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Economic Feasibility of Alternative Technologies and Strategies for Sri Lanka's Fertilizer Crisis: A Simulation Analysis for Paddy-Based Dry Zone Agricultural Systems

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Abstract

The government of Sri Lanka has introduced a mix of controversial fertilizer policies amid its economic crisis. The objective of this study is to assesses economic feasibility of a range of fertilizer technologies and strategies being introduced for paddy based dry zone agricultural systems of the country. A linear programming model was developed for a small paddy land holder considering maximization of profits as the objective and lowland and highland extents, labor, irrigation water, subsistence consumption, and financial resources allocated for fertilizers as constraints. The simulation scenarios included tax on urea-based fertilizers, increase in the cash-grant provided to farmers, innovative marketing arrangements for environmentally friendly products and innovative fertilizer technologies. The results of the simulation experiments provide some quantitative estimates on the magnitude of changes in farm enterprise profits, nitrogen usage by the crops, and wastage of nitrogen from the system owing to the policy changes. The simulation exercises underscored the positive impact of incorporating slow-releasing fertilizer types on farm enterprise profits and nitrogen wastage from the system, contingent upon the financial viability of such fertilizers. The study offers insights into the interplay of policy interventions in shaping the profitability and environmental dynamics of dry zone farming in Sri Lanka.

JEL Codes: Q100, C600, I300

Introduction

Fertilizer policies in Sri Lanka have been subject to extensive discussions and academic inquiry due to their far-reaching economic, environmental, and social implications (Wickramasinghe et al. 2009, Ekanayake, 2006, Weerahewa et al., 2010, Weerahewa et al., 2021, Weerahewa et al., 2022). The policy changes occurred during the period from 2020 to the present demonstrate multiple objectives of the government of Sri Lanka to address short term needs of the country which was in a crisis. At the dawn of the crisis in 2019, paddy farmers immensely benefited from a generous fertilizer subsidy, approximating 86%, while the subsidy for other crops exhibited a range from 48% to 88%. In 2020, the scope of subsidized fertilizer rates was expanded to encompass all crops. Commencing in mid-2020, a landmark initiative facilitated the provision of free fertilizer for paddy cultivation up to 5 acres. On May 06, 2021, the Finance Ministry of Sri Lanka enacted Imports & Exports (Control) Regulation No. 07 of 2021, prohibiting the importation of chemical fertilizers, pesticides, and herbicides. Subsequently, on July 31, 2021, an import licensing requirement for chemical fertilizers replaced the import ban. In 2022, proposals were made to speed up the adoption of various precision fertilizer applications and introduce new technologies to increase fertilizer use efficiency. Regulatory frameworks for organic/biofertilizer production were enforced, and an incentive-based mechanism for the gradual replacement of fertilizer subsidies from all sectors was implemented, as stipulated in the National Agriculture Policy (2021).

Derived from information sourced from the Ministry of Agriculture and Plantation Industries, the more recent interventions include the following. In 2022, the Sri Lankan government, in collaboration with USAID, disbursed a subsidy cash grant of LKR 15,000 to low-income rice farming families. Facilitated by the Asian Development Bank, a cash grant initiative was implemented at two tiers: LKR 10,000 for farmers cultivating up to one hectare and LKR 20,000 for those cultivating up to two hectares in 2022. A budget of LKR 10 billion was earmarked for fertilizer procurement for the 2023 Yala season, encompassing the provision of the entire Triple Super Phosphate (TSP) requirement free of charge to all farmers during the season. Additionally, prices for urea and Murate of Potash (MOP) were reduced for the same season. In March 2023, the Minister of Agriculture in Sri Lanka stated that the government has allocated a total of approximately LKR 109,000 in subsidies for each farmer. These subsidies include offering Urea fertilizer at a discounted price, distributing fuel at no cost, providing free Urea fertilizer, offering MOP at a reduced price, and granting subsidies of Rs. 20,000 and Rs. 40,000 for farmers to procure organic fertilizers (Ministry of Agriculture and Plantation Industries, 2023). In May 2023, vouchers were issued to farmers, entitling them to a subsidy of LKR 20,000 per hectare and a maximum of LKR 40,000 per two hectares (Ministry of Agriculture and Plantation Industries, 2023).

Fertilizer input is a main component of the cost structure of farming and policy interventions in this regard and have a direct impact on the profitability of the farming enterprise. Studies show that farmers maintain the recommended level of fertilizer usage under certain price levels for profit maximization (Kanthilanka and Weerahewa, 2018 Kanthilanka et al., 2023) and this reflects the impact of fertilizer price on farm profitability. Given that the policy interventions on fertilizer, directly impact the price and the input cost of fertilizer, it is evident that they also affect the profitability.

The influence of these policy interventions on profitability is contingent upon the specific farming system under consideration. The agricultural landscape in Sri Lanka encompasses diverse farming systems that vary in scale and other pertinent factors. The plantation sector engages in large-scale monocropping of crops such as tea, coconut, and rubber, and minor plantation crops like coffee and spices. Intercropping farming systems are also prevalent within the plantation sector. Paddy and maize cultivation in Sri Lanka constitutes another distinct farming system, primarily aligned with the annual cultivation seasons, namely Yala and maha, and supported by irrigation tanks (major and minor) or rain. An intermediate season includes the cultivation of crops such as soybean and mung bean. Additional farming systems comprise annual vegetable cultivations in both upcountry and low-country areas, subsistence farming, shifting cultivation (chena), and home gardens (Kendaragama, 2006). The reliance on fertilizers for these diverse farming systems significantly influences how alterations in government fertilizer policies impact their profitability.

Given this context, the objectives of this paper are to formulate a model that realistically reflects the decision-making processes, behaviors, and cropping decisions of a typical farmer in the dry zone of Sri Lanka engaged in irrigated cultivation of paddy, maize, and soybean. Furthermore, the model is employed to understand and analyze the repercussions of various policy shocks and their effects on the crop mix, fertilizer mix, and profitability of the farmer.

Contextual Background

The current farming practices in the Sri Lankan dry zone include seasonal cultivation of paddy, maize, and other field crops. The major cropping seasons are yala (May to August) and maha (November to March). Two intermediate seasons occur between the major seasons: March to May and August to November. The first intermediate season is not usually cultivated with the local New Year celebrations falling during these months. The major seasons are usually cultivated with paddy or maize while the intermediate season is cultivated with a legume. Water is supplied with rain and irrigation by major/minor tanks.

