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Policy Research in the Area of Agriculture Labour Markets

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This report is a consultancy assignment undertaken by the Institute of Policy Studies of Sri Lanka[1] for the Agriculture Sector Modernization Project (ASMP) of the Ministry of Agriculture.

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Contents

List of Abbreviations

A/L	Advanced Level
ADB	Asia Development Bank
AI	Artificial Intelligence
ALS2020	Agriculture Labour Survey in 2020
AMDP	Accelerated Mahaweli Development Programme
AP	Agricultural Productivity
ARTI	Agrarian Research and Training Institute
ASMP	Agriculture Sector Modernization Project
BOI	Board of Investment
BOS	Business Outlook Survey
CBSL	Central Bank Sri Lanka
CIC	Chemical Industries Colombo
CRIB	Credit Information Bureau of Sri Lanka
DAD	Department of Agrarian Development
DAEO	District Agricultural Extension Officers
DCS	Department of Census and Statistics
DL	Dry zone, low country
DOA	Department of Agriculture
DSD	Divisional Secretariat Divisions
EDB	Export Development Board
FAO	Food and Agriculture Organization
FCRDI	Field Crop Research and Development Institute
FGD	Focus Group Discussion
FMRC	Farm Mechanization Research Center
FMTC	Farm Mechanization and Training Centre
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GND	Grama Niladhari Divisions
GOSL	Government of Sri Lanka
HAH	Hayleys Agriculture Holdings
HARTI	Hector Kobbekaduwa Agrarian Research and Training Institute
HH	Household
HIES	Household Income and Expenditure Survey
HoH	Head of the Household
HORDI	Horticultural Crop Research & Development

ICT	Information Communication Technology
ICTA	Information and Communication Technology Agency
IDB	Industrial Development Board
IFAD	International Fund for Agriculture Development
IL	Intermediate low country
IM	Intermediate zone mid country
IPS	Institute of Policy Studies
ITI	Industrial Technology Institute
IU	Intermediate zone up country
KII	Key Informant Interview
LFPR	Labour Force Participation Rate
LKR	Sri Lankan Rupees
LP	Labour Productivity
MDP	Mahaweli Development Programme
MNP	Multinomial Probit Model
MOA	Ministry of Agriculture
MoIC	Ministry of Industry and Commerce
MoF	Ministry of Finance
NARP	National Agriculture Research Policy
NDC	National Development council working group on Agricultural Policy
NEDA	National Enterprise Development Authority
NELM	New Economics of Labour Migration
NGO	Non-Governmental Organization
NHREP	National Human Resources and Employment Policy
NIPHM	National Institute of Postharvest Management
AAIB	Agriculture and Agrarian Insurance Board
NRMC	Natural Resource Management Centre
NVQ	National Vocation Qualification
OECD	Organisation for Economic Co-operation and Development
OFC	Other Field Crops
OLS	Ordinary Least Squares
PPP	Public Private Partnership
R&D	Research and Development
RQ	Research Question
S&T	Science and Technology
SAPP	Smallholder Agribusiness Partnership Programme

SED	Small Enterprise Development Division
SLBFE	Sri Lanka Bureau of Foreign Employment
SLCARP	Sri Lanka Council for Agricultural Research Policy
SLINTECH	Sri Lanka Institute of Nanotechnology
SLSIC	Sri Lanka Standardized Industrial Classification
SME	Small and Medium Enterprise
SOFA	State of Food and Agriculture
SSC	Secondary School Certificate
TEVT	Technical Education & Vocational Training Centres
TFP	Total Factor Productivity
TOR	Terms of Reference
TRCSL	Telecommunications Regulatory Commission of Sri Lanka
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WL	Wet zone, low country
WM	Wet zone, mid country
WU	Wet upcountry

