

RESEARCH ARTICLE

Resource Optimization in Paddy Cultivation, for Developing Countries; A Sector Synergetic Approach

W.D.N. Madhavika^{1*} • Dr.N. Nagendrakumar² • P.S.H. Colombathanthri³
• R.M.T. Rathnayake⁴ • J.H.M.P.S.B. Jayaweera⁵ • M.S. Buddhika⁶

¹Sri Lanka Institute of Information Technology Business School, Malabe, Colombo, Sri Lanka.

²Professor, Sri Lanka Institute of Information Technology, Business School, Malabe, Colombo, Sri Lanka.

³Sri Lanka Institute of Information Technology, Business School, Malabe, Colombo, Sri Lanka.

⁴Sri Lanka Institute of Information Technology, Business School, Malabe, Colombo, Sri Lanka.

⁵Sri Lanka Institute of Information Technology, Business School, Malabe, Colombo, Sri Lanka.

⁶Sri Lanka Institute of Information Technology Business School, Malabe, Colombo, Sri Lanka.

ARTICLE INFO

Article History:

Received: 15.05.2021

Accepted: 24.06.2021

Available Online: 14.07.2021

Keywords:

Chemical Fertilizer Over Usage

Controlled Experiment

Triangulation

Sector Synergy

Sustainable Economic Growth

ABSTRACT

The misleading fallacy of, higher the chemical fertilizer higher the yield therefore, better the income be. Have triggered in an over usage of chemical fertilizer more than the recommend standard. This has created in a self-pressuring situation among farmers in developing countries. This vulnerability occasionally leads into a decision-making situation where both life and death are seen as viable options. Hence in order to safeguard the farmer, with the aims of educating these disobedient farmers, through the process of validating the existing chemical fertilizer standard. This research was carried forth in Sri Lanka, for the paddy farmer. The data were collected in a data triangulation, where a controlled experiment, two series of interviews and two sets of questioners were utilized. Both, quantitative as well as qualitative data and, primary as well as secondary data were collected. Depending on the nature of the data collection instrument, an experiment, thematic, descriptive and a correlation analysis were performed through statistical software applications. Further, a yield and a soil test was performed for the controlled experiment plots. By adjusting the parameters accordingly, this study could be used as a model by other countries, regions or crops. Finally concluding on a policy implication, to eliminate or reducing the chemical fertilizer over usage in developing countries. Further avenues for a managerial implication where the Balance of Payment could be used to positively stimulating a developing countries Gross Domestic Product to achieve sustainable economic growth in the long run are discussed.

Please cite this paper as follows:

Madhavika, W.D.N., Dr. Nagendrakumar, N., Colombathanthri, P.S.H., Rathnayake, R.M.T., Jayaweera, J.H.M.P.S.B. and Buddhika, M.S. (2021). Resource Optimization in Paddy Cultivation, for Developing Countries; A Sector Synergetic Approach. *Alinteri Journal of Agriculture Sciences*, 36(2): 122-131. doi: 10.47059/alinteri/V36I2/AJAS21124

Abbreviations

BOP	- Balance of Payment
CKDu	- Chronic Kidney Disease of unknown origin
CNH	- Colombo National Hospital
DOA	- Department of Agriculture
EC	- Electrical Conductivity
GDP	- Gross Domestic Product
GNH	- Gall National Hospital
MOP	- Murate of Potash
TSP	- Triple Super Phosphate

Introduction

Chemical fertilizer over usage is the root cause for many global pandemics. Addition of chemical fertilizer in excess when cultivating, result these excess amounts to be deposited in soil. The microbes in soil which decompose and degrades the soil is been disturbed due to chemical fertilizer. Chemical fertilizer causes death to these microbes, and prolong additions of these chemicals could sit in soil for years. This results in a soil contamination which results decertification of earths' crust. Hence the

* Corresponding author: W.D.N. Madhavika

cultivable land portions gradually reduces on a daily basis as a result. Further, plants have a tendency to absorb these chemical deposits from soil, resulting chemical deposit to be stored in plants. Furthermore, diffusion of these chemicals with water results in water pollution and eutrophication of water bodies. This creates a life threatening cycle, plants in water and these chemicals consumed by animals' leads chemicals to be deposited in plant and animals. Exposure to these chemical deposits, in soil, water plants and animals by a human causes human health deterioration. Such as, development of cancer cells, skin diseases, hair loss, kidney failure, chronic illnesses, etc. This life threatening cycle threatens and kills the lives on earth and kills the life of earth by triggering environment pollution on a consistent daily basis. Such negative repercussions are enacted due to the over usage of chemical fertilizer by a farmer. This life-threatening cyclic effect needs to be multiplied with other variables and contexts. Such as, number of times a farmer over uses chemical fertilizer, the over used quantity, number of farmers who over uses it etc. Hence, in order to initiate in preventing this consistent global crisis, this study focuses on drawing attention on to these negative counter effects, by considering paddy sector chemical fertilizer usage, of a developing nation.

Agriculture being one of the driving forces which stimulates economic growth of a country and, diverse traditions and culture which revolves with agriculture in under developed and developing nations. Consistent attention on the agriculture industrial needs in under developed and developing nations becomes a vital consideration. Due to geographic location and abundance of natural resources focusing on agriculture growth and resource optimization guarantees a growth in the Gross Domestic Product (GDP) of a country. Out of all the crops, paddy is a tropical climate fond crop which is largely cultivated in these nations. It is consumed at least twice a day and is considered as the staple food in many nations. Due to this some countries cultivates paddy in two cultivating seasons called Yala and Maha. Paddy sector as a result, consumes a lot of human, financial and other resources and hence, requires higher budget allocations. Optimizing these physical and monetary resources, creates significant economic variations of a country. A first step towards flourishing agriculture growth, being eliminating or reducing resource wastage in paddy sector. The focus in this study is to eliminate or reduce chemical fertilizer wastage, in developing countries.