The current fertilizer recommendations for rice cultivated in the region with irrigated practices are as follows,

Urea: 225 kg/ha
TSP (Triple Super Phosphate): 55 kg/ha
MOP (Muriate of Potash): 60 kg/ha
ZS (Zinc Sulfate): 5 kg/ha

These fertilizers are administered in four split applications spanning from 2 to 6-9 weeks after the date of field establishment, contingent upon the age of the variety. The application combinations during these stages are as follows:

TSP and ZS are applied together as a basal application during land preparation.
Urea and MOP are applied together at 4 and 6-7 weeks after establishment.
Urea is applied as a straight fertilizer at 2 and 8-9 weeks after establishment.

It is noteworthy that the current fertilizer recommendation does not advocate the simultaneous use of all four nutrients at a given time, aiming to optimize the efficiency of straight fertilizers by aligning them with the crop's demand as closely as possible. Furthermore, the current Department of Agriculture recommendation does not explicitly emphasize the application of secondary and other micronutrients other than Zinc. The fertilizer requirement is mostly fulfilled by straight fertilizers. Department of Agriculture encourages farmers to return paddy straw to the same field in addition to the application of 5 tons of organic amendments. However, only very few farmers in the dry zone practice the application of organic amendments.

Alternatively, adopting slow-releasing fertilizer types presents an opportunity to promote more environmentally sustainable farming practices (Shaviv 2000). Slow-release straight fertilizers and inhibitors represent potential technologies that could serve as alternative practices. Various methods can be explored in developing these fertilizers, such as incorporating them into biochar (Bhaksi et al., 2021; Jayarathna et al., 2024) and employing inhibitor-coated straight fertilizers (e.g., neem-coated urea) (Azeem, et al., 2014; Singh et al., 2019). Previous studies illustrating the relationship between nitrogen fertilizer application and paddy yields using data from field experimental trials were reviewed to calibrate the baseline equilibrium and design a set of simulation scenarios.

According to a meta-analysis on paddy conducted by Ding et al. (2018), yield responses were significantly positive under all alternative fertilization options relative to those obtained with conventional fertilization, and the magnitude of yield increase exhibited the following the order: Organic Fertilizer (7.8%) > SRF (7.4%) > Green manure M (6.7%). The rice yield response was maximized when approximately 70% slow-release N was combined with approximately 30% conventional N according to the quadratic relationship between the percentage of slow-release N substituting conventional N and the yield response. It was estimated that the total N rate could be reduced by up to 32% without yield loss with the application of slow-release N fertilizer instead of conventional N fertilizer. When organic N is fully or partially substituted with inorganic N, yield response declines with increasing substitution level, and the substitution proportion needed to be controlled below 20% to maintain rice yield.

Paddy yields in Sri Lanka are reduced by 20% under organic-only situations as per the field trials conducted over 11 years according to Sirisena et al., (2013). When 30% of urea-N is replaced by organic fertilizer (cattle manure or poultry manure), N use efficiency has increased only by only by 5% according to Iqbal et al., (2019). Except for liquid fertilizers, solid composts will have the same observations as above. Liquid N fertilizers only situation will reduce yield by about 25-30%

as we cannot supply the plant's required N content as liquid organic fertilizer. According to Senarathna and Rathnasinghe (1995), green manure or legume crops can incorporate 30-100 (Mung bean) to 160-250 (sun hemp) kg N as crop residues to the soil, depending on the locations, and these will supply all or part N (20 -30%, McDonaugh et al., 1995; Palm et al., 1988) requirement of the rice plant during its growth period. This will increase the rice yield by 0 -10%.

According to a meta-analysis on biochar use in paddy cultivations conducted by Liu et al., (2022), 20 t/ha biochar and 150–250 kg/ha nitrogen fertilizer are recommended for improving rice yield and nitrogen use efficiency. Literature suggests an increase in biochar application, increases rice yield and NUE by 10.73% and 12.04%, respectively.

According to Zhang et al. (2018), N wastage can however be reduced by about 10-20% when organic fertilizers are used without changing the yield. It is clear that the yield response to nitrogen as well as nitrogen wastage from the system depends on the type of fertilizer used, frequency of application, soil type, weather conditions, etc.

Regrettably, the fertilizer subsidy historically provided for NPK fertilizers has deterred scientists from conducting essential experiments to assess the efficacy of innovative and advanced technologies under Sri Lankan conditions.

Model, Data, and Simulation Scenarios

The constructed model prioritized profit as the objective within the linear programming framework. The variables encompassed the extent of cultivation for three distinct crops: paddy, maize, and mungbean. Specifically, for paddy and maize, five diverse cultivation technologies, derived from the APSIM model, were integrated into the constructed model for different nitrogen input levels and corresponding yields. Additionally, two urea fertilizer technologies (single application and multiple application) and four organic fertilizer technologies were incorporated into the model in the baseline.

Given the literature available on nitrogen fertilizer application and yields, the baseline equilibrium was calibrated and simulation scenarios were constructed paying attention to the availability of nitrogen in different types of fertilizers, wastage of nitrogen from each fertilizer type, frequency of application of fertilizers, and cost of nitrogen fertilizers. Accordingly, three key types of technologies were considered each having four variants of fertilizer products/technologies.

The first set includes four variants of urea-based fertilizer technologies. The differences within this category are wastage levels owing to the frequency of applications and/or the slow-release nature of the product (sulphur-coated urea). The nitrogen content was considered as the same.

Table 1: Characteristics of urea-based technologies

Technology notation	**Example**	**Cost (Rs/kg)**	**Nitrogen content in 1 kg (kg)**	**Nitrogen wastage (kg)**
Urea1	Urea – One application	200	0.46	0.70
Urea2	Urea – Multiple applications	200	0.46	0.50
Urea3	Coated urea – One application	250	0.46	0.30
Urea4	Coated urea – Multiple applications	250	0.46	0.10

The second set includes four 'Organic' technologies. Different types of so-called 'organic' products available in the market will be included. They may include compost, liquid fertilizers, vermicompost, etc. They differ in price and nitrogen content. The nitrogen wastage among these products were considered to be low and the same within the set.

Table 2: Characteristics of organic-fertilizer-based technologies

Technology notation	**Example**	**Cost (Rs/kg)**	**Nitrogen content in 1 kg (kg)**	**Nitrogen wastage (Kg)**
Organic1	Compost	12	0.01	0.05

Organic2	Compost – Urea added	50	0.04	0.05
Organic3	Vermi compost	100	0.01	0.05
Organic4	Liquid fertilizers	100	0.04	0.05

The third set includes four 'Innovative' technologies: This set is to reflect scientific innovations like urea-bio-char pellets. Different proportions of bio-char and urea are visible in the packages and the prices, nitrogen contents, and nitrogen wastages among these products are considered to be very different.