Chapter 1: Introduction

Agriculture has traditionally been an important sector in the Sri Lankan economy accounting for the largest share of GDP and employment. Nevertheless, structural transformation to the economy has resulted in uneven dynamics in agriculture, where the drop in contribution of agriculture to the GDP is greater than the drop in the share of labour force employed in agriculture. For instance, the share of agriculture in GDP declined from 27.1 percent in 1971 to 7 percent in 2019, while the corresponding drop employment in agriculture was smaller (48.8 percent in 1971 to 25.3 percent in 2019). This retention of a considerable proportion of labour force for a relatively smaller share of GDP reflects efficiency and productivity issues in the agriculture sector. As such, among the three sectors – agriculture, manufacturing and services, agriculture records the lowest labour productivity in Sri Lanka in 2017 at LKR 192.87 per hour worked (CBSL, 2019). Similarly, agricultural productivity has remained low in Sri Lanka. For instance, CBSL (2019, p 60) highlights that "although the agriculture sector has undergone considerable transformation and improvements in response to green revolution practices, productivity levels have been stagnant in recent years. Moreover, in 2019, the agriculture sector contributed for only 1.8 percent of the GDP growth of the economy and recorded a sectoral growth of 0.6 percent. Summarizing such low performance trends in agriculture and agricultural labour productivity, literature notes that in recent years the contribution by as well as the growth of agriculture to the Sri Lankan economy have been the smallest and slowest, respectively (Weerahewa, Thibbotuwawa, & Samaratunga, 2015).

Such low performance in agricultural labour and agricultural productivity is mainly attributed to issues such as small farm sizes, high initial capital costs, slow adaptation to modern technology and inadequate willingness of farmers to purchase or use equipment collectively (Weerahewa J. , 2017). Reasons for such low technical transformation in agriculture is intertwined with the composition of the labour force in agriculture and their affinity and human capital capacity to adopt new technology, lack of financial and other resources to adopt new technology and the sub optimal research and development culture for agriculture in Sri Lanka. Current estimates indicate that agriculture labour force is predominantly consisting of older male cohorts, and it remains less attractive to youth and females. For instance, during the third quarter in 2019, out of total hours per week actually worked by workers in agriculture, forestry and fishing, those in the age group of 40 – 49 years accounted for 34 percent and those above 55 years accounted for 31 percent (DCS, 2019). Similarly, out of all engaged in agriculture, forestry and fishing

65 percent are males (DCS, 2019). In terms of the household size and related labour supply within household, the agricultural households are consistent with all households in Sri Lanka. For instance, in 2016, when the average household size in Sri Lanka was 3.8 individuals per household (DCS, 2016), the average size of agricultural households in 2017 was also 3.8 individuals per household (DCS, 2017). This confirms that at the household level agricultural labour supply is consistent with the overall labour supply within households. Moreover, the male share of 65 percent in agriculture is similar to 68 percent male share in industry and 66 percent in the service sectors. As such, the high involvement of males is not unique to the agriculture sector in Sri Lanka. Rather, it is more likely due to the overall low labour force participation of females in Sri Lanka. Similarly, low involvement of 9 percent of 20-29 year group is consistent with the shares of 8 percent and 6 percent, of industry and services sectors, respectively.

Despite being similar to other sectors in terms of characteristics of labour force in agriculture, the issue is the relatively lower productivity and contribution of the agriculture sector compared to other sectors. As such, an in-depth understanding of agriculture labour market is important to identify knowledge gaps and policy and regulatory inconsistencies to facilitate adjustments, reforms, and new policies to usher in competitiveness, responsiveness to market demand, and sustainability and resilience of the agriculture sector.

1.1 Objectives and scope

Against this backdrop, the goal of the proposed study is to adjust/influence the agriculture labour market in Sri Lanka to modernize the agriculture sector via productivity and efficiency growth. In order to reach these overall goals the objective it is important to identify areas in the agriculture labour market for adjustments to facilitate agriculture modernization. As per the Terms of Reference (TOR) provided by Ministry of Agriculture and the Agriculture Sector Modernisation Project (ASMP) the specific objectives of this study is to develop (1) an assessment of the age profile of agricultural labor force of Sri Lanka by sector, by gender and by geographical regions; (2) a review of previous studies showing why the agriculture sector is no longer attractive for youth and propose suitable mechanisms that can be adopted to attract youth to the agriculture sector; (3) assess the effect of aging labor force, worker out-migration, part time farming & agricultural mechanization on labor & agriculture productivity and measures to improve the situation with regional country experience; and (4) a detail analysis of farm mechanization in Sri Lanka including readiness and barriers for mechanization and involvement of farmer organization or operating customer hiring centers in the farm

mechanization process and success stories with respect to mechanization in regional countries.

