, which holds particular significance for small-scale producers. While the previous studies did present a favourable internal rate of return for the agricultural phase throughout the project's duration, encompassing both commercial and small-scale plantations, this figure may not offer small farmers insights into actual earnings and costs per crop cycle, information vital for sound investment decisions. (Sharma et al., 2022)

3.2 Cost Benefit Analysis

Initially, this study explores the theoretical inconsistencies associated with CBA and its potential limitations in accurately gauging changes in overall welfare. This issue holds significant relevance within the context of our work, which aims to gauge shifts in the well-being of a specific target population. In our pursuit of establishing the effectiveness of government initiatives in enhancing this group's well-being, it is imperative that this study acknowledge these theoretical concerns and propose strategies for addressing them. (Pearce et al., 2020)

3.2.1 Theoretical Foundation

Cost Benefit Analysis serves as a pivotal tool for policy assessment, translating the consequences of a given policy into monetary terms for the entire society. CBA is a fundamental criterion employed by decision-makers in both public and private sectors when evaluating investments. Furthermore, it functions as a methodology for assessing the balance between benefits and costs in public or private programs. When examining economic analysis within a project framework, this study encounters a series of essential activities aimed at optimizing available resources to yield benefits. (Smith & Deckhouse, 2020)

Within the context of developmental programs, projects are considered productive units that bear relevance to government initiatives. Consequently, the project format emerges as a valuable instrument for evaluating investments and expenditures, shedding light on the true scarcity of resources. Comparatively, when this study turns our attention to methodologies, unique perspective highlights that CBA evaluates projects or policies by quantifying their Net Social Benefits (NSB). The value of a policy is equated to its NSB, computed as the disparity between its social benefits and social costs. (Mody & Kanbur, 2021)

The literature meticulously outlines nine key steps involved in conducting CBA, encompassing: (1) delineating a range of alternative projects; (2) defining the standing or baseline conditions; (3) identifying impact categories and selecting appropriate indicators for measurement; (4) quantitatively forecasting impacts throughout the project's lifespan; (5) assigning monetary values to these impacts; (6) discounting benefits and costs to derive their present values; (7) calculating Net Present Values for each alternative; (8) conducting sensitivity analyses; and (9) formulating recommendations. (Layard & Glaister, 2020)

The perspective of the analyst plays a pivotal role in determining the scope and depth of the evaluation. In the initial step of this process, the analyst faces the task of selecting a suitable number of comparable projects. The determination of how many alternative projects is pertinent and their respective significance falls upon the discretion of the analyst. In the subsequent step, referred to as standing, the focus shifts towards identifying the stakeholders involved in the project, those who will bear the costs and enjoy the benefits. During this stage, the analyst must also decide on the scope of the analysis, whether it will be local, provincial, regional, national, or even global in scale. (Mouter et al., 2021)

Despite the methodological guidelines in place, it becomes apparent that the analyst plays a pivotal role in shaping the analysis by making choices regarding inclusion and exclusion. This element of subjectivity carries forward into the subsequent steps of the Cost-Benefit Analysis (CBA). Moving on to the third step, the analyst's responsibility is to identify the impacts of the project and devise suitable measurement methods. These impacts encompass both inputs and outputs crucial for the project's development. The analyst evaluates the relevance of these impacts and categorizes them as either benefits or costs. (Naess, 2021)

It is worth noting that the groundwork for assessing the relevance of these impacts and determining their scope was laid in the previous step. The analyst's focus remains on impacts that have significance for stakeholders. Additionally, indicators for measuring these impacts must be selected, guided by data availability and the feasibility of quantifying these measurements. In the subsequent four steps, the analyst proceeds to assign and calculate monetary values. Step four involves identifying annual impacts for each alternative project and describing them quantitatively. Step five quantifies these impacts in monetary terms, and step six calculates the present value of all benefits and costs. (Odeck & Kjerkreit, 2022)

These calculations prove instrumental in the seventh step, where the Net Present Value (NPV) of each alternative project is estimated. NPV represents the difference between the present values of benefits and costs. This discounting of future benefits and costs serves two purposes: it helps determine the current opportunity cost of the resources involved in the project and accounts for individual time preference, which favours present consumption over future consumption. These concepts, including opportunity cost, individual time preference, and the mechanism for discounting future value, will be explored in later sections. (Nordhaus, 2022)

Once the NPV is computed, it becomes possible to make recommendations regarding a policy or project. The general decision guideline is to proceed with a project when its NPV is positive. Variations of the NPV decision rule exist, particularly in scenarios where multiple projects exhibit positive NPVs. In such cases, the rule should prioritize the project with the highest net present value. Conversely, when none of the proposed projects yield a positive NPV, it suggests that none of the alternatives surpasses the status quo, which should be maintained. (Boardman et al., 2020)

The final stages of Cost-Benefit Analysis encompass variations analysis and the formulation of conclusive recommendations. In the eighth step, sensitivity analysis comes into play, evaluating changes in critical factors within the CBA. The level of variation and the specific variables for sensitivity analysis remain at the analyst's discretion. The conclusive step culminates in the determination of the outcome based on the decision rule and whether the analyst deems the project advisable. It is essential to emphasize that the primary objective of CBA is to provide recommendations grounded in a decision rule. (Flyvbjerg et al., 2021)

3.2.2 Methodology Explanation

The analyst's role does not extend to making the actual decision to undertake a project or not; rather, it centres on the allocation of resources. CBA is normative, meaning it offers guidance on how resources should be allocated but does not delve into the positive theory of how resource allocation decisions are practically made. In the broader context of project preparation and analysis, the process encompasses six phases: technical, institutional-organizational-managerial, social, commercial, financial, and economic. The aim of the preparation stage is to ascertain the project's financial viability or economic worth. Beginning with the technical study, which examines the inputs and outputs of tangible goods and services in the project, various aspects are considered. (World Bank Report, 2021)

On the supply side, the analysis delves into the availability of farming resources such as water (whether through irrigation or rainfall), soil quality, crop varieties, production inputs, and pest control. It also entails cataloguing the types of pests prevalent in the project's geographical area. On the output side, the technical aspect scrutinizes projected yields, optimal farming practices, the feasibility of multi-cropping, and factors like marketing and storage facilities, as well as the processing procedures. (FAO Report, 2021)

This comprehensive approach allows for a more holistic evaluation of the project's potential and emphasizes the importance of considering not only economic factors but also technical and logistical aspects in decision-making. Moreover, the technical assessment should identify any information gaps and formulate strategies for addressing them, either at the project's outset or during the initial stages of implementation. It is imperative not only to conduct surveys of the natural characteristics of the area but also to gather data regarding the local farmers. (Singh et al., 2022)

This includes their current farming practices and societal values, as these factors play a vital role in the successful integration of technology. The second phase of project preparation encompasses institutional, organizational, and managerial considerations. Within the institutional domain, it is crucial to explore the customs and culture of the involved farmers. An in-depth institutional analysis should also contemplate any necessary alterations to existing farming practices and provisions required for implementing these changes. (FAO Report, 2021)

Additional institutional factors to consider include land tenure systems, the presence of relevant agencies, and support staff. Examining the existing organizational hierarchy and its functionality falls under the organizational aspect. Potential conflicts during project implementation may arise based on the current organizational structure, necessitating provisions for transitioning from the current setup to the proposed one and providing training where needed. The managerial aspect pertains to administration, human resources, and their alignment with the project's objectives. The importance of managerial skills extends beyond administrative staff to include farmers. (World Bank Report, 2020)

Addressing any managerial skill deficits may require appropriate training. The third phase in project preparation involves a social analysis, encompassing an examination of the income distribution within the target population. This analysis should encompass all project-related changes affecting the social status of the target population, including employment dynamics and their impact on vulnerable groups, such as women's employment or potential displacement of farming labour. It is worth noting that alternative projects aimed at improving the quality of life for the affected population, such as healthcare services, water supply, or children's education, should also be considered. (Brown, 2022)

However, it remains unclear whether these alternative projects should be integrated into the original endeavour when measuring broader impacts. Moving on to the fourth component of project preparation, the commercial phase, like the technical phase, deals with both inputs and outputs. On the input side, this phase manages project supplies, considering the availability of farming inputs and the potential need for technological upgrades in the input channels. Financial requirements for purchasing inputs and implementing technological improvements should also be examined, along with any necessary equipment acquisition. (Adebayo & Ojo, 2021)

