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Research Paper

Cost:benefit analysis of the potato seed production facility in Seetha Eliya farm of the Department of Agriculture in Sri Lanka

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Abstract: Potato is one of the important tuber crop in Sri Lanka, where high cost of potato seed has shrunken the comparative advantage of the crop. In order to reduce the seed potato production costs, the Department of Agriculture (DOA) has intervened by implementing high tech facility at Seetha Eliya in the Central province of Sri Lanka. In 2017, the facility has produced 1.2 million of potato mini tubers. However, no study has been done to evaluate the financial and economic feasibility of the facility to justify its establishment. This study aimed at fulfilling this gap. Primary data were collected from the seed farm at Seetha Eliya, and were analyzed using non-linear programing models for annual operating profitability. The production levels were used as inputs for the project appraisal techniques to evaluate the overall profitability at project economic lifespan. The results of the study showed that seed production in net houses is financially and economically feasible over conventional method. Even though the financial profitability is high in net house cultivation for production of only G0 seed, the economic profitability is high for the combined cultivation of G0 and G1 seeds. The expansion of the glass house space is strongly recommended owing to its limited capacity. Furthermore, seed production is suggested to be confined to G0 seeds under adverse conditions.

Keywords: Financial feasibility, economic feasibility, seed potato

Introduction

Potato (*Solanum tuberosum* L) is one of the important tuber crops in Sri Lanka. The annual requirement of potato is about 200,000 mt (DOA, 2017a) of which 120,000 mt are imported annually (Sri Lanka Customs, 2017) to the value is about LKR 3.5 billion (Sri Lanka Customs, 2017). Potato industry of Sri Lanka has experienced two major issues, namely, (a) climatic conditions suited for the crop cultivation is mostly limited to Nuwara Eliya and Badulla districts, which are at higher elevations in the central province, and (b) the high cost of seed potato - ranging between LKR 200 to 250 per kilogram, which is 68% of the total production cost (COC, 2017). In order to address the issue of high cost of seed potato, the national crop production plan 2015-2018 helped establishing a special facility at the Seetha Eliya seed farm in the Nuwera Eliya district for production of basic seed potato (G0 seeds) with a high-end technology package. The annual mini tuber production from the facility is about 1.22 million (DOA, 2017a) and is the only facility available in Sri Lanka for potato seed production. No studies have been done to evaluate the financial and economical feasibility of the facility. Hence, the objective of this study were to assess the financial and economic feasibility of the facility, to identify the bottlenecks in production of seeds under the new technology package, and to identify the investment opportunities to mitigate them.

Methodology

The seed potato production facility consists of four major components. Firstly, the tissue culture unit established at the regional agriculture research station Seetha Eliya that produces tissue culture plants (sold to Seetha Eliya seed farm at price of LKR 50/pot). Secondly, multiplication of tissue culture plants and production of pre basic seed is take place in the glass house of the seed farm at three stages (Figure 1). The tissue culture plants and cuttings were cultivated in pots and trays using sand and coir dust media in a controlled environment. After, cuttings were taken every 21 days, till 3 cuttings per plant and planted in new trays. Each multiplication stage is identified by a specific colour which start from green and end with red. Thirdly, the net houses where the basic seed (G0) Production takes place from pre-basic seeds using aeroponic and hydroponic technologies with three cultures per net house annually. Fourthly, the net houses where G1 seed production takes place from G0 using geoponic technology.