This research was conducted in Sri Lanka, a developing country in Asia, where rice is the staple food. The Department of Agriculture (DOA), Sri Lanka issues chemical fertilizer through a subsidy scheme, to a local paddy farmer. The chemical fertilizer issued through the subsidy are offered through a standard scheme (Ekanayeka.H.K.J 2009). This process have been carried on for decades by the DOA. The chemical fertilizer issued via the scheme are Urea, Triple Super Phosphate (TSP) and Murate of Potash (MOP). Even with the subsidy scheme, an over usage of chemical fertilizer by paddy farmer in Sri Lanka, still exists. The cause of this behavior was identified as due to, the mythical belief

that is deeply inculcated in a local paddy farmer. The mythical ideology being, higher chemical fertilizer utility results in better yield growth therefore, lies the potential for a better income. As a result chemical fertilizer is seen as a need more than a necessity by these local farmers. Hence, this vulnerability has resulted in a self-perusing situation upon the local farmer. This mythical ideology has been identified by many scholars, as a local farmers' stubborn behavior.

Although this study looks into a different lens, to see things in a different light from the farmers' point of view and to understand what is causing this behavior to look into solving this issue. The study categorized a local paddy farmer into two categories, based on farmers' chemical fertilizer usage behavior. A paddy farmer who tends to overuse chemical fertilizer by using more than the standard was categorized first, as a disobedient farmer. Next, farmers who uses chemical fertilizer as per the Government recommended standard were categorized as obedient farmers. By categorizing the usage behaviors of these paddy farmers, the aim was to educate the disobedient paddy farmer by, validating the existing standard chemical fertilizer utilization. Thereby leading towards preventing crop damage, reducing chemical fertilizer import cost, educating on precision farming, identifying health conditions and educating on adverse kidney health impacts. Further safeguarding a local farmer by imposing a policy, thereby stepping into potentials on achieving managerial growth as discussed at the end of this study.

The paper is organized as follows, the existing knowledge on this avenue is been addressed through the second section literature review. Method and Data Analysis section three, discusses on the research instruments and the analyzed data. Finally, the conclusion and implications from the study and further research recommendations are been addressed in section four.

Literature Review

Paddy a gain crop is one of annual largest volume generating crops, it is consumed at least by half of the world population. Asian region consumes rice for almost all three meals. The entire Asian region has contributed for a 75% of rice in total, to the world market during the year 2019. (Workman.D 2021). Yet the global paddy supply is decreasing in comparison to the global demand. To cater for this rapidly increasing demand for food with higher yield growth, a green revolution took place. It helped in reducing the gap of demand and supply in the agriculture industry. A long with new technology, chemical or inorganic fertilizer a manmade substitute was introduced. This helped in generating higher crop yield. Soon along with the green revolution chemical fertilizer became a new, widely used addition to farmers' inventory of resources, in cultivation (Gollin.D et al. 2018). Since then, the amounts of chemical fertilizer utilized in paddy sector was increase. Chemical fertilizer is a useful resource in cultivation, when utilized at the optimal point. Although misusing this resource is traumatic on numerous levels as it arise in negative repercussions.

The negative repercussions that arise from over using chemical fertilizer impacts on both monetary and non-monetary terms. The non-monetary repercussions are hard to calculate in quantities and is deadly to all. Such are, accumulation of heavy metal deposits in soil and in plants, diffusion of these heavy metal chemical deposits in soil into water ways. Further, accumulation of these heavy metal deposits in animals, creates a massive human exposure to heavy metals on a daily basis. Through this a prolonged environment pollution is constantly created (Hasan. K.Md et al. 2019; Cai.J et al. 2018; Wu.H and Ge.Y 2019). Furthermore, consistent addition of chemical fertilizer leads in threatening the microbial living, in soil. Death of these microbes results soil to be infertile hence, leads in desertification of land. This situation is faced by the African population, and have become a globally prevalent issue (Morugán-Coronado. A et al. 2014; Duchene. O et al 2017; Huang. S et al. 2010; Khan. S et al. 2013).

The monetary repercussions are arisen due to the wastage of resources in the agricultural sector. These repercussions leads in an economic lag have been identified and addressed by past studies on drawn linkages among agriculture and economic growth, as well as agriculture and policy implications. A close positive relationships among agriculture growth and economic growth was addressed by Martine. W (2019 and by Gollin. D et al. (2018). These studies identified positive linkages among the two avenues and that growth in agriculture could grow an economy. A study conducted in nine developing countries identified the impacts from agriculture upon economic growth. The research data were made in both short term and in long term, and was determined that agricultural growth stimulates the economic GDP of a country to rise. The growth potentials varies based on a countries Political, Economic, Social, Technological, Environment and Legal (PESTAL analysis) status (Xie et al. 2015). A study carried in Finland addresses on chemical fertilizer over usage and concludes with a policy implication where the farmer is been fined (Bostian. A.A 201)

The root cause of these negative repercussions are identified as disobedient farmers' usage behaviors. The tendency to misinterpret the benefits generated from chemical fertilizer. As, higher chemical fertilizer results in better yield therefore, helps in arising at a better personal income (Zhang.Y et al. 2020). This has created a tendency in seeing chemical fertilizer as a need more than a necessity. Thus, have lead into a self-pressuring situation by the disobedient farmer making themselves vulnerable. The level of intensity on this, goes beyond the limit, where the capacity of a farmer to add chemical fertilizer, into the inventory of resources becomes financially limited. In such an intense situation taking off, their own life is seen as the only remedy (Ramadas. S and Kuttichira. P 2017; Wessel. R et al. 2020). Disobedient farmers over uses chemical fertilizer, by buying additional amounts of chemical fertilizer from private fertilizer markets. The Governments in countries like Sri Lanka, Egypt, Africa etc. issues chemical fertilizer through a subsidy scheme. The subsidy issues the total standard amount required by a farmer, for a particular

cultivating season. This is done in order to encourage farmers and to encourage cultivation in countries (Ekanayeka. H.K.J 2009; Warra et al. 2020; Jayne. S.T and Rashid. S 2013). Yet these disobedient farmers tend to misuse this subsidy, by using the subsidy as well as buying additional units of chemical fertilizer. The efficiency, effectiveness and possible changes in such fertilizer schemes, have been discussed by many researchers for decades. Yet the wastage of chemical fertilizer allocation by local farmers even with the effect of the subsidy scheme still exists (Upekshani. H.A.N. et al. 2018; Data Collection Survey on Agricultural Sector in Sri Lanka 2019; Dharshani. S 2020).