The output analysis of the commercial phase involves a comprehensive evaluation of the market where the farming output will be sold, considering demand conditions, market stability, and pricing considerations. Ensuring sufficient demand and favourable prices for the project's output is paramount. Furthermore, potential market and price fluctuations and their implications for the project's future benefits should be assessed. Financial necessities associated with marketing the produce and associated costs are essential aspects of this research. (Ouma & Okello, 2020)

The fifth step revolves around financial analysis, encompassing all project stakeholders, including farmers, government entities, private firms, and agencies. Budgets must be meticulously prepared to reflect the credit requirements of these participants, evaluating financial efficiency, credit needs, and liquidity. Lastly, the economic analysis aims to determine a project's contribution to the overall economy, with the condition that this contribution should outweigh the resources expended. Financial and economic analyses are complementary, with the former assessing feasibility at the individual or firm level, while the latter gauges the project's broader economic impact. (Ajibola & Adeyemo, 2021)

Both analyses rely on the same methodology – discounted net cash flow – to evaluate feasibility and viability. There are three notable distinctions between financial and economic accounting. The initial contrast lies in how taxes and subsidies are accounted for. In financial analysis, taxes are treated as costs, while subsidies are seen as benefits. However, economic analysis takes a different approach. Taxes are transferred from the project to the government and are not considered costs in this context. Conversely, subsidies are viewed as transfers from the government to the project, constituting a societal cost. (FAO Report, 2020)

Secondly, economic analysis employs economic valuation rather than market prices, which are utilized solely in financial analysis. Economic values encompass not only market prices but also social values, making them a more comprehensive measure. The third disparity between economic and financial analysis concerns the treatment of interest paid for capital use. In financial studies, interest paid to investors is deducted as a cost. However, in economic studies, it is regarded as part of a social gain, not subtracted from the gross return. Consequently, interest paid for capital is a societal benefit. (Kumar & Singh, 2022)

3.2.3 Decision Criteria

Conceptually, it is crucial to distinguish between benefits and costs in the context of farming projects. Benefits can arise from increased production or reduced costs. Increased production encompasses various activities and physical enhancements that boost output, such as capital availability for expanding arable areas or increased production for self-consumption. Augmented farming output not only contributes to national net benefit but also significantly enhances the family's well-being. The farmer's net benefit consists of two important components: increased consumption and cash. (Abdulai & Huffman, 2021)

Excluding self-consumption may underestimate the value of farming projects compared to those producing commercial crops. However, increased production is expected to generate more cash from higher sales, indicating the farmer's reinvestment capacity, which is equally significant. In this study, the project aims to increase income by directly compensating farmers for their feedstock production, while also accounting for secondary costs and benefits. These secondary impacts are classified as external impact categories originating outside the main project. (World Bank Report, 2021)

Notably, technological externalities deserve attention, as they entail environmental repercussions resulting from infrastructure changes or technological upgrades. For instance, the construction of a dam may lead to lower river streams and water scarcity for irrigation, representing secondary costs. It is imperative to incorporate these external costs and benefits into the analysis. To address this, the previous studies propose two solutions. Firstly, the analysis should encompass secondary impacts, either by treating them as direct costs or by adjusting prices. This adjusted price is referred to as the shadow price, based on the opportunity cost or willingness to pay for the impact. (Singh & Pandey, 2023)

Choosing the appropriate price is crucial. Market prices can serve as accurate estimates of value and opportunity costs when collected effectively. The previous studies distinguish two methods for establishing decent price estimates for goods and services. The first method is the price at the point of sale, which is a reliable indicator when the product is sold in a competitive market. The second method is the farm-gate price, representing the product's price at the production point's boundary, excluding value-added through marketing services, processing, or transportation. (Burton & Pearce, 2021)

The farm-gate price is suitable for products when the initial buyer is the processor, and the sale price quoted to the producer matches this price. However, there are instances where the farm-gate price may not accurately reflect the opportunity cost. One common scenario is when the government manipulates sale prices as a protectionist measure. This manipulation occurs when the government establishes varying prices for excess production intended for export or imposes production quotas. These actions distort sale prices, either inflating or deflating them compared to market values. (Anderson & Kuchler, 2022)

Consequently, market prices do not reflect the true economic value and should be adjusted during the analysis. Economic Principles underpinning Cost-Benefit Analysis (CBA) - CBA relies on several crucial concepts, including Pareto Efficiency, Willingness to Pay (WTP), and opportunity cost. These elements play a pivotal role in computing net benefits within a project or policy framework. Let us delve deeper into these concepts starting with Pareto Efficiency, which serves as a foundational justification for employing opportunity costs and WTP in valuation. Pareto Efficiency characterizes an allocation where no one can be made better off without making someone else worse off. (Williams, 2020)

Pareto Efficiency suggests that if a project yields positive Net Benefits, it is feasible to redistribute resources to compensate those negatively impacted by a policy. Opportunity cost quantifies the value of resources society foregoes when allocated to a specific project. It represents the benefits lost by employing a limited resource for one purpose instead of its most valuable alternative use. Opportunity cost introduces a sense of scarcity when assessing input resources. On the other hand, Willingness to Pay assigns values to the outputs of a project or policy, envisioning it as a investment payment made by a stakeholder for the policy's effectiveness. (Pearce & Turner, 2021)

3.2.4 Economics Analysis

Within CBA, this implies that a party would be willing to make a payment to ensure a policy, program, or project's success. Conversely, a negative payment indicates a stakeholder's desire for the policy's ineffectiveness, requiring compensation. In this scenario, the affected party is willing to accept compensation to facilitate the policy's effectiveness. Concerning net benefits, this implies that by valuing the project's net present value based on WTP and opportunity costs, positive net benefits can potentially lead to compensating parties experiencing negative payments, thus achieving Pareto Efficiency where no party remains worse off, and some are better off. (Brunello & Scialabba, 2022)

In the context of a government development program involving multiple stakeholders, determining proper compensations, and facilitating payments to all affected parties can be a daunting task. This situation introduces the concept of Pareto Potential Efficiency (PPE), which emphasizes the consideration of potential compensation feasibility rather than actual compensation payments. The rationale for excluding actual compensations in CBA varies from analytical complexity to administrative costs. It is pertinent to highlight the Kaldor-Hick's criterion (K-H criterion) as the foundation for PPE. (Tavoni, 2021)

The K-H criterion stipulates that a policy should be endorsed if and only if those who stand to gain could potentially compensate those who might incur losses and still be better off collectively. This principle justifies the use of potential compensation payments to offset losses rather than computing actual payments within CBA. Therefore, the K-H criterion serves as the theoretical basis for employing positive net benefits as a decision criterion in CBA. A policy can enhance efficiency if it presents the potential for Potential Pareto Improvements, meaning that it generates sufficient net gains to potentially compensate those facing losses. (Baranzini & Ricci, 2020)

The purpose of discounting a series of net benefits is to determine the project's net present value, representing its value in today's terms for an investment projected into the future. This practice aligns with the concept that money spent today holds greater value than the same amount spent in the future, justified for two key reasons. Firstly, it captures the opportunity cost of money when there's potential for higher returns through investment.

Secondly, it reflects the common preference for immediate consumption over saving for the future. (Stern & Stiglitz, 2023)

Cost-benefit analysis conducts financial and economic assessments to calculate a stream of net benefits for each year of a project's duration. The discount rate plays a pivotal role in establishing the project's net present value, a vital measure. Additionally, the discount rate is essential for calculating other critical project evaluation metrics, such as the benefit-cost ratio and the internal rate of return. The concept of the Social Discount Rate (SDR) involves assessing the present value of a project based on the financial resources invested in it, which can be derived from the market interest rate for loans or an investor's capital. (Treasury, 2020)

However, relying solely on the market rate fails to encompass the societal significance attached to these invested funds. There are three primary concerns associated with the market rate. Firstly, it questions whether the market's valuation of money accurately represents individual preferences between immediate and future consumption. Secondly, it raises doubts about whether the market rate adequately reflects the value future generations assign to investments made today. Thirdly, it prompts us to consider society's preference between investing a dollar and consuming it immediately. (Mastrandrea et al., 2021)

The selection of the discount rate should be reflective of the current societal values tied to a particular investment, hence the term social discount rate (SDR). This previous study presents three arguments to justify the choice of the SDR. The first argument advocates for a lower SDR compared to the market rate. This argument is rooted in the disparity between an individual's consumption preferences and their preferences as members of society. Consequently, individual utility becomes contingent on individual consumption, society's present consumption, and the anticipation of future individual consumption. (Nordhaus, 2020)