Based on these objectives, the study aims to propose suitable policy measures with appropriate strategies and the details of responsible authorities to implement such measures, to improve the competitiveness of agriculture by attracting more youth and female participation. Similarly, the study aims to recommend appropriate policy instruments that the Government could use to implement the proposed policy changes to improve agriculture sector competitiveness & sustainability, identify the implementing authorities and the procedure to be followed, in order to make policy changes/policy formulation a reality.

To achieve these objectives this study answers the following four research questions:

RQ1. What is the profile of agriculture labour force?
RQ2. How to improve attractiveness of agriculture for youth and female workers?
RQ3. How to improve labour and agriculture productivity?
RQ4. How to improve farm mechanization?

In terms of agricultural products, the scope of the study is limited to paddy and other agricultural crops. These other agricultural crops are paddy, other cereals, legumes, fruits, vegetables, oil crops, roots and tubers, condiments and spices and high value cash crops. In terms of agricultural activities, the scope of this study includes activities from land preparation to produce exiting the farm gate.

1.2 Conceptual Framework

Success of the agriculture sector depends on the optimal combination of factors of production – land, labour, capital and entrepreneurship, in the context of appropriate support from the government through strong institutions, solid policies and necessary support mechanisms. To achieve such success, Sri Lanka aims to modernize the agriculture sector by way of various channels, and modernization through agriculture labour is one thrust area identified by the ASMP. As such, this study focuses on agricultural labour to identify strategies to modernize agriculture sector in Sri Lanka. In doing so, it is important to identify the profile of agricultural workers in Sri Lanka. Hence, this study involves a detailed analysis of the profile of agriculture workers mainly along the dimensions of age and gender and examines reasons behind the reluctance of groups such as youth and females to engage in agriculture.

The characteristics of the agricultural labour force influences the type of technology and level of mechanization adopted. At the same time, the combination of labour, mechanization and technology determine the productivity in agriculture. As such, this study examines the inter-relationship between labour inputs, mechanization and productivity in agriculture sector in Sri Lanka.

In approaching agriculture labour, the study pays homage to the fluidity between individuals and households, as well as household production and consumption, and adopts analytical elements relevant to individuals, households as well as firms. Thus, the study conceptualizes agricultural households as economic units that perform the combined functions of producing agricultural output, and coordinating consumption and labour supply of its members. The decision of household members to participate in agriculture labour is approached from the neoclassical theory of labour supply, where utility maximizing individuals allocate their time between labour and leisure, subject to a time endowment to maximize utility (Varian 1992, pp. 95-113, 144-146; Blundell and MaCurdy 1999). In the labour supply decision and the calculation of utility maximization, multitude of interrelated factors contribute to an individuals' decisions to supply labor at various points in their life as they evaluate the expected return to market work relative to non-participation.

As per the job search theory, individuals would supply labour only if the market wage offered is higher than their reservation wage. Literature shows that immature and inexperienced new entrants to the labour market have very high expectations and high reservation wages, which inhibit them from accepting most employment offers available in the market. Nevertheless, with maturity and greater length of time spent unemployed, such high reservation wage decrease over time along with their expectations adjusted in line with the reality in the Sri Lankan labour market.