Significant attention on the issue of over using chemical fertilizer, by pointing towards disobedient farmer as the issue creator, emphasizing the needs on changes into subsidy schemes, paddy crop development, chemical fertilizer wastage, negative environmental hazards and health deterioration etc. have been addressed in previous studies. Although, drawing light upon understanding the tendency to over use chemical fertilizer, from disobedient farmers point of view, connecting health, production, education and economic GDP growth needs of a developing country, is what this study have met.

Methodology and Data Analysis

Through the conceptual framework of the study, two hypotheses were formulated and tested. Chemical fertilizer utility impacts on health (H;1) and chemical fertilizer utility impacts on paddy production (H;2). The data were collected in a three step data collection strategic approach. Firstly a controlled experiment, next two sets of surveys' and finally a two series of interviews' were carried forth. This approach of data collection triangulated the data collection process. Each data collection strategy were optimized in testing both the hypothesis. Hence, a data triangulation for each hypothesis was conducted, where the data collection was triangulated twice through this approach. All the three data collection strategies helped in understanding the kidney health associated impact and triggers as a result of a disobedient paddy farmer's behavior. Followed by identifying the root cause for such disobedient behavior.

Controlled Experiment

Controlled experiment being the first data collection strategy, it was performed in Kurunegala, Sri Lanka. Kurunegala in Sri Lanka, falls into the intermediate zone, it helped in carrying the experiment without being subjected to any extreme weather conditions (prevented biases in climate). The experiment was conducted during the Maha season (kanna) in a two acre paddy field under the same land holder. The data were collected through first-hand experience by the researchers. The experiment plot was daily monitoring by the researchers and logs were maintained. Frequent expertise consultation from the paddy land holding farmer, as well as from an agriculture instructor from the DOA was received. The total land area of two acres were utilized for the controlled experiment. One

acre of the paddy field was used for the controlled and the other acre for the non-controlled. The variable which was not controlled was chemical fertilizer utilization. The Sri Lankan Government proposed chemical fertilizer utilization standard, was optimized in the controlled plot. Paddy land holding farmers normal utilization of fertilizer was allowed to be utilized in to the non-controlled plot. Every other variable was controlled in the plot, water utilization for agriculture in this particular region being used only through rainfall, it was allowed to be absorbed to the experiment in the same volumes. Sunlight was allowed in naturally, 50 kg of seeds were added to each experiment plot, same skilled labor, equipment and experience were utilized throughout the experiment.

The controlled experiment land owner was a disobedient paddy farmer, who have been over using chemical fertilizer throughout the entire paddy farming life time. Hence, the researchers aim was to transform this disobedient paddy farmer to an obedient paddy farmer. The chemical fertilizer utilized in each plot were Urea, TSP and MOP. As per the chemical fertilizer standard and time schedule for rain water distribution system, which was issued by the DOA, Sri Lanka. Chemical fertilizer were allocated in set quantities and time periods, in to the controlled plot. Whereas, for the non-controlled plot the normal allocation as per the disobedient farmers' own allocation, was allowed to be utilized. This also included an organic fertilizer mixture of poultry fesses, hay and Silk tree leaves (*Albizia falcataria L*)

Table 1. Controlled experiment chemical fertilizer allocation made as per DOA Sri Lanka fertilizer guidelines, utility allocation as per rainfall system

Type of fertilizer	Controlled plot total fertilizer utilization (Kg)	Non-Controlled plot total fertilizer utilization (Kg)
Urea	70	87
TSP	8	16
MOP	16	16

Source; Authors illustration

After the controlled experiment a yield test followed by a soil test, was conducted at two Government research centers from each experiment plots. As per the testing requirements at each research center, a samples of equal weight and quantity from both the controlled and non-controlled plots were presented to each, research center on the same day. The yield test was conducted at Industrial Technology Institute in Colombo, Sri Lanka. The soil test was conducted at the Bathalegoda research center in Kurunegala, these tests were conducted to support H1.

Table 2. Controlled experiment yield test results tested at Industrial Technology Institute, Colombo, Sri Lanka

Test	Method of test	Controlled plot results	Non-Controlled plot results	Limit of Detection
Crude fat content (on dry basis), percent by mass	AOAC 7.048 11 th Edition	1.4	3.1	-
Protein (on dry basis), percent by mass	Kjeldhal method	10.1	8.7	-
Lead (Pb), mg/kg	Microwave Digestion/ICP -Ms	Not detected	Not detected	0.05
Cadmium (Cd), mg/kg	Microwave Digestion/ICP -Ms	Not detected	Not detected	0.5
Arsenic (As), mg/kg	Microwave Digestion/ICP -Ms	0.06	0.05	-
Mercury (Hg), mg/kg	Microwave Digestion/ICP -Ms	0.15	Not detected	-

Source; Yield test analysis as per Industrial Technology Institute

Records of lower crude fat mass and higher protein mass in the controlled plot than that of the non-controlled plot illustrates, a healthy level of yield record from the controlled plot. Heavy metals (Pb and Cd) was not detected from either of the plots. Although a slight increase rate of As 0.01 was detected in the controlled than that of the non-controlled. A rate of 0.15 Hg was detected in the controlled whereas Hg was not detected in the non-controlled plot. Hence, to determine whether this condition was due to prolonged effects from chemical fertilizer over usage. As, disobedient paddy farmers chemical fertilizer allocation may have resulted the soil of the experiment land to be contaminated, a soil test was conducted.