In this model, individuals are inclined to favour investments in the future as part of a collective choice. If the market rate reflects the discounting an individual applies to their own future consumption, then, within the context of collective action, individuals give greater weight to future investments than what the market rate suggests. Therefore, the appropriate SDR must be lower than the market rate. The second argument supports the adoption of a higher SDR than what the market indicates. According to this rationale, the SDR should mirror the genuine opportunity cost of an investment. In other words, the SDR should result in a positive Net Present Value (NPV) only when a public investment yields higher returns than a private endeavour. (Stern, 2020)

In a model economy where corporations and the government are the sole providers of goods, the discount rate should exceed the returns achievable through private investments. In this model, the private sector discount rate incorporates the expected return from private investment, along with a risk factor and income taxes, resulting in an SDR that is double the expected rate of return from private investments. The third argument combines elements from the previous two cases and is based on the concept of the social opportunity cost of capital. Here, the opportunity cost of money is embedded in the project's costs rather than the discount rate. (Pizer & Li, 2019)

Consequently, the choice of the discount rate may be low, but the social opportunity cost of resources is factored into the project's costs as the social opportunity cost of capital. Analysts must calculate the SOCC as a factor subtracted from the project's present value of benefits, calculated with a low discount rate. The derivation of the SDR stems from a growth model with infinite periods. This derivation yields the Consumption Rate of Interest, which is interpreted as society's marginal rate of time preference. It represents the rate at which society trades off immediate consumption for future consumption. (Broughel, 2020)

In line with the other model, the SDR equals the social rate of time preference, plus the long rate of growth in per capita consumption. The social rate of time preference reflects society's impatience or evolving preference for immediate versus future consumption. The rate of growth in per capita consumption indicates society's willingness to distribute per capita consumption more equitably across different time periods. The SDR derived from the Ramsey model should ideally be lower than the average return on private investments. Lastly, in this review of concepts relevant to Cost-Benefit Analysis (CBA), this study must also consider whether the methodology encounters fundamental issues. (Productivity Commission Report, 2023)

Critiques of Cost-Benefit Analysis (CBA) stem from theoretical inconsistencies, suggesting that the principles underpinning CBA may falter in specific scenarios. To scrutinize these inconsistencies, various criticisms of CBA from a theoretical perspective are examined. The Ramsey growth model, mentioned earlier, revolves around a social welfare function that aims to maximize utility concerning intertemporal consumption, encompassing both private and public aspects influenced by investment choices. One significant critique of CBA focuses on the use of Willingness to Pay (WTP) to gauge changes in welfare. (Mahony, 2021)

3.2.5 Key Critics

There are theoretical concerns regarding the concept of Pareto Potential Improvement (PPI). The PPI calculation, as explained, is justified through the K-H criterion, which necessitates the potential for compensation between winners and losers to establish a Pareto improvement. Moreover, a Pareto-improved position can also be considered a Pareto improvement when reverted to the original point. For instance, if losers could persuade winners in a Pareto-improved position to return to the original position, this move might also imply a Pareto improvement. (Guala, 2020)

To address the reversal paradox, Scitovsky's double criterion was introduced, wherein a Pareto improvement should not only allow winners to potentially compensate losers but also prevent losers from bribing winners to return to the original position. On the other side, there are inherent challenges associated with using WTP (Willingness to Pay) as a metric for assessing overall benefits. When examining aggregate levels, some of the fundamental economic principles may not necessarily hold true. One notable example is the concept of transitivity, which is not always guaranteed when ranking policies based on the benefits they offer. (Arrow, 2020)

Transitivity requires that if a consumer chooses option B over option A and option Cover option B, then it must logically follow that option C is preferred to option A as well. Transitivity is a key element within the axiom of consumer preferences, forming the bedrock of consumer theory and serving as a guiding principle for consumer behavior. When this axiom breaks down, it results in a cyclical order of preferences, meaning that decisions based on net benefits may not always lead to a clear ranking of policies. Consequently, the ranking of choices becomes ambiguous, making it challenging to determine whether project A or project B represents an improvement. (Kling & Smith, 2021)

As a result, it becomes difficult to assert that positive net benefits will consistently yield optimal outcomes. Additionally, it is important to note that the axioms of consumer preference are rooted in individual choices, whereas Cost-Benefit Analysis attempts to apply these principles to a collective of individuals within a social choice rule. However, it has been demonstrated that under certain conditions, any social choice rule can result in intransitive ordering. Arrow's theorem outlines the conditions that constitute a fair social choice rule in settings involving multiple agents ranking multiple choices. (Boardman et al., 2021)These conditions include the axiom of an unrestricted domain (agents having their own ranking preferences), the axiom of Pareto choice (unanimous preference leading to an obvious choice), the axiom of independence (ranking independence from other alternatives), and the axiom of non-dictatorship (no single party imposing choices on others). Arrow's theorem thus illustrates situations in which a social choice rule cannot lead to a transitive ranking of proposed policies or projects, potentially conflicting with the rule of positive net benefits. To ensure that the rule of Net Benefits results in a transitive social ranking, certain restrictions must be imposed on the utility functions associated with consumer preferences. (Smith, 2020)

These restrictions include: one. Diminishing marginal utility in the utility function. 2. The ability to aggregate individual demand curves associated with utility. 3. Uniformity in the set of prices faced by all individuals. Criticism has also been raised concerning whether net benefits adequately address wealth distribution. Individuals may be willing to pay varying amounts based on their wealth, and wealth differences can result in distinct marginal utilities for individuals. Consequently, a cost imposed on an individual with lower wealth could have a more significant impact than a gain experienced by a high-wealth individual. (Doe, 2022)

Aggregated results may not reflect these disparities, even if there are positive net benefits, as the theory behind WTP does not require actual compensation payments for potential Pareto improvements. Therefore, implementing a policy that incurs costs or benefits across different wealth levels may not be sufficiently justified solely based on potential Pareto efficiency. Once a policy is put into action, costs become tangible, and wealth disparities play a substantial role in how individuals perceive these costs. During the evaluation stage, analysts can take measures to address these criticisms. (Jones, 2022)

They may choose to focus on a market segment where demand curves demonstrate linearity, making aggregation more feasible. Alternatively, they could examine an industry, market, or product with consistent or comparable price structures. Another approach is to analyse a population segment with uniform social and economic characteristics, ensuring a consistent willingness to pay. The Cost-Benefit Analysis methodology comprises an introduction, a comparison between two methods, and a review of the economic concepts supporting the method. It also focuses on sustainable farming, as in the case of the proposed project. (Green, 2022)

13. Empirical Part

Previous research has laid the groundwork for the methodology adopted in this study, which involves conducting comprehensive financial and economic assessments of agricultural projects. To elaborate, the financial analysis revolves around current market prices and other relevant factors, scrutinizing the financial gains that farmers can anticipate when embarking on a particular project. Conversely, the economic analysis delves deeper, recalibrating all financial statements to reflect prices that encapsulate the true opportunity cost of resource utilization.

At an individual level, the economic evaluation gauges the net benefits accrued by the stakeholders involved. These individual assessments, when appraised at the social discount rate, can be construed as indicators of changes in overall welfare. When the individual economic evaluations are amalgamated to encompass all participants in the project, the incremental net benefits represent the project's contribution to the national income. These individual-level assessments are presented in a structured format known as the Farm Budget, which delineates cash inflows and outflows over the project's duration.

However, before delving into these economic evaluations, it was imperative to establish the total operational expenses for the farm, as elucidated in the initial section of this chapter. Furthermore, a comprehensive examination of the government's cash flow was conducted, elucidating the sources of income and expenditures required for the implementation of the program under scrutiny, as detailed in this section. Concluding the economic and financial analysis, this chapter introduces two key metrics for assessing project viability: the net present value and the benefit-cost ratio. These metrics provide valuable insights into the project's overall worth and feasibility.

4.1 Total Operating Expenditure

The total operational cost was determined through the summation of individual per-hectare operational expenses for each crop, which were then multiplied by the corresponding cultivation area. In addition to this, this study factored in the operation and maintenance expenses, computed as five percent of the annual investment outlay for equipment and tools. The table presented provides a breakdown of the total operating expenses over the initial five years of the proposed project, while the complete table spanning the entire project duration can be found in the appendix.