Table 3: Characteristics of Innovative Fertilizer Products

Technology notation	**Example**	**Cost (Rs/kg)**	**Nitrogen content in 1 kg (kg)**	**Nitrogen wastage (Kg)**
Innovation1	60%Biochar_40%Urea	75	0.15	0.20
Innovation2	50%Biochar_50%Urea	100	0.20	0.30
Innovation3	40%Biochar_60%Urea	125	0.25	0.40
Innovation4	30%Biochar_70%Urea	150	0.30	0.50

The fertilizer types discussed above were incorporated to the model in two stages. Organic technologies and straight urea applications (single and multiple) were modeled into the baseline model. The coated urea technologies and the innovative fertilizer types were introduced to the model under scenarios four and five, which will be discussed in the subsequent section. Fertilizers were incorporated into the model using their price, nitrogen content and the wastage level.

The program operated under several key constraints designed to mirror the realities of dry zone farming in Sri Lanka. Among these were constraints related to labor availability and land. In the baseline, the assumption was made that the farmer had access to 300 man-days of labor per hectare throughout the entire duration. Land availability was categorized into upland and lowland. The monthly water supply constraint was designed using the CROPWAT model which is explained in the later parts of this section. The financial resource constraint was represented by the cash grant allocated by the government of Sri Lanka. Additionally, a subsistence-level paddy farming requirement was introduced to capture habitual aspects of paddy farming. The minimum subsistence requirement was calculated based on per capita rice consumption, assuming a family of five. The rice-to-paddy conversion ratio and the average yield per hectare were incorporated into developing the subsistence constraint.[1]

Water constraints in the model were addressed by incorporating derived water levels, utilizing crop water requirements, and the CROPWAT 8.0 software. CROPWAT 8.0 for Windows is a computer program designed for calculating crop water requirements and irrigation needs, leveraging data related to soil, climate, and specific crop characteristics. Moreover, the program facilitates the formulation of irrigation schedules under various management conditions and computes scheme water supply for diverse crop patterns. Using the software and crop water requirements for the seasons, water availability for different months was formulated and used as constraints in the model. These are shown in the table below,

Table 4: Water constraints

Month	Water constraint (m/ha)
January	1,254
February	14
March	620
April	1,073
May	1,599
June	2,232
July	3,083
August	694
September	907

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[1] Refer to appendix one for the detailed model

October	1,432
November	1,285
December	1,385

Paddy and maize cultivations were included in five different cropping technologies based on the level of nitrogen input. In developing the technologies, APSIM model data were used. The schedule of nitrogen input and corresponding yield was instrumental in determining the yield levels for maize[2]. For paddy, the following production function was used to arrive at different yield levels for nitrogen input,[3]

$$Y= a+b\ (1-\exp(K*N))$$

Coefficients for a,b, and K were adopted for imperfectly-drained reddish brown earth soil, separately for yala and maha seasons following Kanthilanka et al. (2023). Five different nitrogen input levels (N) were incorporated into the equation to arrive at corresponding yield levels (Y). The yield level for the legume was extracted from secondary data sources from the Department of Agriculture. Nitrogen contribution from the legume was incorporated into the model at 50kg per hectare. Twenty percent of this was considered to be made available after the legume growing period. The following table describes the nitrogen input level and the corresponding yield level for paddy and maize for the two major seasons that were incorporated into the model.

Table 5: Crop yields and nitrogen input levels

Crop	Season	Technology notation	N-input requirement (kg/ha)	Yield (kg/ha)
Paddy	Yala	1	150	2402
		2	120	2399

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[2] Refer to appendix two

[3] Refer to appendix three for the calculations

		3	105	2397
		4	90	2390
		5	75	2377
	Maha	1	150	4196
		2	120	4095
		3	105	4019
		4	90	3920
		5	75	3790
Maize	Yala	1	150	5500
		2	135	5500
		3	120	5400
		4	105	5100
		5	90	4700
	Maha	1	150	5500
		2	135	5500
		3	120	5400
		4	105	5100
		5	90	4700

Data for developing the model were sourced from diverse secondary outlets. Farmgate prices of crops, labor rates, and cost information were gleaned from the AgStat booklet, which was published by the Socio-Economics and Planning Centre of the Department of Agriculture in Sri Lanka. For yield information, crop enterprise budgets from the same source were utilized. Farmgate prices were adopted to the model as follows,

Table 6: Farmgate prices

Crop	Farmgate price (LKR)
Paddy	58
Maize	278
Mungbean	243
Soybean	322

The developed model was then calibrated to arrive at a realistic baseline equilibrium. The baseline equilibrium is described in the results section. Five policy intervention scenarios were then used to shock the baseline equilibrium and the counterfactual equilibria were analyzed for the impact.

Scenario one (S1):

The first policy intervention introduced to the baseline equilibrium was the introduction of a tax regime on urea fertilizers. A tax rate of 10% was assumed to incur. Hence, the prices of urea technologies incorporated in the model were increased by the relevant percentage to arrive at prices that would reflect the new prices under such tax introduction. Hence, the price of urea for both single-application technology and multiple-application technology was increased. This simulation aimed to understand how different tax policies on fertilizer impact the farmer's decisions and overall farm profitability.

Scenario two (S2):

The cash grant used to develop the financial resource constraint was simulated to increase by 10% under the second scenario representing a government intervention to increase the cash grant. This increased the baseline cash constraint of LKR 45,000 to LKR 49,500. The cash grant was assumed to be utilized in fertilizer procurement and the simulation aimed to understand how changing the grant impacted farmers' choice of cultivation and the impact of it on the profitability.

Scenario three (S3):

The third scenario incorporated a subsidy of 10% for eco-friendly products. Eco-friendly products were defined as the paddy-growing technology that used the least amount of input in terms of nitrogen fertilizer. The low-input product was assumed to receive a 10% subsidy (comparable to the tax impact on urea fertilizer) and this was reflected in an increased farmgate price for the product. This intervention simulation was aimed at understanding how subsidies impact profitability, environmentally sound decisions, and overall cultivation practice.

Scenario four (S4):

The market introduction of innovative fertilizer options was modeled for the fourth policy intervention. The price, nitrogen content, and nitrogen waste of the fertilizer types were discussed above in Table 3. Under the scenario, coated urea was introduced to the model along with two application technologies: single and multiple. In addition, four innovative fertilizer technologies were included in the model as discussed in the above sections. These were incorporated into the model using their prices, nitrogen content, and wastage levels. A new legume crop was also introduced to the simulation. Soybean cultivation choice was provided along with mungbean during the intermediate season. The adoption of new fertilizer technologies by farmers was analyzed by performing this simulation.