Table 3. Controlled experiment soil test results tested at Bathalegoda research center in Kurunegala, Sri Lanka

Characteristics	Controlled plot	Interpretation	Non-Controlled plot	Interpretation
	Values		Values	
pH (1:2.5 Soil:D.W)	4.75	Acidic	5.17	Acidic
EC (dS/m)-(1:5 Soil:D.W)	0.01	Very low	0.04	Very low
Exchangeable Potassium (ppm)	17.7	Very low	20.4	Very low
Organic Matter percentage	4.68	Optimum	4.0	Optimum

Source; Soil test as per Bathalegoda research center

As per the soil test of the controlled plot, it detected a higher acidity state than that of the non-controlled plot. Recorded an Electrical Conductivity (EC) which was 0.03 units less than the non-controlled. A lower Exchangeable Potassium of 17.7 was detected in the controlled plot, which is 2.7 units lower than the non-controlled. Even though organic matter was not allocated in to the controlled plot, an optimum level of organic matter were detected in soil test results. This is due to the over usage and prolonged additions of organic fertilizer. As per Thomas.G.W (1996), treating soil to neutralize, may take three to seven years of organic bases addition and consistent soil tests. Lands that were not treated to achieve a neutral state could comprise of previously added fertilizer deposits thus, validates the contamination of soil in the controlled plot. Hence, this test elaborates that, the controlled plot yield As and Hg detection more precisely. Therefore, the research test validates, over usage of chemical fertilizer impacts on health.

To determine whether there is an impact from chemical fertilizer utilization on paddy production yield volumes (H2). The yield obtained from both the plots of the controlled experiment were weighed (kg) and analyzed using Microsoft Excel 2010. The controlled plot was conducted in the same exact methods as per the non-controlled plot, except for chemical fertilizer utilization. As per the data records, a yield growth of 81.27 kg greater than that of the non-controlled plot was recorded from the controlled plot. Hence, it was evident that this massive growth of yield was due to the standard utility of chemical fertilizer.

Table 4. Controlled experiment yield data (Maha season 2020)

Year; season	Controlled plot (kg)	Non-Controlled plot (kg)	Difference (kg)
2020; Maha	1309	1227.73	81.27

Source; Authors illustration

Five years of yield data from both Yala and Maha seasons were obtained from the paddy land owner. The non-controlled which was cultivated as per any other season, was used to determine seasonal variations. Hence, a comparison of this seasons' non-controlled plot record (2020; Maha) with Maha seasonal records from previous years since, 2016 were made.

Table 5. Yala season yield harvest records (2016 - 2020)

Harvest Year	Seasonal harvest; Yala (kg)
2017	1270
2018	960
2019	1190
2020	1209

Source; Authors illustration

Table 6. Maha season yield harvest records (2016 - 2020)

Harvest Year	Seasonal harvest; Maha (kg)	Seasonal variation (kg)
2016	1279	-51.27
2017	1034	193.73
2018	1028	199.73
2019	1238	-10.27

Source; Authors illustration

The non-controlled plot comparison against previous year Maha seasonal records elaborated that, there is no significant effect from this year's Maha season on yield quantity growth. Controlled plot yield growth record, was recorded as the highest yield growth obtained by the controlled experiment land owner since, 2016. Once again the known fallacy of, higher the chemical fertilizer higher the yield be, is further justified as a mythical concept. Therefore, this illustrates that chemical fertilizer utilization as per the standard, impacts on paddy production growth.

Nephrology Senior Registrars and Paddy Farmer survey

The second data collection strategy was a survey, where two sets of questionnaires were prepared and presented to each survey sample group. Each set of surveys were carried, following simple random sampling process. The researchers collected data through first-hand experience, through an open ended semi structured Likert scale questionnaire. The data gathered were analyzed using Statistical Product and Service Solutions software. Descriptive and correlation analysis were performed, as data analytical approaches.

First set of survey respondents were Nephrology Senior Registers, and data collected were optimized in validating H1. These respondents were identified through the Sri Lankan, MOH registry on Nephrology Senior Registrars. A sample of total 12 respondents participated in the survey, from a population of 20. Aim here was to identify most prevalent health conditions, to determine chemical fertilizer impacts on human health (kidney). The male to female ratio among the respondents was 4:8. The average respondent was within the age range of 30 to 35 (30-35) years of age. Years of service experience as an average is of seven to ten (7-10) years, as a Nephrologist.

Based on the responses, it was identified that Diabetes Mellitus as the most prevalent kidney disease among, Sri Lankan population. Followed by an equal agreement on Chronic Kidney Disease of unknown origin (CKDu) and Glomerulonephritis.

Table 7. Mostly prevalent kidney diseases in Sri Lanka

Prevalent kidney diseases in Sri Lanka	Responses (as a percentage)	Number of respondents
Diabetes Mellitus	10	83.3
Chronic Kidney Disease of Unknown origin (CKDu)	1	8.3
Glomerulonephritis	1	8.3
Total	12	100

Source; Authors illustration

Table 8. Rate of agreement by the respondents

Question	Rate of agreement		
Exposure to chemical fertilizer impacts on kidney failure	16.7% Neutral	83.3% Agree	Highly agree
The importance of addressing this issue as a local and global context	27.1% Neutral	23.1% Important	Highly important 49.8%

Source; Authors illustration

As per the analysis Table 8 83.3% Nephrology Senior Registrars, agrees that chemical fertilizer exposure causes kidney failure. A total of 72.9% agrees that it is important to address this issue locally and globally. No, Nephrology Senior Registrar in the sample disagreed with either of the statements hence, these arguments are satisfied at a 100% agreement.