In addition to wages, other factors that affect the supply labour decision in a utility maximization setting include returns to education, skills and experience, nature of work (white collar or blue-collar work), stage in life and household characteristics such as household size and structure, and income etc. Empirical evidence in Sri Lanka suggests that relatively low opportunity cost for education promotes those with higher ability to acquire more years of education, and thus those with high levels of education, skills and experience are less likely to resort to engage in agriculture due to its low average productivity and related low earnings, especially in the context of high dependency of agriculture income on favourable weather conditions. At the same time, those who are depending on parents, with no dependents themselves, are more likely to be economically inactive with higher reservation wages. Additionally, cultural

characteristics of the paternal patriarchal society in Sri Lanka further add a disproportionate burden on females for care and domestic activities. As such, females prefer for economic inactivity or economic activity that enable them to balance home and work-related activities in a seamless manner. Moreover, literature indicates that children's occupational choices have a strong positive correlation with parents' (Black & Devereux, 2011). At the same time there is a tendency for parents' preference and expectation for their children to do better than themselves. In the case of parents involved in agriculture in Sri Lanka, there is a strong parental preference of farmer parents for their children to not be engaged in agriculture. The socio-economic situation of the household would also influence the decision to involve in agriculture. For instance, in better off families in rural areas, young adults and females can afford to be economically inactive. At the same time, there is an emerging trend of youth from well off/urban families to become aware about sustainability, good food habits, growing your own food etc. and using rural land inherited from parents to cultivate crops as a part-time endeavor.

Additionally, in Sri Lanka, there are many push factors that discourage workers to engage in the field. For instance, lack of access or restricted access to land restricts farmers from mechanizing their activities, and inadequate poor transportation networks limits them from connecting to the agriculture supply chains. At the same time, credit constraints limit them from expanding or increasing productivity by mechanization or adopting modern technologies, while the presence of uncertainty and risk due to weather and natural disaster further pushes workers away from agriculture. Nevertheless, in the case of females, agriculture possesses pull factors in terms of ability to combine household work schedule with agricultural work schedule and the possibility for part time farming. At the same time, the relatively lower level of risk and uncertainty due to weather and natural disasters in non-agriculture activities serve as pull factors to attract towards these alternative jobs. In trying to maximize utility, in the context of this study, individuals have three choices available. They are to be (i) economically inactive, (ii) economically active in agriculture, or (iii) economically active in non-agriculture. The push and pull factors of each alternative and the individual and household level factors influence one's choice among the three alternatives. The analysis of the attractiveness agriculture examines what determines females' and youth's choice of economic activity.

The assumed ability of the labour market to absorb any excess labour in the household and provide hired labour for shortage of family labour, forms the basis for the decisions to engage in farm versus off farm activities, to use hired versus family labour, use male versus female workers, and use mature versus young workers. While some workers are pulled towards agriculture work some are pushed away towards other occupations. The resulting labour shortage in agriculture can be addressed by adopting modern methods,

machinery and equipment. As such, characteristics of labour influence the level and barriers for mechanization, while labour and mechanization together influence productivity. Hence, by understanding the profile of agriculture workers and identifying strategies to improve the attractiveness of agriculture for employment, the sector can sustain with the involvement of the appropriate labour force, that can improve mechanization and productivity of the sector.

Mechanization and productivity of agriculture sector is analyzed in this study by enhancing the theory of household decision making with household production function (Becker 1965, (Huffman, 2010). Households maximize a discounted future stream of expected utility from a combination of consumption goods produced at home and purchased in the market, and leisure, subject to a set of constraints, such as cash income, family time and endowments of fixed productive assets, and production technologies (Taylor & Adelman, 2003). In household-farm models the household budget is endogenous and varies based on the production decisions, and influences farm income and profits. When analyzed from this analytical view point, production aspects and profit maximizing motives of the households determine what crops to cultivate, method of cultivation, level of mechanization, and technology adoption etc., which influence their agricultural and labour productivity and profitability.

By understanding the level, barriers, readiness of the agriculture workers towards mechanization and the determinants of mechanization, labour related strategies are developed to improve mechanization. Similarly, by understanding the inter-relationship between labour characteristics such as age, migration and part time farming, mechanization, and productivity, strategies and recommendations are developed to improve productivity in agriculture. The combined identification of such strategies, recommendations, and relevant institutions to carry out these activities are carried out with the intention to contribute towards the improvement of the competitiveness of the agriculture sector in Sri Lanka.