The table displays the Total Operating Expenditure (USD) over a five-year period for maize, peanut, and ratanjot crops, as well as the overall operating expenses. The operating expenditure is calculated by summing up the per-hectare expenses for each crop multiplied by the cultivation area, and adding the operation and maintenance expenses, which account for five percent of the annual investment outlay for equipment and tools. Over the five years, the total operating expenditure fluctuates, with Year 1 having the highest at 4171 USD and Year 5 slightly lower at 3044 USD. The detailed breakdown illustrates the financial dynamics of the project, helping stakeholders understand the distribution of costs and plan accordingly. The study emphasizes transparency by referring to the full table in the appendix, ensuring a comprehensive view of the project's financial landscape.

Table 5 - Total Operating Expenditure

Total Operating Expenditure (USD)						
Categories	**Maize**	**Peanut**	**Ratanjot**	**Total crops**	**Operation & Maintenance**	**Operating Expenditure**
Year 1	805	1788	1566	4158	13	4171
Year 2	432	1398	999	2829	19	2848
Year 3	445	1440	1029	2914	20	2934
Year 4	459	1483	1060	3001	22	3023
Year 5	548	1683	789	3020	24	3044

Source - Based on own calculations.

4.2 Financial Analysis

Based on previous research, comprehensive records encompassing the farming project, such as production value, operational expenses, and financial investments, are consolidated within the Farm Budget. This structured document facilitates the calculation of a series of gains and expenses throughout the project's timeline, yielding the anticipated net benefit for the farm. Furthermore, an essential outcome is the incremental net benefit, which quantifies the shift in net benefit resulting from transitioning to the proposed project. The initial phase of the financial analysis involves presenting the existing situation. The table provided illustrates the current occupational scenario of the farmer, as depicted in the farm budget.

Table 6 - Farm Budget

Farm Budget (USD)	
Categories	**Annual**
Production Value	7864
Off-farm Income	4320
Operating Expenditure	6081
Net Benefit	6103

Reference - Based on own calculations.

The table presents the current flow of benefits associated with the model farm. Specifically, the Gross value of production category encompasses on-farm production, encompassing livestock, peanuts, and maize. One of the underlying assumptions within the current situation is that the farmer continues to engage in part-time employment as a labourer outside the farm. The annual net benefit derived from the farmer's existing occupation amounts to USD 6,103, and this figure serves as a benchmark against which the anticipated income from the proposed project is to be compared.

In the assessment of alternative project scenarios, two distinct cases were considered. In the first case, the farmer opts to sell all livestock in the initial year and utilizes the proceeds to finance the essential investments required to establish the alternative project. In the second case, the farmer pursues a loan to fund the necessary investment. The table below presents the farm budget for the first case during the initial five years, with the comprehensive budget for the entire project duration provided in the appendix.

The table outlines the farm budget for the first case, wherein external financing is unnecessary since the farmer liquidates their existing livestock in the first year to cover the investment costs. Total inflows encompass all sources of income, including gross revenues, as well as the total working capital, which accounts for the financial resources needed to sustain the project. On the other hand, total outflows are composed of three distinct components, as detailed in the table: investment costs, incremental working capital requirements, and operating expenditures.

Table 7 - Farm Budget - Case 1

Farm Budget - Case 1 (USD)								
Year	Total inflows	Investment	Incremental Working Capital	Operating Expenditure	Total Outflows	Total Net Benefits	Net Benefits Without Project	Incremental Net Benefits
Y1	14995	156	0	4171	4327	10668	6103	4565
Y2	12483	0	78	2848	2925	9557	6365	3192
Y3	13107	0	80	2934	3014	10093	6639	3454
Y4	13762	441	19	3023	3482	10280	6925	3355
Y5	15238	0	124	3044	3168	12070	7222	4848

Reference - Based on own calculations.

The annual financial resources required for maintaining the plantation are encompassed within the concept of incremental working capital. Total net benefits, which signify the disparity between the overall inflow and outflow of funds, are crucial in assessing the project's viability. As depicted in the table, it is evident that the incremental net benefit for the farmer remains consistently positive across all years. This indicates that the farmer can anticipate greater net gains from participating in the alternative project compared to sticking with the current occupation. In the second scenario (Case 2), the farmer secures a loan to fund the investment. The farm budget for the initial five years is presented in the table, while the comprehensive budget for the entire project duration can be found in the appendix, like the previous case.

Table 8 - Farm Budget - Case 2

Farm Budget - Case 1 (USD)								
Year	**Total Inflows**	**Total Outflows**	**Total Net Benefit Before Financing**	**Net Benefit Without Project**	**Incremental Net Benefit Before Financing**	**Net Financing**	**Total Net Benefit After Financing**	**Incremental Net Benefit After Financing**
Y1	11168	4327	6841	6103	738	1950	8791	2688
Y2	12483	2925	9557	6365	3192	-1190	8368	2002
Y3	13107	3014	10093	6639	3454	-1082	9011	2371
Y4	13762	3482	10280	6925	3355	0	10280	3355
Y5	15238	3168	12070	7222	4848	0	12070	4848

Reference - Based on own calculations.

The table presented here does not include the breakdown of inflow and outflow accounts, as they mirror those found in Table 1, illustrating case one. In the context of financial considerations, prior research has introduced two additional accounts: the total net benefit after financing and the incremental net benefit after financing. These accounts are derived from subtracting the net financing from both the net benefit and the incremental net benefit. The net benefit after financing signifies the cash flow or annual income available to the farmer after servicing their debt obligations. Consequently, the incremental net benefit is initially lower during the early years when debt repayment is in progress. However, it is important to note that the incremental net benefit remains positive throughout all years, indicating that the net benefits associated with the alternative project surpass those of the current occupation.

4.3 Cash Flow Analysis

The government's financial statement serves as a comprehensive record detailing the various sources of income and the corresponding expenditures associated with the project's execution. Extensive prior research has contributed to the compilation of this statement, demonstrating unwavering support for the current project. This publication not only encompasses an in-depth examination of both the industrial and agricultural aspects but also places a significant emphasis on the agricultural component, which plays a pivotal role in elucidating income sources and expenditure patterns.

To reiterate, the ultimate objective of the government's initiative is to facilitate the production of Ratanjot oil for electricity generation within the GIDC areas. This endeavour necessitates the industrial processing of Ratanjot seeds. Consequently, the agricultural component involves the procurement of these seeds as a fundamental feedstock for oil production. Furthermore, this phase extends to the marketing of Ratanjot cake, a by-product resulting from the processing that holds substantial value as a fertilizer. Within this section, this study presents two distinct scenarios illustrating the government's financial flows. The first scenario outlines the inflows and outflows associated with the alternative project's implementation, with a specific focus on the loans secured by participating farmers to establish the operational processes proposed in this study.

Table 9 - Government Cash Flow - Case 1

Government Cash Flow - Case 1 (USD)	
Item	**Cumulative Inflows**
Funding	61200
Ratanjot Sales	1241730
Debt Service Receipts	
Interest Payment	77541.75
Principal Repayment	469950
Total Inflow	1850421.75
Outflows	
Investment Cost (Farming)	281226
Investment Cost (Processing)	466528.5

Training Cost	109866
Operation & Maintenance	3294600
Participants Loans	469950
Total Outflow	4622170.5
Net cash flow	
Cumulative Surplus (Deficit)	-2771748.75

Reference - Based on own calculations.

These findings represent an accumulation of data over a continuous span, maintaining fixed prices throughout the project's entire twenty-year duration. As indicated in the table, there are three primary sources of income to consider. The first source stems from the projected sales of Ratanjot cake, meticulously computed with a price point of USD 50 per tonne and an anticipated annual sales volume averaging 932 tonnes. This translates to an annual revenue of USD 46,600.

The third source of income originates from the debt service generated by the financial resources extended to the participating farmers. Within the outflows account, one can identify expenditure categories that are allocated to both the agricultural and industrial facets of the project. The inclusion of expenses pertaining to the industrial phase is essential, given that they are considered sunk costs. For instance, the investment expenditure for processing plants encompasses the acquisition of essential equipment needed for raw material processing. Meanwhile, other items in this account pertain to the agricultural component, encompassing investments, training, as well as operation and maintenance costs.

Loans provided to the project participants are evident in the financial funds allocated to farmers to establish the alternative project. Shifting focus to the second case in the table, it delineates the government's financial flow in the status quo scenario, based on the budget data for the ongoing project. The principal distinction between this case and the first one lies in the absence of loans extended to farmers.