After the first survey, the second survey set was executed, here the respondents were paddy farmers in Kuruengala, Sri Lanka. The respondents were reached through a paddy farmer list which is maintained by the agrarian service center in Kurunegala. It comprised paddy farmer data, through this data set a sample of 189 respondents were selected. The data obtained from these 189 paddy farmers helped in validating H2. The data that were collected looks into a paddy farmer's chemical fertilizer buying behavior Table 9.

Table 9. Correlation on total cost spent on chemical fertilizer and income obtained by a paddy farmer

Variable	Pearson Correlation	Sig. (2-tailed)
Total cost spent on fertilizer	-0.168*	0.021
Income of a paddy farmer	-0.168*	0.021
N	189	189

*Correlation is significant at 0.05 level (2-tailed)

Source; Authors illustration

The focus was drawn on to cost of buying chemical fertilizer and the income earned from paddy farming. By statistically modeling these data, the accuracy of higher chemical fertilizer results in higher paddy production was tested. In order to do so a correlation analysis was performed, the correlation value obtained being a negative 0.168 determines that the relationship among, a paddy farmers cost incurred due to chemical fertilizer and income earned have a weak negative relationship. The model being significant (0.05) this implies that, adding chemical fertilizer more than the standard does not result in higher yield hence, the disobedient paddy farmer incurs an unnecessary loss.

Interview Series; Consultant Nephrologists and DOA Provincial Directors

The two series of Interview was the final data collection strategy but, the first qualitative data collection approach. Each interviewee was reached through snowball sampling technique. The interviewees were interviewed by the

researchers and by the contact person. Alternative interview methods of, face to face interview and/or a group telephone interview were conducted based on interviewees' preference. Data were categorized into themes and thematic analysis was conducted.

The first series of interviews were held with two Consultant Nephrologists and was used in validating H1. The first Consultant was from the Galle National Hospital (GNH) unit and the other Consultant was from Colombo National Hospital (CNH) unit. Both the Consultants were reached through a Doctor at the General hospital, who was personally contacted by one of the researchers. The themes used for the analysis of this interview series were, areas where kidney diseases are mostly prevalent, impacts from chemical fertilizer, research studies, quality of life and average patient count.

Through the interviewee's knowledge and expertise, the resemblance of chemical fertilizer impacts on kidney organ and kidney death toll was discussed. Numerous amounts of evidence prevail that chemicals such as, As and Cd are toxic. Although the exact compound is not yet known, the existence of a relationship among chemical fertilizer and kidney diseases can be justified (Nephrology Consultants GNH). Before chemical fertilizer usage roughly around early 1960s, patients with kidney diseases originating among the agricultural community, was not found. Although, years after this period where the chemical fertilizer was used, kidney diseases among the agricultural community was found hence, this is now called "CINAC". Whether the origin is due to one single particular chemical attribute or several attributes is yet unknown (Nephrology Consultants CNH). The cause and growth of Kidney disease, certain cancers and diabetes were reported as a result of over usage of chemical fertilizer in Sri Lanka. The World Health Organization has given a warning regarding the unhealthy amounts of chemical fertilizer over utility in the country, mentioning that it could worsen the prevailing health situation (Karunaratne. S 2013). Diabetes and hypertension arise as a result of high blood pressure, are the main reasons for humans being subjected as Chronic Kidney Disease (CKD) patients. CKD is a progressive disease which cannot be reversed, which ultimately leads in to kidney failure. Diabetes is the common cause of kidney diseases in Sri Lanka, and in developing world. Although, there are numerous reasons leading to diabetes, as it is multifactorial (Nephrology Consultants CNH). The number of CKDu patients have been rising in Sri Lanka in the past decades. This is mostly prevalent in the north central province of the country and is a prevailing epidemic condition. A study carried validates the hypothesis that, chemical fertilizer is a potential source of Arsenic. Conclusions on, chemical fertilizer being a major source for the heavy metal Arsenic, TSP fertilizer being highly rich with the presence of Arsenic and "farmers in CKDu endemic areas in Sri Lanka should be encouraged to minimize the use of imported chemical fertilizer" (Jayasumana. C et al. 2015), are being discussed in some studies. "Urine excretion of cadmium individuals with CKDu and the dose effect relationship between urine cadmium concentration and CKDu stages suggests that

cadmium exposure is a risk factor for pathogenesis of CKDu.” (Jayatilake. N et al. 2013). Cd is a toxic heavy metal and the nutritional value of it is not yet clear although, low levels of Cd are required for growth. Cd is present in most organs and out of all the organs, it prevails mostly in Kidney (Dawada.S and Valentine.M 2013).

Further, the availability of adequate research studies and the impact from chemical fertilizer on quality of life, discussions on these were made with the interviewees. There is a need for research and education regarding the chemical fertilizer impacts on kidney and other human health conditions. Even though chemicals or heavy metals, such as As and Cd impacts on kidney is evident. Further research are under way to address the origin of the issue (Nephrology Consultants GNH). There had been ongoing research on kidney impacts to understand the causes in originating this condition mainly among the agricultural community. To understand whether, there is any particular single factor leading to its originality although, at present the rate of research on this is slow and limited (Nephrology Consultants CNH). Kidney diseases could gradually deteriorate quality of life, in Sri Lanka. CKDu in Sri Lanka is mainly seen only in one part of the country, mainly in Anuradhapura, Polonnaruwa and North Central (Kurunegala) regions. This is present in Anuradhapura, because of its vulnerability (Nephrology Consultants GNH). CKD is prevalent mostly among the Anuradhapura and Polonnaruwa agricultural communities than that of Colombo. The income of the agricultural community is lower than that of the average income earning people. Hence, with kidney diseases we could say that the quality of life in people is drastically decreasing. As the agricultural community cannot bear the costs in kidney dialysis treatments and kidney transplant surgeries, this will continue to grow. Due to the growing lack of healthy kidney donors, whom a transplant can be made, this situation could further increase. As of now average patient count in CNH are around 800 per year and it is about 80 per month (Nephrology Consultants CNH). Current great majority of Sri Lankans who are subjected to kidney diseases are due to diabetes. This condition is medically defined as diabetes nephropathy, this is diabetes induced and pressure induced. Hence, high blood pressure induces kidney diseases, and it is more prevalent. There are a lot of other causes affecting kidney such as kidney stones, as discussed by Nephrology Consultants GNH.