Scenario five (S5):

The final scenario introduced all four above-mentioned policy interventions at once as a composite shock to the baseline equilibrium. The policy impacts were incorporated into the model in a similar manner to the individual scenarios. Policy interventions do not usually impact individuals in the real-world case and this scenario aimed to simulate how a multitude of policy interventions impact the farming enterprise.

The constraints developed for the model are presented in the following table. Water constraints were not changed for the scenarios and remained as described in Table 4.

Table 7: Constraints of the Model

Constraint		Value
Labour		300 mandays
Land	Upland Yala	1 ha
	Upland Maha	1 ha
	Lowland Yala	2 ha
	Lowland Maha	2 ha
	Intermediate	2 ha
Cash		LKR 45,000
Subsistence paddy cultivation		0.4 ha

Results and Discussion

The baseline equilibrium model was subjected to policy shocks through the aforementioned scenarios, yielding counterfactual equilibria. A comprehension of the results and impacts of these scenarios is facilitated by understanding the baseline equilibrium concerning the crop mix, fertilizer mix, profit level, and associated constraints. The linear programming model was configured to maximize the profit of the individual farmer, with the initial baseline profit level standing at LKR 851,433.05. This was calculated by reducing the total cost for nitrogen input to LKR 45,000, representing the stipulated cash constraint within the model. The cumulative revenue generated during the specified duration amounted to LKR 896,433.05.

The farmer, confronted with the prospect of cultivating one hectare of upland and two hectares of lowland, had the option to engage in maize and paddy cultivation during the major seasons, namely Yala and maha. The model featured five distinct cultivation technologies for both crops, each correlated with varying levels of nitrogen input and corresponding yield levels. In the baseline equilibrium, the farmer chose to cultivate 0.46 hectares of maize during the maha season. Employing a low-nitrogen input technology, the farmer applied 80 kg of nitrogen per hectare, deviating from the recommended level of 150 kg/ha. Concurrently, the cultivation of 0.4 hectares of paddy for subsistence purposes occurred during the maha season, also under a low-nitrogen input regimen, with the farmer applying 65 kg/ha as opposed to the recommended nitrogen input level of 150 kg/ha. The farmer did not cultivate any crops during the Yala season and this can be attributed to the lower level of nitrogen requirement for crops during maha season after the legume cultivation in the intermediate season. When profit maximization is set as the sole objective, farmers tend to include the most profitable crops in the crop mix (Begum and Manos, 2005).

Intermediate season cultivation was delimited to the cultivation of mungbeans, covering an expanse of 1.13 hectares. It was presumed that the legume crop would engage in nitrogen fixation, serving both its sustenance and contributing to subsequent seasons, thereby diminishing the nitrogen requirement for the ensuing cultivation periods as discussed above (After soybean season, paddy yield response to N curve should have different constants as the initial N level now has been changed. Anecdotal evidence indicate that after mung bean, paddy yields have reached 8 tons/ha (200 bushels) in Thissamaharaamaya area of Sri Lanka.

Given a selection among six fertilizer technologies, including four organic applications, the farmer opted to satisfy the entire nitrogen requirement exclusively through urea, applying it in multiple stages. Adhering to the cash constraint, the farmer utilized 225 kg of fertilizer. It is important to emphasize that, in the profit-maximizing baseline, the farmer deviated from the recommended fertilizer input level for all cultivations. The nitrogen waste level of the baseline equilibrium was 112.50 kg.

Taking into account the constraints within the baseline equilibrium, labor, land, and the water supply for the majority of the months were non-binding. However, water constraints for August emerged as binding, with an associated shadow price of 611. Both nitrogen usage and the cash constraint were binding, carrying shadow prices of 15,885 and 17, respectively. Furthermore, the subsistence paddy requirement constraint was also binding within the optimal solution.

The following table provides a summary of the results obtained by introducing policy shocks to the baseline equilibrium as discussed in the above section. The table displays the results for the variables that carried a solution in at least one of the scenarios.[4] Scenarios are denoted S1 to S5 as follows,

S1: Introduction of a 10% tax for urea fertilizers
S2: Increasing the cash grant by 10%
S3: Eco-friendly (low nitrogen input) products receive a subsidy of 10%.
S4: Introduction of innovative fertilizers to the market
S5: Composite shock of the above scenarios

Table 8: summary of the results

Description	**Baseline**	**S1**	**S2**	**S3**	**S4**	**S5**
Int. mungbean (ha)	1.13	1.13	1.13	1.13	0.00	0.00
Int. Soybean (ha)	-	-	-	-	1.13	1.13
Maha Maize (ha)*	0.46	0.40	0.53	0.46	0.75	0.81
Maha Paddy (ha)*	0.40	0.40	0.40	0.40	0.40	0.40
Urea-multiple applications (kg)	225	204.6	247.50	225	0.00	0.00
Coated urea-multiple (kg)	-	-	-	-	180	0.00
Innovative	-	-	-	-	-	660

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[4] Refer the Appendix four for the full table with detailed results of simualtions

Fertilizer (kg)						
Profit (LKR)	851,433	776,700	929,139	860,529	1,749,837	1,934,870
Nitrogen cost (LKR)	45,000	45,000	49,500	45,000	45,000	49,500
Nitrogen waste (kg)	112.50	102.27	123.75	112.50	18.00	132.00

* low nitrogen input technologies as discussed in the baseline

The initial scenario employed to disturb the baseline equilibrium involved the introduction of a tax policy targeting urea fertilizers. The fixed tax rate was set at 10%, and it was implemented in the model by increasing prices for urea fertilizers by 10%. This policy shock yielded several noteworthy outcomes. The application of nitrogen fertilizer witnessed a decrease of 9.07%, declining from 225 kg to 204.6 kg. This outcome is attributed to the escalated prices within the context of a fixed cash grant. The decrease in fertilizer usage with increasing fertilizer prices is often discussed in previous literature (Manos et al., 2007). Constrained by financial resources, the farmer had to curtail fertilizer purchases, consequently reducing nitrogen input. While this reduction aligns with environmental considerations, it is essential to acknowledge that the diminished input level translates to an 8.78% reduction in profit compared to the baseline. This observation aligns with the impact of fertilizer prices on farm income as observed by Begum and Manos in 2007. The positive environmental impact is evident in the decrease in nitrogen wastage from 112.50kg to 102.27kg (-9.09%).