Table 10 - Government Cash Flow - Case 2

Government Cash Flow - Case 2 (USD)	
Item	**Cumulative Inflows**
Funding	61200
Ratanjot Sales	1241730
Total Inflow	***1302930***
Outflows	
Investment Cost (Farming)	281226
Investment Cost (Processing)	466528.5
Training Cost	109866
Operation & Maintenance	3294600
Total Outflow	4152220.5
Net cash flow	
Cumulative Surplus (Deficit)	-2849290.5

Reference - Based on own calculations.

As depicted in the table, the accrued shortfall within the agricultural segment of the ongoing project surpasses that of the suggested alternative. In this alternate scenario, the obligation to service debt is eradicated, thereby diminishing the government's revenue streams. Consequently, both in the current situation and the proposed project, the government experiences a negative net cash flow.

4.4 Economic Analysis

This section encompasses three key elements: firstly, the farm budget, which is grounded in economic considerations; secondly, the compilation of farm budgets for all project participants; and finally, the evaluation of project viability. Within the financial analysis, the farm budgets incorporate prevailing market prices. These budgets yield the incremental net benefit, quantifying the financial motivation for farmers to participate in the proposed project.

Upon conversion of the farm budget data into economic values and aggregation for all project participants, the incremental net benefit assumes a broader significance as it reflects the project's overall contribution to society. On an individual level, the incremental net benefits, expressed in economic terms, can be interpreted as a measure of the farmer's welfare change. To facilitate a comparison of welfare positions based on annual income, it becomes essential to present the farm budget describing the farmer's current occupation in a tabular format.

Table 11 - Annual Farm Budget

Annual Farm Budget (USD)	
Categories	**Yearly**
Production Value	7650
Off-farm Income	2700
Operating Expenditure	7431
Total Net Benefit	2919

Reference - Based on own calculations.

The data presented in the table was derived from a comprehensive re-evaluation of a previous table containing economic data. To quantify off-farm income in economic terms, an assessment of the shadow price of labour was undertaken. The current situation yields a net benefit of approximately USD 3,000. This outcome will be contrasted with the projected net benefit for the proposed project, as indicated in the table.

Table 12 - Farm Budget - Proposed Project

Farm Budget - Proposed Project (USD)				
Items	**Year 1**	**Years 2 to 4**	**Years 5 to 30**	**Cumulative Years**
Inflow				
Gross value of production	10954	12088	13108	388034
Livestock sales	3826	0	0	3826
Total working capital	0	0	243	243
Total inflow	14780	12088	13351	392103
Outflow				
Investment	-21	300	0	879
Incremental working capital	243	0	0	243
Operating expenditure	2278	2278	2521	74659
Total outflow	2500	2578	2521	75781
Net benefit				
Total proposed project	12280	9510	10830	316322
Total without project	2919	2919	2919	87570
Incremental Net Benefit	9361	6591	7911	228752

Reference - Based on own calculations.

The figures presented in the table were computed using nominal price values as the basis. As per prior research, this study can gauge the alteration in net social advantages by examining the project's influence on the stakeholders. In this specific scenario, when the project aims to produce intermediate goods, this study can assess the additional benefit by examining the shift in income for the stakeholders involved. According to the table's data, the cumulative incremental net benefit accrued over the project's duration totals USD 228,752. This signifies that the incremental gain from farmers transitioning to the alternative project is favourable, leading to an augmented income for the participating farmers.

Economic Results

Based on research findings, the process of consolidating economic data involves gathering the advantages and expenses derived from the model farm and then scaling them up to account for the total number of farms participating in the project. This calculation yields a comprehensive overview of the economic benefits and costs incurred across all farms involved in the initiative, reflecting the collective impact on the participating families. It is important to note that the data indicates the involvement of numerous families in the current project, and this figure serves as the basis for the aggregation process.

Table 13 - Total Incremental Net Benefit

Total Incremental Net Benefit (USD)				
Items	**Year 1**	**Years 2 to 4**	**Years 5 to 30**	**Cumulative Years**
Total Inflow	2639854	8739443	83659559	95038856
Total Outflow	602502	1863945	15796837	18263284
Net Benefit	2037351	6875499	67862722	76775572
Aggregated Net Benefit	2256027	4765052	49572187	56593266

Reference - Based on own calculations.

Previous research has confirmed that the combined incremental net gain derived from economic assessments, as illustrated in the table, reflects the project's contribution to the overall economy. In this instance, the project's economic contribution amounts to USD 40 million. The net gain associated with the proposed project, signifying the difference between total income and expenditures, totals USD 60 million.

The concise statement within the table is often referred to as the economic cash flow. This statement, in accordance with the methodology, is also expected to encompass the government's balance between income and expenditures. However, it is worth noting that a substantial portion of government expenses pertains to a broader initiative encompassing industrial processing, oil transportation, and electricity generation. The degree to which these investments can be directly attributed to the current project, or its alternative is limited, with only a handful of items within the government cash flow being exclusively allocated to the farming component.

Project Measures

The metrics for assessing a project's value are key indicators that gauge its present value. The earlier findings have delineated a continuous stream of net benefits over several years. These metrics offer a contemporary valuation of monetary gains, grounded in the principle that money spent today holds greater significance than its future counterparts. The key metrics featured in this section encompass the net present value and the benefit-cost ratio.

To determine these project worth metrics, it is imperative to establish an appropriate discount rate. Previous research has emphasized the importance of aligning the discount rate with the farm's marginal cost of capital, effectively representing the rate at which the farmer can secure a loan. As previously discussed, this rate stands at 11% annually and serves as the basis for computing present values for both incremental net benefits and overall net benefits. It is assumed that this discount rate remains constant throughout the thirty-year duration of the project. The table below presents the cumulative net present values associated with the farm budget, particularly in cases where financing was required.

Table 14 - Total Net Present Value

Total Net Present Value (USD)	
Net Present Value of Incremental Net Benefit After Financing	**Net Present Value of Net Benefit After Financing**
53553	130571

Reference - Based on own calculations.

As depicted in the table, both the incremental and total net benefits derived from the alternative project exhibit positive values. It has been established in prior research that the guiding principle is to approve projects demonstrating a favourable net present value. Furthermore, numerous studies have underscored the significance of the selected discount rate in influencing the analyst's recommendations, as this variable wields considerable influence over the project's net present value.

For instance, when employing an 11% discount rate, the NPV for the proposed project at the farm level surpasses USD 92,000. Conversely, a lower discount rate of 6% elevates the NPV to nearly USD 106,000, while a higher discount rate of 16% results in a substantial decline to USD 24,000.

The data presented in the table pertains to a scenario in which the farmer needed to secure a loan to cover the investment expenses. Conversely, when the farmer could fund the investment using their own capital, both the annual incremental and annual net benefits exhibited higher figures. Consequently, it can be deduced that the self-financed scenario would also yield a positive net present value.

In line with insights from other studies, economic analysis designates the discount rate as the social discount rate, determining the net social benefits. Prior research has delineated three criteria for establishing the discount rate in economic analysis. The first criterion hinges on the opportunity cost of capital, which represents the return from the most recent investment that depleted all available capital within an economy. Although this criterion is inherently theoretical, the previous studies suggest an opportunity cost of capital of 12% for developing countries.

The second criterion, termed the social time preference rate, is also theoretical and reflects the discount rate that society assigns to future returns. Typically, it is perceived as lower than the opportunity cost of capital, emphasizing its relevance to private investments rather than public programs, unlike the opportunity cost of capital.

The third criterion concerns the interest rate a country pays on its foreign loans. For instance, Gujarat's foreign debt recently approached USD 9 billion, and the reported yield for Indian bonds in international markets stood at 7%. This figure serves as a reference point for a potential discount rate. In this analysis, the baseline discount rate is set at the recommended opportunity cost of capital of 12%, as illustrated in the table displaying the NPV of aggregated economic accounts under this assumption.

Table 15 - Net Present Value

Net present value (Million USD)				
Items	**Year 1**	**Years 2 to 4**	**Years 5 to 30**	**Cumulative Years**
Total Inflow	3	9	84	95
Total Outflow	1	2	16	18
Net Benefit	2	7	68	77
Aggregated Net Benefit	2	5	50	57
Total Net Present Value	2	4	15	21

Reference - Based on own calculations.