With the interview series among Nephrology Consultants it was evident that, even though the exact compound cause is unknown, there is an impact from chemical fertilizer on health. This is further justified with the number of kidney patient’s growth, which prevails mainly in Anuradhapura, Polonnaruwa and Kurunegala regions of Sri Lanka. Thus, as explained by the consultants and further validated through literature, kidney conditions are an epidemic health condition which needs more attention.

The next series of interviews were carried to validate H2 and was conducted with two Provincial Directors from DOA, the provinces were from Kurunegala and Anuradhapura. These interviewees were reached through the aid of a former DOA officer, who was personally

contacted by one of the researchers. The questions for the interviewee were asked based on, researchers experience, doubts concerning this issue (which were drafted before the interview series) and through impromptu questioning. Finally concluded each session by presenting the findings from the controlled experiment and emphasizing on the need of proper education on this issue, to their respective communities. The themes used in the analysis for this interview were over usage of fertilizer impacting GDP, disobedient farmers and lack of knowledge among the farmers, leads towards health impacts and environment pollution.

The first interviewee was the Provincial Director from DOA in Kurunegala district and the next interviewee was the Provincial Directress from DOA in Anuradhapura district. The issue of chemical fertilizer over usage was discussed while linking this issues impacts on to GDP. There is a massive over usage of chemical fertilizer among the Kurunegala and Anuradhapura district paddy farmers. DOA has a recommended standard for chemical fertilizer usage which is offered to all farmers through a subsidy. Although, most farmers misuses the subsidy by using the offered fertilizer amounts as well as purchasing additional amounts from private fertilizer markets. Thereby wasting the imported chemical fertilizer on a seasonal basis (Provincial Director DOA Kurunegala). Definitely there is an over usage among most of the paddy farmers in Anuradhapura and it has resulted in a chemical fertilizer wastage. These disobedient farmers tend to find successful ways to misuse the given standard, there are numerous issues, as results of this behavior by the disobedient farmer. The number of farmers who overuse and wastes chemical fertilizer as an average, is about 40% percent in Anuradhapura (Provincial Director DOA Anuradhapura). The fertilizer allocation amounts of a farmer who overuses is purely based on personal instincts or based on the gut feeling (Provincial Director DOA Kurunegala). These disobedient farmers neither follow the standard, nor follow a proper consistent mechanism set by them. The allocation of chemical fertilizer by these farmers are purely based on personal judgment (Provincial Director DOA Anuradhapura). The main issue is that these farmers believe that, higher fertilizer usage gives better yield. Hence, they for sure overuse the chemical fertilizer and does not have standard utility for their own over usage behavior (Provincial Director DOA Anuradhapura). Overusing chemical fertilizer has its own contribution for it (Cai.J et al. 2018). Inorganic or chemical fertilizer has become a nutrient that the farmers cannot live without (Dharshani.S 2020). Therefore, this mythical belief has encouraged farmers to use excessive amounts of fertilizer into the soil. As a result of using excessive amounts of fertilizer it has resulted in many negative impacts (Wu.H and Ge.Y 2019).

There is an over usage of chemical fertilizer by disobedient farmers in developing countries, it has impacted on the country’s GDP and on its economic performance. As explained by the Provincial directors, chemical fertilizer is imported to Sri Lanka, and the cost associated with it is extremely high. Further explained by the Provincial Director from DOA in Kurunegala, there is no profit from the

chemical fertilizer importation to the Government and hence, a huge cost is incurred. This is further justified through literature published specially in Sri Lankan newspapers. Such as, Karunaratne.S (2013) which stated, Sri Lanka was recorded as the highest chemical fertilizer importer in the Asian region. The total importation quantities were of 284 kg/hectare of arable land, which is eight times higher than that of other Asian countries. Explained through a recent plethora of publications regarding this over usage issue by the Sri Lankan disobedient farmers, in the Dharshani.S (2020) it explains, the presence of this issue even after seven years since, 2013. In the hopes of obtaining higher yields, farmers of developing countries such as Sri Lanka, have been over using these inorganic fertilizers for a prolonged period of time. This is also a common issue for countries that follow fertilizer usage through a subsidy scheme such as Africa (Warra et al. 2020) and Sri Lanka (Ekanayake.H.K.J 2009).

Further considerations were made on, disobedient farmer's lack of knowledge and inflexibility towards understanding, have lead into negative environment and health impacts was discussed with the interviewees. The over usage among disobedient paddy farmers has risen as a result of lack of knowledge, which has limited the understanding and flexibility among disobedient paddy farmers. Hence, DOA is currently hosting a provincial training program, where the farmers are educated on fertilizer over usage and the need of regular soil testing to be carried by the farmer themselves. DOA consistently advises the need of conducting soil tests, as it helps in maintaining the health of soil, through regular monitoring and treatment. Understanding the right treatment for the unique paddy field due to numerous soil conditions, is proposed and communicated by DOA throughout, on a regular basis. If not possible farmers are advised to use at least the color coded chart recommended by DOA. The chart helps in understanding the crop need, through the color of the paddy plant being compared with the color coded chart. The present soil health conditions in Sri Lanka is at the border of being infertile due to, lack of knowledge and inflexibility in understanding the issues that would arise as a result of chemical fertilizer over usage (Provincial Directors DOA Kurunegala and Anuradhapura). The state of tarnished soil health is the cause of the commonly visible issue of desertification of land. Most soil areas that are limited in supply of nutrients are a result of desertification. This major issue is faced by the present world, and has threatened the agricultural industry. Prolonged addition of chemical nutrients plays a major role in creating this unfortunate traumatic situation of soil desertification (Arthus-Bertand.Y 2011).