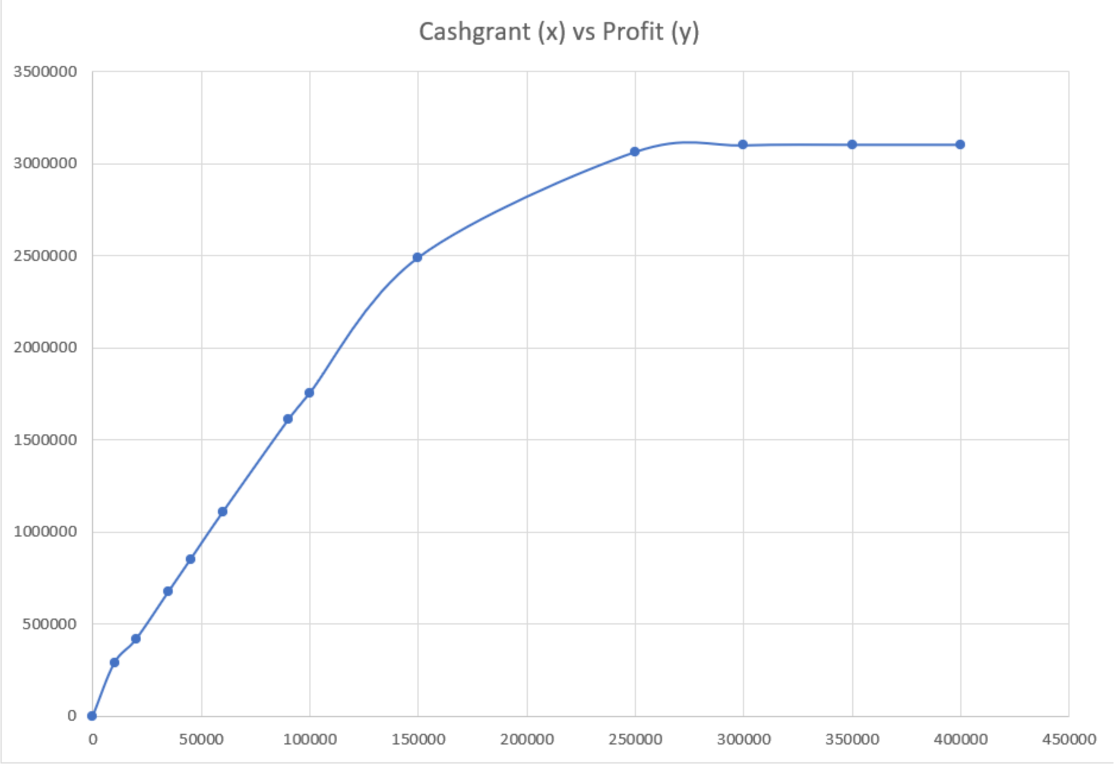
The policy intervention did not impact the crop mix or the fertilizer mix. However, there was a reduction in the extent of cultivation corresponding to the diminished input supply. Maize cultivation during the maha season experienced a reduction of 13.04%. Other cultivation extents remained similar to the baseline equilibrium. The impact of the tax policy is observed for maize cultivation extent, which is comparatively the more fertilizer-utilizing crop. This finding is comparable to previous studies which have found that fertilizer price policies threaten fertilizer-intensive crops (Begum and Manos, 2005).

Further simulations were carried out to see the effect of varying tax rates at 20% and 30%. At a 20% tax rate, maize cultivation dropped to 0.36 ha, representing a percentage change of 21.7%. More importantly, the farm profitability dropped by 16.1% while the environmental benefits increased represented by a 16.6% drop in nitrogen wastage. Similar changes were observed with a 30% tax rate on urea fertilizer where the profit, nitrogen wastage, and maize cultivation extent continued to drop further. This simulation depicts how taxation impacts fertilizer utilization, nitrogen waste, land utilization, and farm enterprise profitability.

Scenario 02, denoted as S2 in Table 1, entailed a 10% increase in the cash grant provided to farmers. This cash grant functions as a government subsidy scheme designed to support farmers in their fertilizer purchases. Literature has demarcated the impact of fertilizer support subsidy schemes on fertilizer demand. Removal of subsidy schemes directly increases the fertilizer cost to farmers (Bartelings et al., 2016). The baseline model featured a cash grant of LKR 45,000, and the policy intervention associated with Scenario 02 elevated it to LKR 49,500. In response to this increase, the farmer opted for a higher level of fertilizer utilization, resulting in a 10% upswing in urea application across the cultivation. The impact of changes to the subsidy in fertilizer demand has been evidently captured by these results as discussed by Bartelings et al. in 2016. The counterfactual equilibrium witnessed a substantial expansion in the land extent dedicated to maize cultivation during the maha season, escalating from 0.46 hectares to 0.53 hectares (reflecting a 15.22% increase compared to the baseline equilibrium). The subsistence-level paddy cultivation remained constant at 0.40 ha along with the legume crop in the intermediate season. The heightened input supply was mirrored in the increased profitability of the farm enterprise, with the profit level escalating by 9.13%. Despite the less environmentally desirable high nitrogen input, the profit increase and the farmer's preference for low nitrogen input technologies merit consideration when assessing the policy intervention. The shadow prices and binding constraints remained comparable to the baseline. Nitrogen wastage increased along with the input by 10%. This presents a clear picture of the overall impact of cash grants and other fertilizer-related subsidy policies on farm profitability, nitrogen fertilizer usage and wastage, and crop choice of farmers.

The model was simulated with various levels of cash grants to determine corresponding profit levels. The resulting information is presented in graph one below.

Graph 1: Cash grant vs Profit



The cash constraint becomes binding after surpassing LKR 300,000 and the profit level does not change with the cash grant afterward.

The third policy intervention (S3) analyzed through the simulation model involved a subsidy for eco-friendly products. As described in the above section, eco-friendly products were identified as low-nitrogen input crop technologies of paddy (paddy technology 05 in both seasons). The subsidy rate was fixed at 10% in the model. This was simulated by increasing the farmgate price for paddy technology 05 by 10%, thereby resulting in a price of LKR 64 per kg.

The intervention did not change the crop mix, fertilizer mix, or the cultivation extent in the counterfactual equilibrium. Even without the subsidy for low-input paddy, the farmer chose the technology given its comparatively low fertilizer cost. The farmer satisfied the subsistence paddy requirement by engaging in low-input cultivation in the baseline. However, the increase in price caused a higher farm profitability where the profit level hiked by 1.07%. Policy interventions with a direct impact on fertilizer (scenarios one and two) had a more prominent impact on the farm profitability compared to the subsidy on low-input cultivation products. Additional simulations were performed at higher subsidy rates at 20% and 30% which resulted in higher profit levels without any changes to the rest of the factors compared to the baseline equilibrium.