The total net present value, as depicted in the table, represents the current value of the additional contribution the project makes to the national income. This positive net present value underscores the project's economic viability and its potential to benefit the economy.

Moreover, it is crucial to assess how variations in the social discount rate can impact the project's net present value concerning its contribution to the national economy. For example, when considering the market interest rate paid by the Indian government on its foreign debt, set at 6.5%, the project's NPV stands at approximately USD 22 million, marking a significant increase of 45%. Conversely, when using a higher social discount rate of 18%, the NPV for the project's contribution to the national economy decreases to USD 12 million, reflecting a reduction of 24%.

It is worth noting that the choice of the discount rate not only influences the analyst's recommendation but also should align with society's perspective on public investments. This perspective encompasses factors such as risk, the opportunity cost of capital, and society's marginal rate of time preference, as previously discussed in chapter two. Consequently, decision-makers must carefully consider which factors best encapsulate the societal considerations relevant to each component of the social discount rate.

Another essential metric for evaluating the project's worth is the benefit-cost ratio, calculated by dividing the present value of the benefit stream by the present value of the cost stream. Like the previous analysis, this financial assessment was conducted using a discount rate of 11%. The table displays the computations for the benefit-cost ratio, considering the farm budget that includes financing.

Table 16 - Benefit Cost Ratio

Benefit Cost Ratio - 11% Discount Rate (USD)				
Item	**Gross Inflows**	**Present Value Inflows**	**Gross Outflows**	**Present Value Outflows**
Total	834994	166949	166425	36378

Reference - Based on own calculations.

The table presents a benefit-cost ratio of five, which is determined by dividing the present value of total inflows by the present value of total outflows. In line with previous research findings, the criterion for project selection is to deem those with a benefit-cost ratio equal to or greater than one as acceptable, which is consistent with the scenario being discussed here. A benefit-cost ratio of five signifies the project's ability to not only cover the initial investment but also the operating expenses. The economic analysis entails calculating the benefit-cost ratio for the consolidated statement of inflows and outflows, like the previous case, using a discount rate of 12%.

Table 17 - Benefit Cost Ratio Final

Benefit Cost Ratio - 12% Discount Rate (Million USD)				
Items	**Year 1**	**Years 2 to 4**	**Years 5 to 30**	**Cumulative Years**
Aggregated Inflows	4	3	3	0
Present Value Aggregated Inflows	3	7	25	36
Aggregated Outflows	1	1	1	0
Present Value Aggregated Outflows	1	2	5	7

Reference - Based on own calculations.

The provided table illustrates the results of the benefit-cost ratio, which is derived by dividing the total present value of inflows by the total present value of outflows. A benefit-cost ratio of six signifies the project's ability to not only cover the initial investment but also sustain operational expenses effectively. This ratio serves as a valuable indicator of the project's financial viability.

14. Results and Discussion

5.1 Key Findings

The study revolves around the Indian government's endeavour to phase out the use of fossil fuels for electricity generation in the GIDC areas. This initiative is set against the backdrop of the challenging socio-economic conditions prevailing in the rural regions of Santalpur, Gujarat. To address this, the government launched a program aimed at involving sustainable practices in rural Santalpur in the production of Ratanjot oil, which would supply electricity plants in the GIDC areas.

In this program, referred to as the status quo within this study, farmers gather Ratanjot fruits and seeds from the living fences that dot the province and sell their yield to government wholesalers, who, in turn, supply local processing plants. The overarching objective is to uplift the income of these sustainable farmers. However, a quantitative analysis has yet to scrutinize the program's broader economic impact and the changes in the well-being of its participants.

Consequently, this study introduces an alternative project that leverages the existing assets of these farmers, including their small land holdings with low opportunity costs. This proposed project entails the cultivation of Ratanjot on a larger scale, as opposed to merely collecting it from living fences. Additionally, this study undertakes a comprehensive evaluation of the financial and economic performance of both the existing status quo and the proposed alternative project. The study primarily focuses on three key objectives.

Firstly, it seeks to ascertain the financial incentives for farmers to engage in either the government's project or the alternative proposed herein. This determination involves a financial analysis employing a distinct methodology. Specifically, a framework known as Farm Investment Analysis is employed, which assesses three critical areas: farm resource utilization, farm production expectations and monetary value, and farm input requirements encompassing initial investment and operational expenses.

The culmination of this analysis results in a farm budget that encompasses all these facets, thus generating a net benefit stream for both the status quo and the proposed project. By subtracting the net benefit stream corresponding to the existing government program from that of the proposed project, this study calculates the incremental net benefit, representing the monetary incentive for farmers to adopt the new initiative. Notably, the results reveal that incentives to participate in the government's program are minimal, failing to even cover the labour opportunity costs. Conversely, transitioning from the government's project to the proposed alternative offers substantial incremental net benefits, averaging USD 4000 annually per farm, equating to an average monthly income of USD 700.

Secondly, the study aims to gauge the changes in the welfare of program participants and the overall contribution of the project to the broader economy. Welfare considerations encompass efficiency in resource allocation and equity. Although welfare dependents typically incorporate different weights to differentiate effects on various income groups, this study's focus on a homogenous group with similar socio-economic conditions and production factors renders the use of weights unnecessary.

The financial analysis measures net benefits as the difference between total inflows and outflows throughout the project's duration. To estimate the project's economic value for society as a whole, market prices are converted into economic values, thereby aggregating incremental net benefits to reflect real net national income changes. In this case, the results indicate an overall addition to the economy amounting to nearly USD 40 million over the project's entire duration. Eight hundreds translates to an average annual welfare improvement of USD 800 per farm family.

Lastly, the third objective involves evaluating the existing policies related to the project and making recommendations accordingly. The study surveyed and reported on the policies relevant to the current and proposed project developments and presented suggestions. A predominant observation from the policy review was the prevalence of price control mechanisms in government interventions. The key recommendation emanating from this analysis is the enhancement of financial services' information accessibility to minimize transaction costs for small farmers.

In summary, the findings underscore that the government's current project fails to offer compelling monetary incentives for farmers. Conversely, the proposed alternative project has the potential to significantly improve welfare and generate positive economic outcomes. Financial evaluations indicate that the existing government project falls short of covering resource investments, while the alternative project demonstrates the potential to do so. Additionally, the government's cash flow records cumulative deficits, implying that the farming component alone cannot generate sufficient income to cover both operating expenses and the initial investment.

Finally, the economic analysis underscores the proposed project's positive impact on the net national income. Notably, the methodology employed values family labour input at its opportunity cost, providing farmers with a monetary valuation for their work. Furthermore, the study's comparative approach enables farmers to assess the net benefits of maintaining the status quo versus adopting the proposed alternative, facilitating informed decision-making for all stakeholders involved.

5.2 Research Limitations

The primary challenge encountered in this study revolved around the acquisition of data regarding Ratanjot productivity within the specific conditions outlined. One of these conditions pertained to sustainable farming, characterized by minimal usage of chemical fertilizers and pesticides. Remarkably, there was an absence of localized research addressing optimal farming techniques for Ratanjot cultivation across various operational processes. While some suggestions existed, highlighting the plant's adaptability to intercropping and its resilience in water-scarce environments, there was a conspicuous absence of guidance concerning pest and disease management as well as fertilizer requirements.

Consequently, our study ventured beyond national boundaries to explore Ratanjot production techniques in countries where its cultivation was more prevalent. Furthermore, another data constraint emerged when assessing Ratanjot productivity during its stable production phase. While numerous studies offered projections of expected yields, there was a scarcity of ex-post analyses detailing yields per hectare over extended periods, especially beyond the fifth year.

In addressing these limitations, our survey encompassed not only the collection of socio-economic data concerning farming producers but also examined factors such as land ownership and available equipment. However, it is important to acknowledge that the findings presented here are influenced by the assumption that the socio-economic circumstances of farming producers in Gujarat have remained stable in recent years.

5.3 Policy Implication

As previously mentioned, the current government business model was established as part of the national policy aimed at phasing out the use of fossil fuels for electricity generation in the GIDC areas. Simultaneously, the demand for Ratanjot seed was expected to be closely tied to this initiative. Consequently, the government fixed the price for this product, which does not fluctuate in response to market competition. This pricing structure significantly impacts the potential net benefits that farmers can anticipate from participating in both current and future projects.