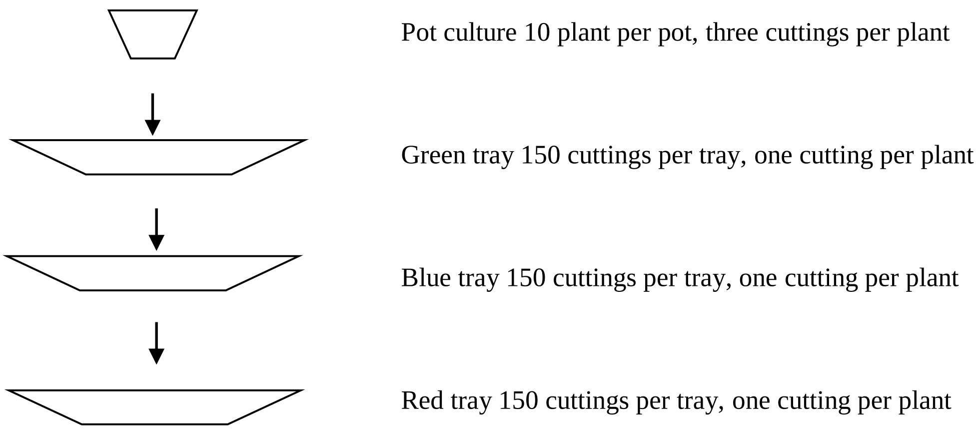

Figure 1: Potato pre basic seed multiplication in the glass house

The conceptual framework of the study is illustrated in Figure 2. The analysis consists of operating profit analysis of the present system where the number of pre-basic seed production is limited to 126,000 per annum and thus, seed farm is not operating at its full capacity. Further, the optimal resource allocation in production of mini tubers (Go and G1) was measured. The present pricing for G0 mini tubers at a rate of LKR 6 per tuber to obtain operating profitability (G0 and G1 mini tubers priced at the same rate of LKR 6 per tuber) was also assessed using the non-linear programing (NLP) technique. As the farm targets a high number of mini tuber production, it was considered worthy to compare the optimal production of the mini tubers. Thus, operating profit under maximum production was measured using the maximum production model (Model 1) representing the public sector perspective. Furthermore, the operating profit under optimal production was measured using the minimal cost model (Model 2) representing the private sector motive.

Then the earlier restriction of pre-basic seed production was relaxed by assuming doubling the glass house capacity in a production of 252,000 pre-basic seeds. However, even at this stage, the public sector motive and private sector motive will not change. Thus, two new situations were tested with two new models, *i.e.* the operating profitability at the maximum production under new situation was measured using the maximum production model (Model 3), and that under optimal production was measured using the minimal cost model (Model 4). These operating profitability results were compared with the cost and revenues of conventional farming method that were extracted from farm records of the seed farm at Seetha Eliya (DOA, 2017b).