The depth of this issue is further explained by the provincial directors relating their service region. No matter how we teach and train there are some farmers in Kurunegala who never listens, Changing this attitude in disobedient farmers is nearly impossible, yet we try by carrying forth training programs (Provincial Director DOA Kurunegala). The DOA recommended standard varies from zone to zone and through the water obtaining system. No

matter how hard we train and teach these farmers, they do not obey the chemical fertilizer standard utility (Provincial Director DOA Anuradhapura). These disobedient farmers apply fertilizer when a heavy rainfall could be expected, then these fertilizer gets mixed with water. If not, they allow the paddy field to be over flooded, then apply chemical fertilizer. There is a lack of knowledge among these disobedient farmers (Provincial Director DOA Kurunegala). The overused chemicals tend to mix with water, this is due to lack of knowledge in understanding among disobedient paddy farmers (Provincial Director DOA Anuradhapura). Once a Medical Doctor in the village informed that, over using chemical fertilizer impacts on human health. Hence, paddy farmers were advised to limit the use of chemical fertilizer, yet there are disobedient farmers (Provincial Director DOA Kurunegala). This issue is further explained by stating that, chemical fertilizer over usage is the cause and growth of Kidney diseases, certain cancers and diabetes. According to an experiment carried in China, it was proven that the over usage of inorganic fertilizer has resulted in fertilizer losses. This has incurred resource wastage, lower efficiency in ergonomic use (Ren.H et al. 2020). Changes of soil property, declining productivity in soil, deterioration of agricultural production quality. Further, loss of microbes and changes in the environment, all these negative causes are rooted to the addition of excess fertilizer into soil. Overly used chemicals depleted into soil as deposits, such as lead deposits, etc. Plants absorb nutrients from these soil, which has resulted in these chemical deposits to be accumulated by plants and these deposits to be stored in plants. The contaminated soil is diluted into ground water and diffused into water bodies, causing contamination of water (Tiller.K.G 1989; Chen et al. 2020).

Hence, as per the interview series with Nephrology consultants and once again validating the discussions through literature, prevalence of kidney disease in high paddy cultivating regions is due to the exposure to chemical fertilizer. Chemical fertilizer impact on the kidney and negative impacts on human health were discussed. As per the interview series with DOA Provincial Directors, the existence of an over usage of chemical fertilizer by disobedient paddy farmers were discussed. This impact on agriculture, soil and paddy production were justified through the discussions and was identified as, disobedient farmers' lack of knowledge and inflexibility towards understanding this issue. Further addressed by the Provincial Directors in DOA and was identified that, tremendous monetary losses are incurred by Government of Sri Lanka.

Conclusion and Implications

Based on the data collected through each data collection strategic instrument. It was identified through the interview series that, there is an over usage of chemical fertilizer more than the standard. This situation has caused in the creation of a massive resource wastage. Further causing, negative human health and prolonged environment pollution. The data computed through the survey and

controlled experiment, disproves the mythical fallacy hosted by disobedient paddy farmers. By statistically proving that, over using chemical fertilizer more than the standard results in higher costs to be incurred by the disobedient paddy farmer, due to lower yield volume generated by the crop. Further, the survey proved that communication could get the disobedient farmer to listen and think although, it does not guarantee obedience in disobedient farmers' behavior. On the other hand the controlled experiment adds practical value to this statement, as it managed to practically educate and prove the effects from chemical fertilizer usage as per the standard. Thereby, transforming a disobedient farmer to voluntarily participate in using chemical fertilizer as per the standard. The standard utility of chemical fertilizer resulted in higher paddy yield growth and thereby, resulted in the income of the paddy farmer to grow. Therefore, due to these positive results generated from the controlled experiment, emphasis on the importance of chemical fertilizer usage as per the standard, through practical education, is proven effective.

Reduction in chemical fertilizer wastage limits the threats of desertification of land, environmental pollution and human health deterioration. The potential capabilities in achieving higher yield through standard estimates of resource allocation, which in turn reduces the damage upon crop and soil, limits the financial burden upon both farmers and upon nations. Hence, in order to support this positive atmosphere and to protect the local disobedient farmer in developing nations, a policy on chemical fertilizer importation needs to be imposed by government bodies. A policy to promote the practice of importing only the standard utility needed for the country for each agriculture cultivating season. This behavior would reduce the urgency and vulnerability that drives a farmers' disobedient behavior. Leaving these farmers only the standard utility thereby, safeguarding the local farmer.

Further this atmosphere promotes in a managerial implication where by, encouraging on importing only the standard amount of chemical fertilizer, a BOP could be achieved by a country. Allocating this BOP into enhancing the per-capita income of citizens. Further on to, economic development could positively stimulate a country's GDP as a byproduct. Thereby, flourishes the economy and leads in potential of achieving a sustainable economic growth in the long run. Thus, lies the potential of underdeveloped nations to be developing nations and developing nations to be developed nations.

The study uses indirect, verbal and practical education to educate disobedient farmers in to understanding the effectiveness of chemical fertilizer usage, as per the standard. Further educating and encouraging the respective field agents, on promoting the standard chemical fertilizer utility behavior. Although, educating a disobedient farmer to be an obedient farmer is proven much effective, through practical transformation. Hence, encouraging education through practical approach, is recommended. Further, more research and emphasis on this avenue and on synergetic approach among sectors as considered in the study is

recommended for further development and sustainability of nations.

Acknowledgement

This research was made possible with a collective effort of many hence, the researchers would like to extend their gratitude to all who have helped in making this research possible. Sri Lanka Information Technology (SLIIT) Business School, Mr Jayaweera, Mr. Ekanayeka, Mr. Rathnayake, Dr. Colombathanthri, Dr. Mohamed Mujahit. Mrs Colombathanthri and Mr Firthows.