The baseline model and equilibrium incorporated fertilizer options encompassing urea fertilizer and organic fertilizer technologies as discussed above. The fourth policy intervention introduced a range of innovative fertilizers for the farmer to choose from, integrated into the model as detailed in the previous section. In addition, coated urea was also added to the fertilizer mix with two application technologies (single and multiple). The policy shock witnessed the farmer meeting the entire nitrogen requirement solely from coated urea at a rate of 180 kilograms. The chosen technology was multiple applications. Compared to the high level of nitrogen waste of regular urea (70% at single application, 50% with multiple applications) coated urea had a significant reduction of Nitrogen wastage. With the intervention, Nitrogen waste was reduced by a staggering 84%.

Along with the introduction of new fertilizer options, a new legume crop was also introduced to the model. With the choice of mungbean and soybean, the farmer opted to cultivate soybean during the intermediate season on an extent of 1.13 ha. This can be justified by the higher revenue generated from the cultivation of soybeans. Apart from the legume, the crop mix remained unaltered in response to the intervention. However, the land cultivation extent for maize during the maha season observed a noteworthy increase of 63% compared to the baseline. Low wastage levels of coated urea allowed the farmer to have more nitrogen availability for the crops, which is reflected by the increased extent of maize cultivation.

The combined effect of the introduction of a higher income-generating legume and the availability of efficient fertilizers led to a substantial increase in farm profitability. Compared to the baseline, the profit increased by 106%. This is attributed to the higher farmgate price of soybean (33% more than mungbean) and the increased nitrogen availability in the soil.

The simulation depicts that given the choice, farmers opt for cost-effective fertilizer options. It further shows that a profit-maximizing farmer will prefer higher income-generating crops such as soybean in this scenario.

The final simulation constituted a composite shock, encompassing all four previous shocks concurrently. Consequently, the baseline model encountered simultaneous shocks, including a tax on urea fertilizers, an increase in the cash grant, an elevation in prices for eco-friendly products reflecting a subsidy scheme, and the introduction of innovative fertilizer to the fertilizer mix. While the preceding four scenarios delineated the individual impacts of the interventions on the baseline equilibrium, the composite shock unveiled the cumulative effect of the amalgamation of policy interventions.

The crop mix exhibited no deviation from the baseline equilibrium in the two major seasons, with the farmer continuing to opt for low-nitrogen input technologies. However, the farmer chose to cultivate soybeans during the intermediate season, akin to the fourth simulation. Maize cultivation during the maha season increased by 76% in the final simulation resulting in up to 0.81 ha of land for maize. The subsistence paddy cultivation continued to happen similar to the baseline scenario. The most significant impact of the composite policy scenarios was the change in the fertilizer mix. With straight urea prices affected by the tax increase of 10%, the farmer opted to go for an innovative fertilizer package (one) 60% biochar and 40% urea. Given that this package had a comparatively low content of nitrogen, the input quantity of fertilizer increased drastically to 660 kilograms. The higher input quantity resulted in a higher level of nitrogen wastage correspondingly. This amounted to a 17.3% increase compared to the baseline. The profit level in this simulation was the highest among all, depicting a 127% increase from the baseline.

Another simulation was performed under this scenario where the tax did not impact slow-releasing urea fertilizers (i.e. coated urea) which retained the environmentally sound fertilizer mix which resulted in scenario four.

Conclusions and Recommendations

Based on the above scenario analysis in comparison to the baseline model, several conclusions can be drawn. The baseline model and equilibrium provide an accurate representation of the current practices of dry zone farmers, showcasing a preference for low-nitrogen fertilizer input technologies in cultivating major crops like paddy, maize, and legumes. Across all policy intervention scenarios, the farmer consistently adheres to low-input technologies, with the binding cash constraint preventing the application of recommended input levels for higher yields.

The simulations highlight how various government policy interventions impact the profitability of the farming enterprise. Policies related to fertilizer directly influence the farmer's profit levels. Implementing a fertilizer tax leads to reduced fertilizer usage and subsequent profit decreases. While this diminishes the environmental impact of direct fertilizer usage, the reduction in profits should be considered when assessing the effects of a tax regime on fertilizer.

Another crucial finding from this study is that the introduction of innovative fertilizer and coated fertilizer has positive effects on farm profitability due to increased nitrogen availability for crop uptake, leading to reduced fertilizer N wastage. This approach is both environmentally friendly and economically desirable. However, it's important to note that the economic feasibility of using such new fertilizers is directly influenced by their pricing, impacting farmers' decisions to adopt them. Farmers utilize these fertilizers when it is a financially sound option compared to direct fertilizers. When implementing tax and other policies, the government should ensure that the environmentally beneficial options do not become financially unattractive. This was the case depicted in the composite simulation where the farmer did not choose the environmentally sound coated fertilizer when a tax was imposed on it.

The cash grant subsidy scheme plays a pivotal role in the Sri Lankan agricultural system, serving as a crucial resource for many farmers to meet their input requirements. Alterations to the grant amount have a direct and significant impact on the farm's profitability. A higher cash grant empowers the farmer to expand cultivation, thereby increasing the profits derived from farming activities. Interestingly, despite an increase in the cash grant, the simulations indicate that it does not result in higher levels of nitrogen usage technologies. The cash constraint remains binding, preventing the farmer from adopting high-nitrogen technologies. It is crucial to design the cash grant amount thoughtfully to avoid the potential overuse of fertilizer by farmers, which could occur if the grant amount is increased beyond the binding point. This emphasizes the importance of finding an optimal balance to maximize the benefits of the cash grant without causing unintended consequences such as excessive fertilizer usage.

Promoting a heightened demand for environmentally friendly products with low nitrogen usage is a prudent strategy for mitigating environmental impact while concurrently increasing profits for farmers. This assertion is substantiated by the outcomes observed in the third simulation of the analysis. To effect this change in the profitability of farming enterprises, policy interventions should include targeted marketing efforts aimed at fostering a preference for environmentally sustainable products.

The study yields the conclusion that government policy interventions wield significant influence over both farm profitability and environmental considerations. To enhance farm profitability, policies ought to concentrate on providing well-calibrated cash grants and formulating fertilizer packages that align with both environmental benefits and financial prudence. Furthermore, the potential impacts of interventions, such as taxes, adversely on profitability and environmental benefits should be thoroughly examined. The introduction of elevated prices for environmentally friendly products emerges as a commendable means of bolstering farm profits while upholding environmentally sustainable fertilizer practices.

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References

Azeem, B., KuShaari, K., Man, Z. B., Basit, A., & Thanh, T. H. (2014). Review on materials & methods to produce controlled release coated urea fertilizer. Journal of controlled release, 181, 11-21.