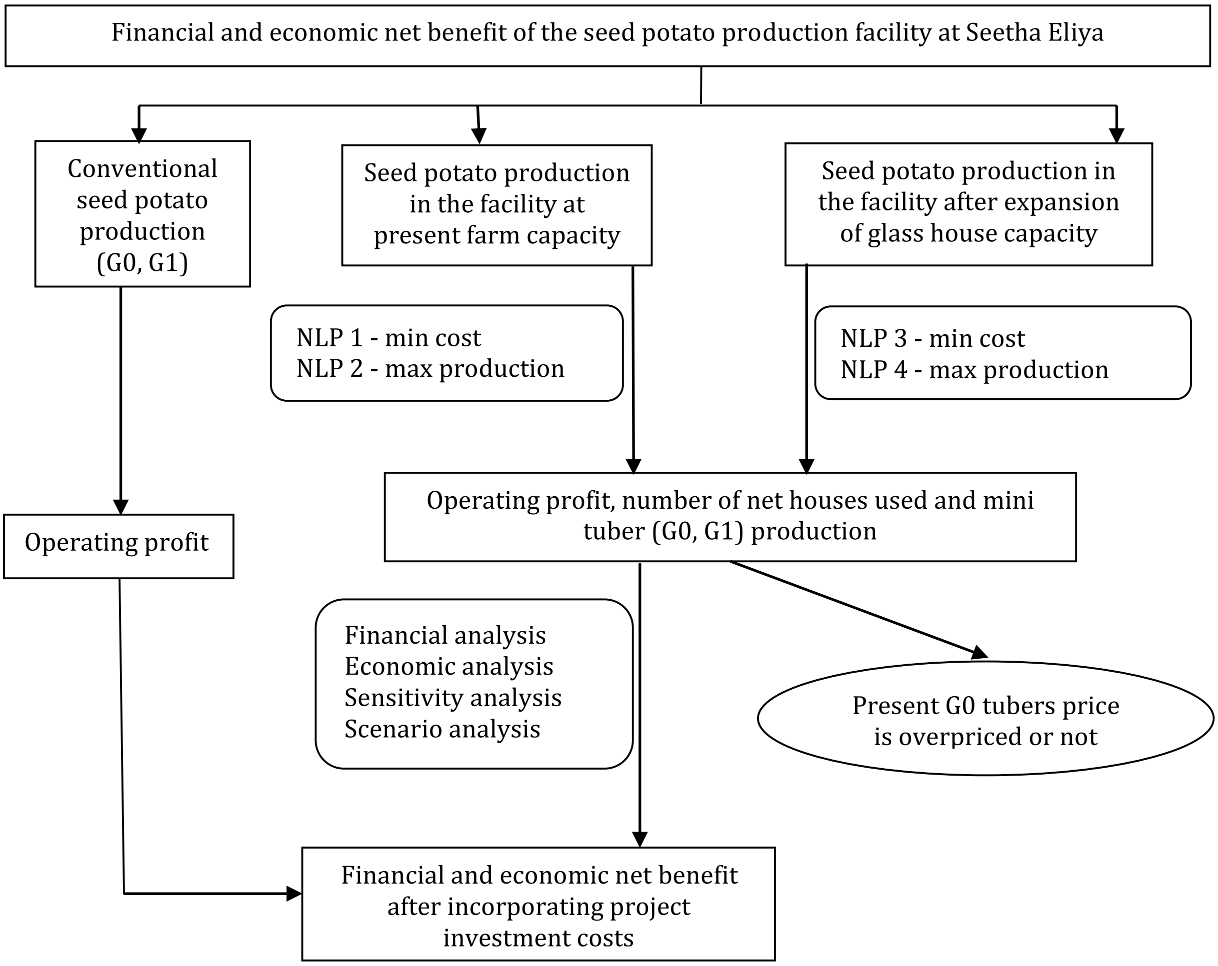

Figure 2. Conceptual framework of the study

<u>Nonlinear programing models:</u>

(1) With existing resource base - Minimum cost / maximum profit model

$$MinY = (c_1 * x_1 * f) + (c_2 * x_2 * g) + (c_3 * x_3 * h) + (c_1 * y_1 * 2f) + (c_3 * y_3 * 2h) \qquad \text{[Model 1]}$$

Cost subjected to: $a_2x_1 + b_2x_2 + c_2x_3 \geq 13$ (400 m² net houses); $d_3y_1 + e_3y_3 \geq 1$ (800 m² net houses), $a_4x_1 + b_4x_2 + 2a_4y_1 \leq 126000$ (pre-basic seeds), $c_4x_3 + e_4y_3 \geq 0$ (G0 seeds for geoponic cultivation); $x_1, x_2, x_3, y_1, y_3 =$ positive integers

(2) With existing resource base - Maximum production model

$$MaxY = fx_1 + 2fy_1 + gx_2 + hx_3 + 2hy_3 \qquad \text{[Model 2]}$$

Production subjected to: $a_2x_1 + b_2x_2 + c_2x_3 \geq 13$ (400 m² net houses); $d_3y_1 + e_3y_3 \geq 1$ (800 m² net houses), $a_4x_1 + b_4x_2 + 2a_4y_1 \leq 126000$ (pre-basic seeds), $c_4x_3 + e_4y_3 \geq 0$ (G0 seeds for geoponic cultivation); $x_1, x_2, x_3, y_1, y_3 =$ positive integers

(3) Improvement of glass house by doubling current capacity of pre-basic seed production - Minimum cost

$$MinY = (c_1 * x_1 * f) + (c_2 * x_2 * g) + (c_3 * x_3 * h) + (c_1 * y_1 * 2f) + (c_3 * y_3 * 2h) \qquad \text{[Model 3]}$$

Cost subjected to: $a_2x_1 + b_2x_2 + c_2x_3 \geq 13$ (400 m^2 net houses), $d_3y_1 + e_3y_3 \geq 1$ (800 m^2 net houses); $a_4x_1 + b_4x_2 + 2a_4y_1 \leq 252000$ (pre-basic seeds); $c_4x_3 + e_4y_3 \geq 0$ (G0 seeds for geoponic cultivation); $x_1, x_2, x_3, y_1, y_3 =$ positive integers