Declaration

Funding

This research was partly funded by Sri Lanka Institute of Information Technology (SLIIT), Business School.

Conflict of Interest/Competing Interests

The researchers hereby attest that this study is subjected to no conflict of interest and competing interests.

Availability of Data and Material

The researchers hereby attest that the data and material presented in this study are purely original, and granted on full disclosure from respective parties.

Code Availability

'Not applicable'.

References

- Arthus-Bertrand, Y., M.B., 2011. *GoodPlanet, Desertification*. <https://www.youtube.com/watch?v=w9RxnuBiFbg>
- Bostian, A.A., M L. e. a., 2019. Assessing the productivity consequences of agri-environmental. *Journal of Productivity Analysis*, Volume 53, pp. 141-162.
- Cai, J., X.C.W.Z., 2018. Decomposition of Fertilizer Use Intensity and Its Environmental Risk in China's Grain Production Process. *Sustainability*, Volume 10, p. 498.
- Chen, X.X., L.Z.C., C.Z., 2020. Health risk assessment associated with heavy metal accumulation in wheat after long-term phosphorus fertilizer application. *Environmental Pollution*, 262(0269-7491).
- Data Collection Survey on Agricultural Sector Sri Lanka, F. r., 2019. s.l.: Japan International Cooperation Agency (JICA) Nippon Koei Co., Ltd. Kaihatsu Management Consulting, Inc.
- Dawada, S., V., 2013. The nutritional composition of four rice varieties grown and used in different food preparations in Kasseena-Nankana district. *International Journal of Research in Chemistry and Environment*, 3, pp. 308-315.
- Dharshani, S., 2020. Colombo (western province): Vijaya newspaper limited.

Duchene.O, V.F. a.C., 2017. Intercropping with legume for agroecological cropping systems: Complementarity and facilitation processes and the importance of soil microorganisms. *A review Agriculture, Ecosystems & Environment*, Volume 240, pp. 148-161.

Ekanayake.H.K.J, 2009. The impact of fertilizer subsidy on paddy cultivation in Sri lanka. p. 36.

Gollin.D, H. a. W., 2018. Two Blades of Grass: The Impact of the Green Revolution. *National Bureau of Economic Research Working Paper Series*, Volume 24744.

Hasan.K.Md, S., 2019. Water pollution in Bangladesh and its impact on public health. *Heliyon*, 5(8).

Huang.S, Z.Y. a. H., 2010. Effects of long-term fertilization on corn productivity and its sustainability in an Ultisol of southern China. *Agriculture, Ecosystems & Environment*, 138, 138(1-2), pp. 44-50.

Jayasumana Channa, F.K.A.M.S.S.G.S. a. P.P., 2015. Phosphate fertilizer is a main source of arsenic in areas affected with chronic kidney disease of unknown etiology in Sri Lanka.

Jayatilake.N, M. a. F., 2013. Chronic kidney disease of uncertain aetiology: prevalence and causative factors in a developing country. *BMC Nephrology*, Volume 14, p. 180.

Jayne.S.T, R., 2013. Input subsidy programs in sub-Saharan Africa: a synthesis of recent evidence. *The Journal of International Association of Agricultural Economists*, volume 44, issue 6, 44(6), pp. 547-562.

Karunaratne.S, 2013. s.l.:Dinamina newspaper.

Khan.S, A I. a. K., 2013. Plant-bacteria partnerships for the remediation of hydrocarbon contaminated soils. *Chemosphere*, 90(4), pp. 1317-1332.

Martine.W, 2019. Economic growth, convergence, and agricultural economics. *Agricultural Economics*, 50(51), pp. 7-27.

Morugán-Coronado.A,C. a.G.O., 2014. The impact of land use on biological activity of agriculture soils. An State-of-the-Art In. *EGU General Assembly*, Volume 16.

Ramadas.S, a. K., 2017 Feb. Farmers' suicide and mental disorders perspectives in research.. *International Journal of Community Medicine and Public Health*, 4(2), pp. 300-306..

Ren.H, C.R.Q.P.a.B., 2020. Integrating density and fertilizer management to optimize the accumulation, remobilization, and distribution of biomass and nutrients in summer maize. *Scientific Reports*, Volume 10.

Thomas.G.W, 1996. *Soil pH and Soil Acidity*. 1 ed. s.l.:Soil Science Society of America and American Society of Agronomy.

Tiller.K.G, 1989. Heavy Metals in Soils and their Environmental Significance. *Advances in Soil Science*, Springer, New York, NY, Volume 9, pp. 113-142.

Upekshani.H.A.N, D. W. a. D., 2018. Fertilizer Usage and Land Productivity in Intensively Cultivated. *Tropical Agricultural Research Vol. 30 (1)*: 30(1), pp. 44-55.

Warra, A.M.N., 2020. African perspective of chemical usage in agriculture and horticulture—their impact on human health and environment. *Agrochemicals*

Detection, Treatment and Remediation - Chapter 16, pp. 401-436.

Wessel.R, K.K.O., 2020 September. Psychosocial health of farmers. *European Journal of Public Health*, 30(suppliment _5), p. ckaa166.1026.

Workman.D, 2021. *World's Top Exports*.
http://www.worldstopexports.com/rice-exports-country/

Wu.H.G., 2019. Excessive Application of Fertilizer, Agricultural Non-Point Source Pollution, and Farmers' Policy Choice. *Sustainability*, 11(4).

Xie, T.A.a.R., 2015. Does Agriculture Really Matter for Economic Growth in Developing Countries?. *Canadian Journal of Agricultural Economics*, 63, p. 77-99.

Zhang.Y, L.W.L.M.C.Z.a.J., 2020. The hidden mechanism of chemical fertiliser overuse in rural China. *Habitat International*, Volume 102.

Appendix

Literature review references strategy diagram