Bakshi, S., Banik, C., Laird, D. A., Smith, R., & Brown, R. C. (2021). Enhancing biochar as scaffolding for slow release of nitrogen fertilizer. ACS Sustainable Chemistry & Engineering, 9(24), 8222-8231.

Bartelings, H., Kavallari, A., Meijl, H. and Lampe, M. (2016) Estimating the impact of fertilizer support policies: A CGE approach. GTAP Annual Conference on Global Economic Crisis

Begum, A.A. and Manos, B. (2005) Impacts of Fertilizer Pricing Policy in Bangladesh: A Multicriteria Analysis. Agricultura Tropica et Subtropica 38(2)

Dayananda D., Weerahewa J. and Weerasooriya S.A. (2023) Resource-use efficiency and environmental sustainability in the village tank cascade systems in the dry zone of Sri Lanka: An assessment using a bio-economic model. *Front. Sustain. Food Syst.* 7:1084973.doi: 10.3389/fsufs.2023.1084973

Dayananda, D., Weerahewa, J. and Weerasooriya S. A. (2021). Water Availability, Crop Choices, and Profitability of Farming: A Case Study of the Mahakanumulla Tank Village. Tropical Agricultural Research, 32(1): 81-94. DOI: http://doi.org/10.4038/tar.v32i1.8444

Department of Agriculture (2022) AgStat Agricultural statistics (XIX) Socio-economic Planning Centre

Ding, W., Xu, X., He, P., Ullah, S., Zhang, J., Cui, Z., & Zhou, W. (2018). Improving yield and nitrogen use efficiency through alternative fertilization options for rice in China: A meta-analysis. Field Crops Research, 227, 11-18.

Ekanayake, H. K. J. 2006. Impact of fertilizer subsidy in paddy cultivation in Sri Lanka. Staff Studies (Central Bank of Sri Lanka) 36 (1 and 2):73–92.

Iqbal, A., He, L., Khan, A., Wei, S., Akhtar, K., Ali, I., ... & Jiang, L. (2019). Organic manure coupled with inorganic fertilizer: An approach for the sustainable production of rice by improving soil properties and nitrogen use efficiency. Agronomy, 9(10), 651.

Jayarathna, M.K.N.W., Dharmakeerthi, R.S. and Igalavithana, A.D. (2024). Effects of biochar based N fertilizer application on ammonia volatilization from a rice growing soil: a laboratory scale closed chamber study. Tropical Agricultural Research, 35(1): 34-45.

Kanthilanka, H. and **J. Weerahewa** (2019). Do Price Subsidies Lead to Over Application of Fertilizers?: An Analysis of *Kethata-Aruna* Program in Sri Lanka. Tropical Agricultural Research, 30(4), pp.133–142. DOI: http://doi.org/10.4038/tar.v30i4.8335

Kendaragama, K.M.A. (2006). Crop growing environment in Sri Lanka with special emphasis on plant nutrient use. J. Soil Sci. Soc. Sri Lanka. 18:1-18.

Liu, Y., Li, H., Hu, T., Mahmoud, A., Li, J., Zhu, R., ... & Jing, P. (2022). A quantitative review of the effects of biochar application on rice yield and nitrogen use efficiency in paddy fields: A meta-analysis. Science of the Total Environment, 830, 154792.

Manos, B., Begum, M.A.A., Kamuruzzaman, M., Nakou, I. and Papathanasiou, J. (2007) Fertilizer price policy, the environment and farms behavior. *Journal of Policy Modeling 29.* pp 87-97

Mathangaweera, S., Chandrawathi, L.M. and Abeykoon, A.M.C.K.M. (2020) Crop Enterprise Budget of Paddy, Other Field Crops and Vegetables. Socio-economic Planning Centre, Department of Agriculture

McDonagh, J. F., Toomsan, B., Limpinuntana, V., & Giller, K. E. (1995). Grain legumes and green manures as pre-rice crops in Northeast Thailand: I. Legume N 2-fixation, production and residual nitrogen benefits to rice. Plant and Soil, 177, 111-126.

Ministry of Agriculture and Plantation Industries (2022) News https://www.agrimin.gov.lk/web/index.php/en/news-scroll

Ministry of Agriculture and Plantation Industries (2022) National Agricultural Policy (NAP) https://www.agrimin.gov.lk/

Palm, O., Weerakoon, W. L., de Silva, M. A. P., & Rosswall, T. (1988). Nitrogen mineralization of Sesbania sesban used as green manure for lowland rice in Sri Lanka. Plant and Soil, 108, 201-209.

Senaratne, R., & Ratnasinghe, D. S. (1995). Nitrogen fixation and beneficial effects of some grain legumes and green-manure crops on rice. Biology and fertility of soils, 19, 49-54.

Singh, A., Jaswal, A., & Singh, M. (2019). Impact of neem coated urea on rice yield and nutrient use efficiency (NUE). Agricultural Reviews, 40(1), 70-74.

Shaviv, A. (2000). Advances in controlled release of fertilizers. Advances in Agronomy, 71, 1-49.

Weerahewa, Jeevika, Shashika D. Rathnayaka, Naduni Nayanathara, and Devesh Roy (2022). Decomposition of Productivity Growth in Sri Lanka’s Paddy Sector: Roles of Area Expansion and Chemical Fertilizer Use. Sri Lanka Statistical Review Volume 1 Issue 1. Pp. 1 – 26.

Weerahewa, J., Senaratne, A. and Babu, S. (2021) Reforming Fertilizer Import Policies for Sustainable Intensification of Agricultural Systems in Sri Lanka: Is there a Policy Failure? Feed the Future

Weerahewa, J., & Dayananda, D. (2023). Land use changes and economic effects of alternative fertilizer policies: A simulation analysis with a bio-economic model for a Tank Village of Sri Lanka. Agricultural Systems, 205, 103563. DOI: https://doi.org/10.1016/j.agsy.2022.103563

Weerahewa, Jeevika, Sarath S. Kodithuwakku, Anoma Ariyawardana (2010). Case Study #7-11, "The Fertilizer Subsidy Program in Sri Lanka". In: Per Pinstrup-Andersen and Fuzhi Cheng (editors), "Food Policy for Developing Countries: Case Studies." 12 pp.
URL: http://cip.cornell.edu/dns.gfs/1289505412

Wickramasinghe, W., G. Samarasinha, and S. Epasinghe. 2009. Fertilizer policy on paddy farming: Evaluation of subsidy program 2005. Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo. Unpublished report.