(4) Improvement of glass house by doubling current capacity of pre-basic seed production - Maximum production

$$MaxY = fx_1 + 2fy_1 + gx_2 + hx_3 + 2hy_3 \qquad \text{[Model 4]}$$

Production subjected to: $a_2x_1 + b_2x_2 + c_2x_3 \geq 13$ (400 m^2 net houses); $d_3y_1 + e_3y_3 \geq 1$ (800 m^2 net houses); $a_4x_1 + b_4x_2 + 2a_4y_1 \leq 252000$ (pre-basic seeds); $c_4x_3 + e_4y_3 \geq 0$ (G0 seeds for geoponic cultivation); $x_1, x_2, x_3, y_1, y_3 =$ positive integers.

The x_1 denotes number of 400 m^2 net houses used for production of G0 seeds using aeroponic technology, x_2 is the number of 400 m^2 net houses used for production of G0 seeds using hydroponic technology and x_3 indicates the number of 400 m^2 net houses used for production of G1 seeds using geoponic technology; y_1 denotes the number of 800 m^2 net houses used for production of G0 seeds using aeroponic technology and y_3 denotes number of 800 m^2 net houses used for production of G1 seeds using geoponic technology.

As the hydroponic cultivation was not practiced due to low profitability and complexity of handling in the farm for 800 m^2 net houses, the y_2 variable did not exist and thus was not considered in the analysis. Further in the cost models (1 and 3), c_1, c_2 and c_3 are constants denoting the unit cost of production (excluding costs apportion on investments) of aeroponic, hydroponic and geoponic technologies, respectively. f and g are constants denotes G0 mini tuber production under aero phonic and hydro phonic systems under 400 m^2 net houses. h is a constant denotes G1 mini tuber production under 400 m^2 net houses.

Merging the results of NLP analysis with the project investment costs project analysis technique was used in MS excel solver to identify financial and economic feasibility of the project. This analysis compared the public sector and private sector motives with present resource availability and measuring the worthiness of investment decision of expansion of glass house capacity. All four models used for NLP analysis and the results were used in the project analysis. Later, the project stability and new investment ability was tested with the project risk assessment. Project sensitivity analysis was carried out for two adverse situations, as the sensitivity analysis did not allow accompanying two or more adverse conditions at a time. The scenario analysis was carried out accompanying above two adverse conditions simultaneously. Results of the facility were compared with conventional seed production results of a similar land area of the plant houses (0.6 ha and 1.2 ha). All the costs and revenues were extracted from farm records at the seed farm at Seetha Eliya and the BOQ reports of farm development programme (DOA, 2015).

<u>Financial feasibility:</u>
Financial feasibility of this study consist of two major components namely financial measures of project worth and project sensitivity analysis. Financial measures of project worth were analyzed using three major parameters, which are commonly use in project analysis and interpreted together, namely, (a) Internal Rate of Return (IRR) - the discount rate that makes the discounted net present values of benefits after costs equal to be zero, project is accepted when IRR is more than or equal to the cost of capital, (b) Net Present Value (NPV) - the difference between the present value of cash inflows and the present value of cash outflows, project is accepted when value is positive, and (c) Cost Benefit Ratio (B/C ratio) – the ratio between discounted cash Inflows over discounted cash outflows, project is accepted only when ratio is more than or equal to 1.

The sensitivity analysis measured the financial feasibility of the project under unfavourable conditions that exist during the economic period of the project. It was tested for three situations, namely, (a) Increase in all operation costs by 10% (Sensitivity 1), (b) Decrease in product prices by 10% (Sensitivity 2), and (c) Increase in costs by 10% and decrease product prices by 10% (Scenario 1).