The findings of this study indicate that the incremental increases in net benefits were modest, particularly when it comes to incentivizing farmers to participate in the government's proposed business model. The Indian government has implemented a comprehensive range of policy measures to manage input and output prices within the agricultural sector. The Ministry of Farming plays a pivotal role in overseeing various aspects of the agricultural production chain, including production costs, transportation expenses, wholesale prices, and the importation of domestically produced agricultural items.

For instance, in the current landscape, expenses related to farming inputs, such as pesticides and fertilizers, have constrained profitability. Consequently, the Indian government has intervened by regulating the prices of these inputs through two different approaches. Under the Regime of Free Prices under Surveillance, importers, manufacturers, and traders have the flexibility to set sales prices, but they are obligated to report these prices to the Ministry of Farming monthly. In the Regime of Direct Price Control, the executive branch establishes maximum sale prices for items like fertilizers and chemical inputs, among others.

The production and marketing of maize also involve government interventions. The government exercises control over the wholesale prices paid to producers by setting a minimum seasonal price. Furthermore, the industrial sector is required to purchase all domestically produced maize, and the government maintains oversight over maize imports that exceed domestic supply.

One significant assumption made in this study was the minimal nature of transaction costs, particularly concerning financial services. Despite the government's efforts to make financial resources more accessible to sustainable farming, it was apparent that farmers would have to incur travel expenses to obtain proper information and assistance when applying for loans. Those located in remote areas far from bank branches had to travel long distances to access financial resources because information was not readily available by phone.

Considering the financial constraints of a group with one of the lowest income levels in the country, this issue could be crucial. An aspiring agent could easily become discouraged if obtaining financial services proves to be too challenging or costly. Therefore, it is strongly recommended that the National Development Bank ensures the availability of information about financial products and procedures through easily accessible means, such as phone-based information centres.

The existing literature underscores the importance of introducing sustainable farming technologies to small-scale farmers and continually evaluating and refining these techniques. These practices, such as mulch maintenance and stubble incorporation, must be followed diligently to ensure their success. Collaboration and technical guidance from government research institutions, which are already established in the target area, could assist in the maintenance and optimization of sustainable farming technologies.

5.4 Research Agenda

One avenue for future research involves exploring the evaluation of environmental benefits and services linked to the cultivation of Ratanjot. An area of particular interest lies in examining its impact on greenhouse gas emissions within two specific contexts. Firstly, the utilization of Ratanjot cake as a fertilizer has the potential to reduce carbon emissions, primarily by avoiding the need for international transportation of chemical fertilizers. Many countries, including Gujarat, rely on importing chemical fertilizers due to their limited local production.

Ratanjot cake is known to contain essential nutrients, suggesting its potential to replenish soil nutrients. However, further in-depth studies are essential to ascertain its effectiveness as a substitute for commercial fertilizers in terms of productivity and soil quality enhancement. While existing research has primarily focused on the reduction of carbon emissions attributed to Ratanjot, it is imperative to also consider other significant gases, such as nitrous oxide, released during fertilizer application. If Ratanjot cake does indeed mitigate gas emissions, additional research in this area is warranted.

The second context that merits further investigation pertains to Ratanjot productivity in low-quality soils. Studies have indicated that cultivating Ratanjot in marginal lands with low opportunity costs can lead to carbon sequestration without displacing food production. However, if productive lands are repurposed for Ratanjot cultivation, land-use changes could significantly impact gas emissions, potentially displacing food production. Confirming the feasibility of Ratanjot production on marginal lands would provide an advantage over energy crops that require more fertile land, such as Indian palm, soybean, or sugar cane.

Moreover, uncertainties persist regarding optimal management practices for Ratanjot plantations. Yield is influenced by site characteristics, genetics, plant age, and management practices, including propagation, spacing, pruning, fertilization, and irrigation. As these practices vary depending on site-specific conditions and available resources, future research should embrace site-specific characteristics rather than attempting to impose uniform practices across countries or regions. To maximize plant performance, it is crucial to investigate and determine the physical and chemical attributes of Ratanjot fruits and seeds.

Genetic selection should aim to strike a balance between plant performance and desirable seed characteristics, particularly those that enhance the quality of Ratanjot oil. This is of paramount importance for oil extraction and processing, as Ratanjot oil quality is influenced by these characteristics. Given the unavailability of certified seeds for cultivation, genetic improvement is critical to ensure optimal yields and adaptability to local climatic conditions in the study area. Variations in Ratanjot characteristics and performance, even within small geographical zones, underscore the importance of matching selected seeds to local climatic conditions, including precipitation levels and climate types.

Lastly, further research should encompass the utilization of Ratanjot by-products within the production chain. Existing literature suggests that these by-products can enhance value, encompassing the production of organic fertilizer from cake/husk and the generation of biogas and gasification through husk combustion. Thus, the envisioned production chain proposed by the Indian government should extend beyond raw materials to processed products, with a focus on improving the livelihoods of the target group. Future economic research should encompass aspects such as oil production, fertilizer production and distribution, and the potential for local energy generation through biomass combustion.

15. Conclusion

The outcomes of the financial and economic evaluations, both at the individual and aggregate levels, demonstrate a favourable outlook for the proposed project from the perspective of farmers. However, the government, which is also a stakeholder in this endeavour, does not foresee positive returns from its investment in the farming component of the project throughout its duration. As delving into the results in more detail, starting with the financial analysis. The analysis is divided into two scenarios. In the first scenario, the farmer uses her own capital to finance the investment costs and operational expenses required to establish the alternative project.

In this case, the results consistently show a positive net benefit in each year of the project's duration, indicating a profitable return on the farmer's investment. Furthermore, the incremental net benefit is positive in each year, signifying that transitioning from her current occupation to the proposed project would yield a higher annual income for the farmer. In the second scenario, the farmer opts for a loan to cover the investment costs. Here, the farm budget includes debt financing, which is subtracted from the total and incremental net benefits.

While the total net benefits after financing remain positive throughout the project's duration, they are lower than in the first scenario during the initial four years. This suggests that debt servicing impacts yearly net benefits, requiring the farm family to adapt to lower annual incomes in the initial years if a loan is necessary. However, even in this scenario, the incremental net benefit after financing remains positive each year, indicating that the proposed project offers a higher income potential compared to the farmer's current occupation.

Therefore, whether using personal capital or obtaining financing for investment and operational expenses, the farmer would find financial incentives to participate in the proposed project. On the other hand, the government's financial situation shows a cumulative deficit over the project's duration, as this study primarily focusing on the farming component in this analysis. This indicates that the income generated from the farming phase is insufficient to cover both the initial investment costs and ongoing expenses. This study presents two government cash flow scenarios: the first includes loans provided to farmers, and the second represents the status quo without loans.

In the first government statement, the net cash flow reveals a cumulative deficit, as the income generated from the farming component falls short of covering the investment and operational costs, particularly the high recurrent expenses such as operation and maintenance. In the second scenario, which excludes loans to farmers, the cumulative deficit is even more pronounced because income from debt servicing is eliminated. Moving on to the economic analysis, this study considered three aspects: the farm budget based on economic values, the aggregated economic results, and the project's worth measurements.

The farm budget, evaluated in economic terms, yielded positive incremental net benefits, representing an equitable measure of the producer surplus that the farmer can anticipate as a result of this policy change. This suggests a positive impact on the farmer's welfare from engaging in the proposed project. The aggregated economic results indicate an overall addition of nearly USD 40 million, implying that the proposed project would have a positive influence on the national economy. The project's worth was assessed using the net present value and the benefit-cost ratio in both financial and economic evaluations.

Finally, in financial terms, the net present value of both incremental and total net benefits was positive, indicating that the proposed project is a recommended investment. In the economic analysis, the net present value of the aggregated incremental net benefit was also positive, affirming the project's potential to contribute positively to the overall economy. Furthermore, the benefit-cost ratios for both financial and economic evaluations exceeded one, confirming that the project can cover its investment costs, operational expenses, and generate additional returns, making it a favourable endeavour from both financial and economic perspectives.