1.3 Theoretical Framework

The broad objective of the larger ASMP is to modernize the agriculture sector in Sri Lanka. In this effort, a key focus area is agriculture labour, as all efforts for modernization finally converges to the farmers and various agricultural workers working hands on in agriculture. The manner in which agricultural workers combine labour, machines, equipment and technology would influence their productivity and profit margins. By adopting the optimal combinations of labour, machines, equipment and technology, the level of mechanization, productivity and profitability would improve, leading towards

modernization of the sector. As such, this theory and framework of analysis focus on the nexus between agriculture labour, mechanization and productivity, starting from agricultural households as the source of supply of agriculture labour.

Agricultural households are dissimilar to traditional households considered in economic analysis. In farm households, some of the commodities consumed by agricultural households are self-produced, while part of all of the labour used in the farm are supplied by the household. Hence, agriculture households perform the combined the functions of producing agricultural output, and coordinating consumption and labour supply of its members. As such, agricultural households include a continuum of households ranging from purely subsistence, which consume all of their output and do not buy or sell labour in the market, to commercial farming households, which sell their entire output produced using family (and sometimes hired) labour (Strauss, 1984). In this context, the analysis of agricultural households needs to factor in the interdependence between household production and consumption, and thereby combined firms as well as households in the analysis. Due to this dual role - as producer and consumer, the household decisions in terms of production, labor allocation and consumption are likely to be interdependent. The objective of the household is to maximize a discounted future stream of expected utility (from a list of consumption goods produced at home and purchased in the market, and leisure), subject to a set of constraints, such as cash income, family time and endowments of fixed productive assets, and production technologies (Taylor & Adelman, 2003). The solution to the household-farm model represents all endogenous variables as functions of exogenous variables (prices of tradable, farm assets, household time constraint, other household characteristics, policies). These interactions between production and consumption are highly sensitive to underlying assumptions concerning the level of integration of the household with the product and factor markets. In household-farm models the household budget is endogenous and varies based on the production decisions, which influence farm income and profits. As such, in addition to the standard Slutsky effects of the consumer model applicable to traditional households, agricultural household models have an extra "farm profit" effect (Taylor & Adelman, 2003). This basic farm household model can be applied to aspects such as off-farm labor supply, migration, and technology adoption, which are focused in this study.

The decision to participate in agriculture labour is based on the fundamental models of labor supply decisions of household members. The neoclassical demand theory is enhanced by adding leisure time to the list of goods that a household consumes and adult human time endowments as a resource constraint (between leisure and work for pay) (Varian, 1992, pp. 95-113, 144-146; Blundell & Macurdy, 1999). This incorporates the opportunity cost of time into household decision making. Further enhancing this the

household production function is added to the theory of household decision making which combines the theory of the firm on household decisions, including the demand for food and supply of labor (Becker G. , 1965). Given the assumed ability of the labour market to provide jobs to any excess labour in the household as well as a source of hired labour for shortage of family labour, allows the household optimization problem to be solved in two steps – profit maximizing farm input and output, and maximize unified utility by deciding how much family labour is supplied to farm and off farm activities, and how much labour is hired from the market. Thus, those working on agriculture related activities are considered agricultural labour supply.

The theoretical discussion on agriculture labour can be traced far back. In the Classical Lewis model (1958) the dual economy the modern sector is identified with industry , while the traditional sector is identified with agriculture, while commercial agriculture fits Lewis' definitions of "modern". In Lewis' traditional subsistence sector there was an "unlimited" with thus potentially "perfectly elastic supply of labor to the capitalist sector at a fixed wage" (Gollin, 2014). In the neoclassical model of economic development, labor is never redundant due to the underlying assumption of positive labor productivity in the agricultural sector.