The discount rate is used for calculation of present values and rate representing the cost of capital of the project was calculated using the weighted average cost of capital (WACC) of equity and loans (Farber *et al.*, 2006; Equation 1);

$$WACC = \frac{D * r + E * i}{I} * 100 \qquad \text{Equation 1}$$

Where D = Loan value, r = Loan rate, E = Equity (Own finance), and I = Equity cost of capital. The equity cost of capital is the cost of capital of own finance (opportunity cost of capital) and was calculated using the capital assets pricing model (CAPM) (Kisman and Shintabelle, 2015; Equation 2);

$$CAPM = r_f + (r_m - r_f) * \beta \qquad \text{Equation 2}$$

Where, r_f = Risk free interest rate (Treasury bill rate), r_m- r_f = Market risk premium, and β = beta factor (performance compared to bench mark of 1).

The equity risk rates were calculated for different countries and equity risk for Sri Lanka was obtained as 12.2% (Country Default Spreads and Risk Premiums, 2019). Treasury bill rate was 7.5% (Central Bank, 2019). In project analysis, the IRR is one of the most important measures of project worth, nevertheless subjected to problem of multiple optimal solutions (multiple IRR) and hence, the modified internal rate of return (MIRR) was used to correct the issue. However, MIRR requires a reinvestment rate and for calculation of optimal IRR, the weighted average cost of capital was used as the reinvestment rate (Kierulff, 2008; Balyeat *et al.*, 2015). Studies have shown that the economic life of a project is finite and is in the range of 10 to 35 years (Gryglewicz *et al.*, 2008).

Key assumptions:

It was assumed that the farm is operating for 365 days per annum, 51% of the required investment is financed through subsidized loan and balance 49% financed through own equity. Loan availability is at the rate of 6.75% (*Jaya isura* loan scheme) with 6 years of repayment period including one-year grace period. Discounting rates used for NPV and B/C ratio calculations was 13.1%, which was the WACC of the project. The economic life span of the project was assumed as 20 years.

Economic feasibility:

Economic analysis measures the economic contribution of the project to the society and rationality of requisite resources allocation to the project. The discounted measures of the project worth were used to estimate returns. The analysis include two steps, namely, (1) Adjustments to transfer payments- project loan effect removed by ignoring the finance through loan and there are no taxes involved in imports of the materials, machinery and equipment used in the projects as these taxes were not paid by the government seed farm and was not included in the costs of purchases, and (2) Both input and output of the project were categorized into tradable and non-tradable items Table 1, where market prices of all non-tradable items were multiplied with standard conversion factors (Table 2) for Sri Lanka calculated by the Asian Development Bank (Martin, 2004).

Table 1: Tradable and non-tradable inputs

Input	**Tradable**	**Non-tradable**
Land		Yes
Building		Yes
Machinery	Yes	
Labour	Yes	
Chemicals	Yes	
Seed	Yes	
Furniture and fittings	Yes	
Water		Yes
Electricity		Yes

Table 2: Shadow price calculation

Item	SCF/SWRF	SCF value	Shadow Price	ADB Project reference
Labour - Unskilled	SWRF	0.75	SCF*SWRF	Southern province rural economic
Other non-tradable items	SCF	0.90	SCF	advancement project, 2001

*SWRF – Shadow Wage Rate Factor

All the adjusted cash flows with shadow exchange rates were discounted at Social Discount Rate (SDR). Studies have shown that for developing countries the SDR ranges between 8% to 15% and rates reduced when they become developed (Gunathilake *et al*., 2013). The SDR calculated using social opportunity capital cost approach (SOC) was used for this study instead of the Social Time Preference (STP) approach, and the calculated value for Sri Lanka was 9.8% (Valentim and Prado, 2008), as the STP approach used to under-value the SOC due to market distortions (Gunathilake *et al*., 2013). For this project evaluation, SDR use was 12% of India (Gunathilake *et al*., 2013). Although it has been calculated for India, the value is justifiable as it is within the range of 8% to 15 % (Gunathilake *et al*., 2013). The IRR, MIRR, NPV and B/C ratios were recalculated after discounting the values with a SDR of 12%.