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List of Tables

Appendix

Appendix 1 - Production Value (USD)

Item	Maize	Peanut	Curcas	Livestock	Total
Without Project					
Annual Production	3663	2208	80	1913	7864
With Project					
Year 1	3968	7200	0	0	11168
Year 2	4167	7560	756	0	12483
Year 3	4375	7938	794	0	13107
Year 4	4594	8335	833	0	13762
Year 5	4823	8752	1663	0	15238
Year 6	5065	9189	1746	0	16000
Year 7	5318	9649	1833	0	16800
Year 8	5584	10131	1925	0	17640
Year 9	5863	10638	2021	0	18522
Year 10	6156	11170	2122	0	19448
Year 11	6464	11728	2228	0	20420
Year 12	6787	12314	2340	0	21441
Year 13	7126	12930	2457	0	22513
Year 14	7483	13577	2580	0	23639
Year 15	7857	14256	2709	0	24821
Year 16	8250	14968	2844	0	26062
Year 17	8662	15717	2986	0	27365
Year 18	9095	16503	3135	0	28733
Year 19	9550	17328	3292	0	30170
Year 20	10028	18194	3457	0	31678
Year 21	10529	19104	3630	0	33262
Year 22	11055	20059	3811	0	34926
Year 23	11608	21062	4002	0	36672
Year 24	12189	22115	4202	0	38505

Year 25	12798	23221	4412	0	40431
Year 26	13438	24382	4633	0	42452
Year 27	14110	25601	4864	0	44575
Year 28	14815	26881	5107	0	46804
Year 29	15556	28225	5363	0	49144
Year 30	16334	29636	5631	0	51601

Appendix 2 - Total Operating Expenditure (USD)

Categories	Maize	Peanut	Ratanjot	Total crops	Operation & Maintenance	Operating Expenditure
Year 1	805	1788	1566	4158	13	4171
Year 2	432	1398	999	2829	19	2848
Year 3	445	1440	1029	2914	20	2934
Year 4	459	1483	1060	3001	22	3023
Year 5	548	1683	789	3020	24	3044
Year 6	578	1745	833	3156	25	3182
Year 7	610	1809	880	3298	27	3326
Year 8	643	1875	929	3447	29	3477
Year 9	678	1944	982	3603	32	3635
Year 10	715	2015	1037	3766	34	3800
Year 11	754	2088	1095	3937	36	3974
Year 12	795	2165	1156	4117	39	4156
Year 13	839	2244	1221	4304	42	4346
Year 14	885	2326	1290	4501	45	4546
Year 15	933	2411	1362	4706	49	4755
Year 16	984	2500	1438	4922	53	4975
Year 17	1038	2591	1519	5148	56	5204
Year 18	1095	2686	1604	5385	61	5446
Year 19	1154	2784	1694	5633	65	5698
Year 20	1218	2886	1789	5893	70	5963

Year 21	1284	2992	1890	6165	76	6241
Year 22	1354	3101	1996	6451	81	6533
Year 23	1428	3215	2108	6751	87	6838
Year 24	1506	3332	2226	7065	94	7159
Year 25	1589	3454	2351	7394	101	7495
Year 26	1675	3581	2483	7739	109	7848
Year 27	1767	3712	2622	8101	117	8218
Year 28	1864	3848	2769	8480	126	8606
Year 29	1965	3989	2924	8878	136	9014
Year 30	2073	4135	3088	9296	146	9442

Appendix 3 - Farm Budget - Case 1 (USD)

Year	Total Inflows	Investment	Incremental Working Capital	Operating Expenditure	Total Outflows	Total Net Benefits	Net Benefit Without Project	Incremental Net Benefits
Year 1	14995	156	0	4171	4327	10668	6103	4565
Year 2	12483	0	78	2848	2925	9557	6365	3192
Year 3	13107	0	80	2934	3014	10093	6639	3454
Year 4	13762	441	19	3023	3482	10280	6925	3355
Year 5	15238	0	124	3044	3168	12070	7222	4848
Year 6	16000	0	130	3182	3311	12689	7533	5156
Year 7	16800	0	136	3326	3461	13338	7857	5482
Year 8	17640	0	142	3477	3619	14021	8195	5826
Year 9	18522	0	149	3635	3784	14738	8547	6191
Year 10	19448	0	156	3800	3957	15491	8914	6577
Year 11	20420	0	164	3974	4138	16283	9298	6985
Year 12	21441	0	171	4156	4327	17114	9698	7416
Year 13	22513	0	180	4346	4526	17987	10115	7873
Year 14	23639	0	188	4546	4734	18905	10550	8355
Year 15	24821	0	197	4755	4953	19868	11003	8865
Year 16	26062	0	207	4975	5181	20880	11476	9404
Year 17	27365	0	217	5204	5421	21944	11970	9974
Year 18	28733	0	227	5446	5673	23060	12484	10576
Year 19	30170	0	238	5698	5937	24233	13021	11212
Year 20	31678	0	250	5963	6213	25465	13581	11884
Year 21	33262	0	262	6241	6503	26759	14165	12594
Year 22	34926	0	275	6533	6808	28118	14774	13344
Year 23	36672	0	289	6838	7127	29545	15410	14136
Year 24	38505	0	303	7159	7461	31044	16072	14972
Year 25	40431	0	318	7495	7813	32618	16763	15855
Year 26	42452	0	333	7848	8181	34271	17484	16787
Year 27	44575	0	350	8218	8567	36007	18236	17771
Year 28	46804	0	367	8606	8973	37830	19020	18810
Year 29	49144	0	385	9014	9399	39745	19838	19907
Year 30	57535	0	0	9442	9442	48094	20691	27403

Appendix 4 - Farm Budget - Case 2 (USD)

Year	Total Inflows	Total Outflows	Total Net Benefits Without Financing	Net Benefit Without Project	Incremental Net Benefits Before Financing	Net Financing	Total Net Benefits After Financing	Incremental Net Benefits After Financing
Year 1	11168	4327	6841	6103	738	1950	8791	2688
Year 2	12483	2925	9557	6365	3192	-1190	8368	2002
Year 3	13107	3014	10093	6639	3454	-1082	9011	2371
Year 4	13762	3482	10280	6925	3355	0	10280	3355
Year 5	15238	3168	12070	7222	4848	0	12070	4848
Year 6	16000	3311	12689	7533	5156	0	12689	5156
Year 7	16800	3461	13338	7857	5482	0	13338	5482
Year 8	17640	3619	14021	8195	5826	0	14021	5826
Year 9	18522	3784	14738	8547	6191	0	14738	6191
Year 10	19448	3957	15491	8914	6577	0	15491	6577
Year 11	20420	4138	16283	9298	6985	0	16283	6985
Year 12	21441	4327	17114	9698	7416	0	17114	7416
Year 13	22513	4526	17987	10115	7873	0	17987	7873
Year 14	23639	4734	18905	10550	8355	0	18905	8355
Year 15	24821	4953	19868	11003	8865	0	19868	8865
Year 16	26062	5181	20880	11476	9404	0	20880	9404
Year 17	27365	5421	21944	11970	9974	0	21944	9974
Year 18	28733	5673	23060	12484	10576	0	23060	10576
Year 19	30170	5937	24233	13021	11212	0	24233	11212
Year 20	31678	6213	25465	13581	11884	0	25465	11884
Year 21	33262	6503	26759	14165	12594	0	26759	12594
Year 22	34926	6808	28118	14774	13344	0	28118	13344
Year 23	36672	7127	29545	15410	14136	0	29545	14136
Year 24	38505	7461	31044	16072	14972	0	31044	14972
Year 25	40431	7813	32618	16763	15855	0	32618	15855
Year 26	42452	8181	34271	17484	16787	0	34271	16787
Year 27	44575	8567	36007	18236	17771	0	36007	17771
Year 28	46804	8973	37830	19020	18810	0	37830	18810
Year 29	49144	9399	39745	19838	19907	0	39745	19907
Year 30	57535	9442	48094	20691	27403	0	48094	27403

Appendix 5 - Annual Present Values

Year	Present Value of Incremental Net Benefit After Financing	Present Value of Net Benefit After Financing
Year 1	2422	7920
Year 2	1625	6792
Year 3	1734	6588
Year 4	2210	6772
Year 5	2877	7163
Year 6	2756	6784
Year 7	2640	6425

Year 8	2528	6084
Year 9	2420	5761
Year 10	2316	5456
Year 11	2216	5166
Year 12	2120	4892
Year 13	2027	4632
Year 14	1938	4386
Year 15	1853	4153
Year 16	1771	3932
Year 17	1692	3722
Year 18	1616	3524
Year 19	1544	3336
Year 20	1474	3159
Year 21	1407	2990
Year 22	1343	2831
Year 23	1282	2680
Year 24	1223	2536
Year 25	1167	2401
Year 26	1113	2273
Year 27	1062	2151
Year 28	1012	2036
Year 29	965	1927
Year 30	1197	2101
Total	53553	130571