Agriculture labour involves many types. Based on their involvement to the farmer agricultural workers can mainly be identified as family labour and hired labour. In the case of agriculture labour that is traded in the agriculture labour market, literature identifies two main groups. Eswaran and Kotwal (1985) identifies permanent workers (alternatively referred to as tied laborers, estate laborers, farm servants, or attached workers), and casual workers. Additionally, there are other types of farm workers such as sharecroppers or tenant farmers. Two important groups of agricultural workers are female and youth. In female agriculture labour three aspects of the general analysis of the family has been influential (i) conceptualization of the unified family as a coordinator of the production and consumption of a group of persons over an extended period of the life cycle, constrained by the pool of household endowments (Becker G. , 1981; Becker G. , 1965); (ii) role of separability of production and consumption decisions in the agriculture household (Barnum & Squire, 1979; Singh, Squire, & Strauss, 1986); and (iii) the individualistic bargaining or collective coordination of the family that preserves the distinct endowments of the individual and the expression of the possible differences in personal preferences (Schultz T. P., 1999). In the case of youth, their heterogeneity and diversity are important. As a social category youth suffers from assumptions and knowledge gaps, and there is wide heterogeniety within youth in terms of age differences, gender, related backgrounds and norms, abilities and opportunities

(Rhiannon Pyburn, Dido, Quiroga, & Flink, 2015). As such the involvement of youth in agriculture is influenced by many diverse factors.

Common issues found with agricultural workers in unemployment or underemployment due to the absence of continuous work in agriculture and the seasonal nature of activities. The associated low income is often resulting in mobility of agricultural workers in search of alternative activities. Such mobility can be theorized along livelihood diversification motive, where push and pull factors influence agricultural workers to transition out. The push factors away from farm work include the performance of agriculture, risk and uncertainty, incomplete markets for factors, missing or incomplete land, credit, and insurance markets push (Bezu & Holden, 2014). The pull factors include earnings from non-agriculturale employment. The trade-off between the returns from farm versus off farm income would determine who remains in agriculture. In rural areas where there is a strong and vibrant non-farm sector rural resident would diversify into the off-farm activities, while still remaining in the area - some would become part time farmers. From areas where there is few off farm employment opportunities high levels of outmigration can be experienced.

Early theories on migration focused on push - population growth, land scarcity and enclosure (Ravenstein, 1885; Redford, 1927), and pull factors - rapid development in manufacturing (Engels, 1845), for rural rural-to-urban migration. Later Lewis' (1954) seminal work laid the foundation for neoclassical two sector model to analyze the reallocation of excess labour supply in rural agriculture sector by the modern sector in urban areas. The classical model assumed that labour is available in the industrial sector in unlimited quantities at a fixed real wage, while in the rural sector there is redundant labour of which the marginal product is zero, which thus can be reallocated to the urban sector without sacrificing any loss in agriculture output (Taylor & Martin, Human Capital:Migration and Rural Population Change, 2001). At the micro level in neoclassical theories on rural to urban migration are based on maximization of expected income. Todaro (1969) explains the continuation and frequently acceleration of rural to urban migration in the context of high and rising urban unemployment, due to its consideration of the wages or income in the context of the probability of finding employment in urban areas. As highlighted by Todaro (1980. , p. 377) "migrants typically do not represent a random sample of the overall population". The selectivity in migrants is theoretically tackled by the human-capital migration models (i.e. Sjaastad (1962).

The theoretical framework of a household /family in migration decision making process was initiated with New Economics of Labour Migation (NELM). By bringing in the household level decision making the NELM connected migration to various other issues

in rural areas such as risk, market imperfections and related constraints (Taylor & Martin, Human Capital:Migration and Rural Population Change, 2001). For instance, addressing market imperfections in terms of access to credit and insurance, migration allows families to place one family member in a region where the risk structure in the labour market is uncorrelated with farm production, so that remittances from the migrant acts as an insurance mechanism to downturn in farm production. At the same time, the remittances from the migrant provides the required credit to transition from familial to commercial production, as well as adopt new technology in agriculture (Stark, 1982).