Results and Discussion

The results of NLP model analysis using operating costs is presented in Table 3 and that using the conventional method in Table 4. Accordingly, the production cost of G0 (LKR 1.11/tuber) is low in net houses compared to that of the conventional method. However, the G1 production cost is low under the conventional method (LKR 1.05/tuber) compared to the net houses (LKR 4.42 to 4.44/tuber). Furthermore, increase of pre-basic seed production through increase in the capacity of glass house may increase the farm operating profitability to LKR 11.6 million (Model 3) and in LKR 21.2 million (Model 4).

Table 3: Production information in cultivation in net houses

Parameter	Model 1	Model 2	Model 3	Model 4
Aeroponic (400 m^2) net houses	4.00	2.00	8.00	5.00
Hydroponic (400 m^2) net houses	1.00	1.00	2.00	1.00
Geoponic (400 m^2) net houses		10.00		20.00
Aeroponic (800 m^2) net houses		1.00		1.00
Geoponic (800 m^2) net houses				1.00
G0 seed production (millions)	1.90	1.70	3.80	2.80
G1 Production (millions)		2.20		4.80
Annual Operating cost (LKR millions)	2.10	11.60	4.20	24.40
Unit cost of production G0 mini tuber (LKR)	1.11	1.11	1.11	1.11
Unit cost of production G1 mini tuber (LKR)		4.42		4.44
Operating profit in (LKR millions) at selling price LKR 6	9.30	11.8	18.6	21.20
Unit Operating profit in (LKR/tuber)	4.89	3.02	4.89	2.79

Table 4: Production information under conventional method (0.4 ha)

Parameter	G0	G1
Annual operating cost (2 seasons) LKR millions	0.90	0.80
Production (kg)	12,000	12,000
Unit cost per kg (LKR)	75	69
Number of mini tubers per Kg (15 g per tuber)	66	66
Unit cost in mini tubers (LKR)	1.14	1.05

Source: DOA (2017b); LKR = Sri Lanka Rupees

Financial analysis:
Results of the financial feasibility analysis of the cultivation in net houses and under conventional method are shown in Tables 5 and 6, respectively. Accordingly, all feasibility criteria were consistent and seed production in net houses is feasible over the conventional method. The MIRR values and B/C ratio values showed that the minimal cost models are profitable over the maximum profit models as expected. Moreover, a higher profitability of Models 3 and 4 compared to that of Models 1 and 2 showed an increase in pre-basic seed production through doubling the glass house capacity and an increased farm profitability.

Table 5: Profitability in net house cultivation discounted at 13.1%

Indicator	Model 1		Model 2		Model 3		Model 4	
	Own funds	Finance	Own funds	Finance	Own funds	Finance	Own funds	Finance
IRR (%)	26	37	23	32	27	40	31	48
MIRR (%)	16	19	15	18	16	19	17	20
NPV (LKR million)	31.0	34.1	33.7	38.0	57.4	62.6	89.9	96.4
B/C Ratio	1.50	1.45	1.28	1.27	1.61	1.54	1.42	1.40

IRR = internal rate of return; MIRR = modified internal rate of return; NPV = net present value; LKR = Sri Lanka Rupees

Table 6: Profitability with conventional method discounted at 13.1%

Indicator	Plant house: 0.6 ha		Plant house: 1.2 ha	
	Own Funds	Finance	Own Funds	Finance
IRR (%)	14	17	26	37
MIRR (%)	13	14	16	19
NPV (Rs mn)	1.8	3.0	16.9	18.6
B/C Ratio	1.08	1.11	1.54	1.48

IRR = internal rate of return; MIRR = modified internal rate of return; NPV = net present value; LKR = Sri Lanka Rupees

Sensitivity analysis and scenario analysis:
Results of the sensitivity analysis of seed production in net houses are shown in Table 7 and 8 and the combined results of two sensitivity analysis are shown in Table 9 (scenario analysis). The results revealed that the project sensitivity is high in revenues over the costs. Further, Models 1 and 3 (maximum profit models/minimal costs models) were stable compared to the Models 2 and 4 (maximum production models). Thus, production of seed potato confining to G0 in net houses is profitable compared to production of both G0 and G1 under adverse conditions.