Zhang, M., Yao, Y., Tian, Y., Ceng, K., Zhao, M., Zhao, M., & Yin, B. (2018). Increasing yield and N use efficiency with organic fertilizer in Chinese intensive rice cropping systems. Field Crops Research, 227, 102-109.

Appendices

Appendix 1: Detailed model depicting the baseline equilibrium and shadow prices

Description	Value
Profit (LKR)	851,433.05
Maize 1 (ha) Yala	0.00
Maize 2 (ha) Yala	0.00
Maize 3 (ha) Yala	0.00
Maize 4 (ha) Yala	0.00
Maize 5 (ha) Yala	0.00
Paddy 1 (ha) Yala	0.00
Paddy 2 (ha) Yala	0.00
Paddy 3 (ha) Yala	0.00
Paddy 4 (ha) Yala	0.00
Paddy 5 (ha) Yala	0.00
Mungbean (ha) Intermediate	1.13
Maize 1 (ha) Maha	0.00
Maize 2 (ha) Maha	0.00
Maize 3 (ha) Maha	0.00
Maize 4 (ha) Maha	0.00
Maize 5 (ha) Maha	0.46
Paddy 1 (ha) Maha	0.00
Paddy 2 (ha) Maha	0.00
Paddy 3 (ha) Maha	0.00
Paddy 4 (ha) Maha	0.00
Paddy 5 (ha) Maha	0.40

Urea 1	0.00
Urea 2	225.00
Organic 1	0.00
Organic 2	0.00
Organic 3	0.00
Organic 4	0.00

Constraint	*Usage*	*Slack*	*Shadow Price*
Labour (mandays)	49	250	
Upland Yala	0.00	1.0	
Upland Maha	0.46	1.53	
Lowland Yala	0.00	1.00	
Lowland Maha	0.40	1.6	
Intermediate Land	1.13	0.87	
Water-Sep	362.92	544.38	
Water-Oct	583.94	847.84	
Water-Nov	533.58	751.30	
Water-Dec	582.26	802.58	
Water-Jan	528.14	725.59	
Water-Feb	6.52	7.56	
Water-Mar	0	620.38	
Water-Apr	0	1073.43	
Water-May	540.26	1058.65	
Water-Jun	1153.66	1078.18	
Water-Jul	2011.13	1071.57	
Water-Aug*	699.8	0	611.47

Nitrogen *	0	0	15885.2
Cash*	45000	0	17.26

Appendix 2: Nitrogen input-Yield Schedule for maize

Yield response for N fertilizer application in RBE well-drained soil

N rate (kg/ha)	Average Yield_irrigated (t/ha)	Average Yield_Rain-fed (t/ha)
0	3.4	3.5
15	3.6	3.8
30	3.8	3.9
45	3.9	4.1
60	4.2	4.2
75	4.5	4.4
90	4.7	4.5
105	5.1	4.6
120	5.4	4.7
135	5.5	4.8
150	5.5	4.9
165	5.5	4.9
180	5.5	5.0
195	5.5	5.0
210	5.5	5.1
225	5.5	5.2
240	5.5	5.2
255	5.4	5.3
270	5.4	5.3
285	5.4	5.4
300	5.4	5.4

Source: Personal Communication - Hemali Kanthilanka
(Note: The results are from an APSIM model. The nitrogen response when the cultivation is done following a soybean crop could be higher than what is reported here).

Appendix 3: Calculated paddy yield using the APSIM model

Nitrogen Input (kg/ha)	Yield Level (Yala) kg/ha	Yield Level (Maha) kg/ha
150	2,402	4,196
135	2,399	4,095
120	2,397	4,019
105	2,390	3,920
90	2,377	3,790

Appendix 4: Detailed Results of the Simulations

Season	**Decision Variable**	**Units**	**Baseline Equilibrium**	**S1**	**%**	**S2:**	**%**	**S3:**	**%**	**S4:**	**%**	**S5:**	**%**
YALA	Maize 1	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Maize 2	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Maize 3	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Maize 4	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Maize 5	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Paddy 1	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Paddy 2	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Paddy 3	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Paddy 4	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Paddy 5	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
INT	Mungbean	Ha	1.13	1.13	*0.00*	1.13	*0.00*	1.13	*0.00*	0.00	*-100*	0.00	*0*
	Soybean (S4)	Ha								1.13		1.13	
MAHA	Maize 1	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Maize 2	Ha	0.00	0.00		0.59		0.00		0.00		0.00	
	Maize 3	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Maize 4	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Maize 5	Ha	0.46	0.40	*-13.04*	0.53	*15.22*	0.46	*0.00*	0.75	*63.04*	0.81	*76.0*

	Paddy 1	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Paddy 2	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Paddy 3	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Paddy 4	Ha	0.00	0.00		0.00		0.00		0.00		0.00	
	Paddy 5	Ha	0.40	0.40	*0.00*	0.40	*0.00*	0.40	*0.00*	0.40	*0*	0.40	*0*
Fertilizer	urea 1 S	Kg	0.00	0.00		0.00		0.00		0.00		0.00	
	urea 2 M	Kg	225.00	204.60	*-9.07*	247.50	*10.00*	225.00	*0.00*	0.00	*-100*	0.00	
	Org 1 (com)	Kg	0.00	0.00		0.00		0.00		0.00		0.00	
	Org 2 (C+U)	Kg	0.00	0.00		0.00		0.00		0.00		0.00	
	Org 3 (V)	Kg	0.00	0.00		0.00		0.00		0.00		0.00	
	Org 4 (l)	Kg	0.00	0.00		0.00		0.00		0.00		0.00	
	coated urea-s	Kg	0.00	0.00		0.00		0.00		0.00		0.00	
	coated urea-m	Kg	0.00	0.00		0.00		0.00		180.00		0.00	
	inn 1	Kg	0.00	0.00		0.00		0.00		0.00		660.00	
	inn 2	Kg	0.00	0.00		0.00		0.00		0.00		0.00	
	inn 3	Kg	0.00	0.00		0.00		0.00		0.00		0.00	
	inn 4	Kg	0.00	0.00		0.00		0.00		0.00		0.00	
Cost	Fertilizer	LKR	45,000.00	45,000.00	*0.00*	49,500.00	*10.00*	45,000.00	*0.00*	45,000.00	*0*	49,500.00	*10*
	Profit	LKR	851,433.05	776,700.00	*-8.78*	929,139.00	*9.13*	860,529.00	*1.07*	1,749,837.00	*105.51*	1,934,870.00	*127.24*
	N waste	Kg	112.50	102.27	*-9.09*	123.75	*10.00*	112.5	*0.00*	18	*-84*	132	*17.33*