Table 7: Project sensitivity at 10% increase in costs discounted at 13.1%

Indicator	Model 1		Model 2		Model 3		Model 4	
	Own Funds	Finance	Own Funds	Finance	Own Funds	Finance	Own Funds	Finance
IRR (%)	22.2	27.9	18.7	22.6	24.6	30.6	25.6	34.0
MIRR (%)	15	17	14	16	16	18	16	18
NPV (LKR millions)	24.7	26.6	21.5	24.0	48.0	51.0	68.7	72.5
B/C Ratio	1.4	1.3	1.2	1.2	1.5	1.4	1.3	1.3

IRR = internal rate of return; MIRR = modified internal rate of return; NPV = net present value; LKR = Sri Lanka Rupees

Table 8: Project sensitivity at 10% decrease in revenue discounted at 13.1%

Indicator	Model 1		Model 2		Model 3		Model 4	
	Own Funds	Finance	Own Funds	Finance	Own Funds	Finance	Own Funds	Finance
IRR (%)	21.8	27.1	18.3	21.8	23.6	29.8	25.1	32.7
MIRR (%)	15	17	14	16	15	17	16	18
NPV (LKR millions)	21.6	23.1	18.2	20.2	42.2	44.8	59.8	62.8
B/C Ratio	1.3	1.3	1.1	1.1	1.5	1.4	1.3	1.3

IRR = internal rate of return; MIRR = modified internal rate of return; NPV = net present value; LKR = Sri Lanka Rupees

Table 9: Project sensitivity at 10% increase in costs and 10% decrease in benefits discounted at 13.1%

Indicator	Model 1		Model 2		Model 3		Model 4	
	Own Funds	Finance	Own Funds	Finance	Own Funds	Finance	Own Funds	Finance
IRR (%)	18.5	20.6	14	14.7	20.4	23.2	19.9	22.7
MIRR (%)	14	15	13	13	15	16	15	16
NPV (LKR millions)	15.4	15.5	6.1	6.2	32.9	33.2	38.6	38.9
B/C Ratio	1.2	1.2	1.0	1.1	1.3	1.3	1.2	1.2

IRR = internal rate of return; MIRR = modified internal rate of return; NPV = net present value; LKR = Sri Lanka Rupees

Economic Analysis:
The economic analysis (Table 10) showed that the cultivation in net house is economically viable compared to the conventional method and generate more social benefits. Models 3 and 4 showed expansion options of glass house is economically viable. The maximum production models (Models 2 and 4) generated more social benefits compared to that of the maximum profit models (Models 1 and 3) due to high ENPV, MIRR and B/C ratio. The results revealed that the production of G0 and G1 in the net houses generate more social benefits.

Table 10: Economic analysis at a social discount rate (SDR) of 12%

Indicator	Model 1	Model 2	Model 3	Model 4	Conventional method	
					0.6 ha	1.2 ha
IRR (%)	28	29	29	42	15	26
MIRR (%)	16	17	16	19	13	16
NPV (LKR millions)	37.6	52.3	67.2	130.7	2.3	16.9
B/C Ratio	1.7	1.5	1.8	1.8	1.1	1.6

IRR = internal rate of return; MIRR = modified internal rate of return; NPV = net present value; LKR = Sri Lanka Rupees

Conclusion

Potato seed production facility established at the Seeta Eliya in the Nuwera Eliya District of Sri Lanka is financially and economically viable. The maximum profit/minimal cost models are profitable over the maximum production models and justified the production of G0 seeds only. However, the production of G0 with G1 in the net houses (maximum production models) would generate higher social benefit. Therefore, the current price of LKR 6 per G0 tuber produced under private investment option is justified. The production of the second generation seeds (G1) at present pricing should be reconsidered under the option of private investment. Under public investment option, the maximum production model (G0 and G1 production) is justified based on the economic analysis. Furthermore, the sensitivity and scenario analysis showed the need to confine to production of G0 under adverse conditions. Expansion of glass house capacity will increase financial and economic profitability and thus, the glass house expansion investment option is justifiable. Furthermore, the same pricing for first-generation (G0) and second-generation (G1) seed tubers need to reconsidered and revisited.

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