In the context of various employment situations of members in agricultural household - such as full-time farming, part time farming, rural off farm employment and out migration, investments towards agriculture is a result of combination of income from farm and off farm activities. The combination of agriculture labour and investments determine productivity in agriculture. Agriculture production and related productivity need to factor in specificities of agriculture productions, due to its unique features. These include the involvement of a large number of small farmers, implications due to the interplay between the biological nature of the output and its exposure to widely varying and unpredictable elements of nature, use of a significant volume of inputs from the farm itself. As such, early ideas of agriculture were associated with low productivity. For instance, unlike the more "modern" sectors agriculture was identified with low productivity, with a large pool of cheap labor (Clark 1951; Lewis 1954; Kuznets 1955; Chenery and Syrquin 1975). (Fuglie, Gautam, Goyal, & Maloney, 2020).

Against this backdrop, Schultz (1964) showed this link between agriculture labour and investment as farmers are rational decision-makers who maximize the returns from the resources at their command and respond to incentives. Hence, Schultz theory highlighted the importance of making inputs available to farmers, increasing the capacity of industry to supply inputs, generating new local specific knowledge, and improving education about new technologies through extension services. Hayami's and Ruttan's (1971) furher developed Schultz theory by showing the role of the government in agricultural research, which is a public good. Their model of induced innovation explains the factor bias of technological change, and shows that changes in relative factor scarcities and related changes in factor prices lead to technological advances to save the relatively more expensive factor, and the government is required to react to resource endowments and market signals and provide support for research. As such, viewed as a public good agricultural research and development (R&D) and its capacity to produce more productive technologies triggered the Green Revolution, that led to the development and adoption of new technologies, including High-Yielding Varieties (HYVs) of cereals, chemical fertilizers, agrochemicals, controlled water-supply, and newer methods

of cultivation using mechanization. Together, these developments are referred to as a 'package of practices' to replace 'traditional' technology (Kerr, 2012; Dethier & Effenberger, 2011).

"Productivity is commonly defined as a ratio of a volume measure of output to a volume measure of input use" (OECD, 2001)). Agricultural productivity is measured as output per hectare or per worker (Fuglie, Gautam, Goyal, & Maloney, 2020).Nevertheless, when farmers are involved in producing multiple agricultural outputs using many agricultural inputs, it is important to adopt common units of measurement for outputs and inputs. FAO (2017, pp 40, 42), notes that "putting a monetary value on the respective output allows aggregating the output of different crops and products", while "inputs also must be aggregated, generally by converting them to monetary units". "Labour productivity in agriculture measures the number of units of output(s) produced per unit of labour used in the process of production " (FAO, 2017). Alternatively, Total factor productivity (TFP) is the efficiency with which these inputs are combined to produce output. These productivity measurements are rooted within the theory of the firm in microeconomics. This theory under assumptions shows that scarce resources are optimally allocated as inputs, which enables firms to either maximize profits subject to a cost constraint or to minimize costs subject to an output constraint. Both approaches lead to efficient or optimal allocation of inputs. Productivity increase in general is the increase in output from a given level of inputs. Such productivity increases may take place either due to an improvement in the technical efficiency with, which the inputs are used due to an innovative technology (Fulginiti & Perrin, 1993).

As highlighted by Diao, Silver, and Takeshima (2016, p. 7) "mechanization is a key component of the technology that allows agricultural production to be intensified". With the increased demand for agricultural products often existing land has to be cultivated more intensively, often with the help of mechanization. As per Diao, Silver, and Takeshima (2016) demand for mechanization, can be explained by applying the induced technical change framework developed by Hayami and Ruttan (1970, 1985). The induced technical change model emphasizes agricultural technology innovation and adoption as a continuous sequence often biased toward saving the limiting factor – land or labor. The induced technical change framework views the development and adoption of alternative agricultural technologies as a means to facilitate the substitution of relatively abundant and therefore cheap factors for relatively scarce and thus expensive factors. Therefore, mechanical technology substitutes for labor and biological and chemical technology substitute for land (Diao, Silver, & Takeshima, 2016).

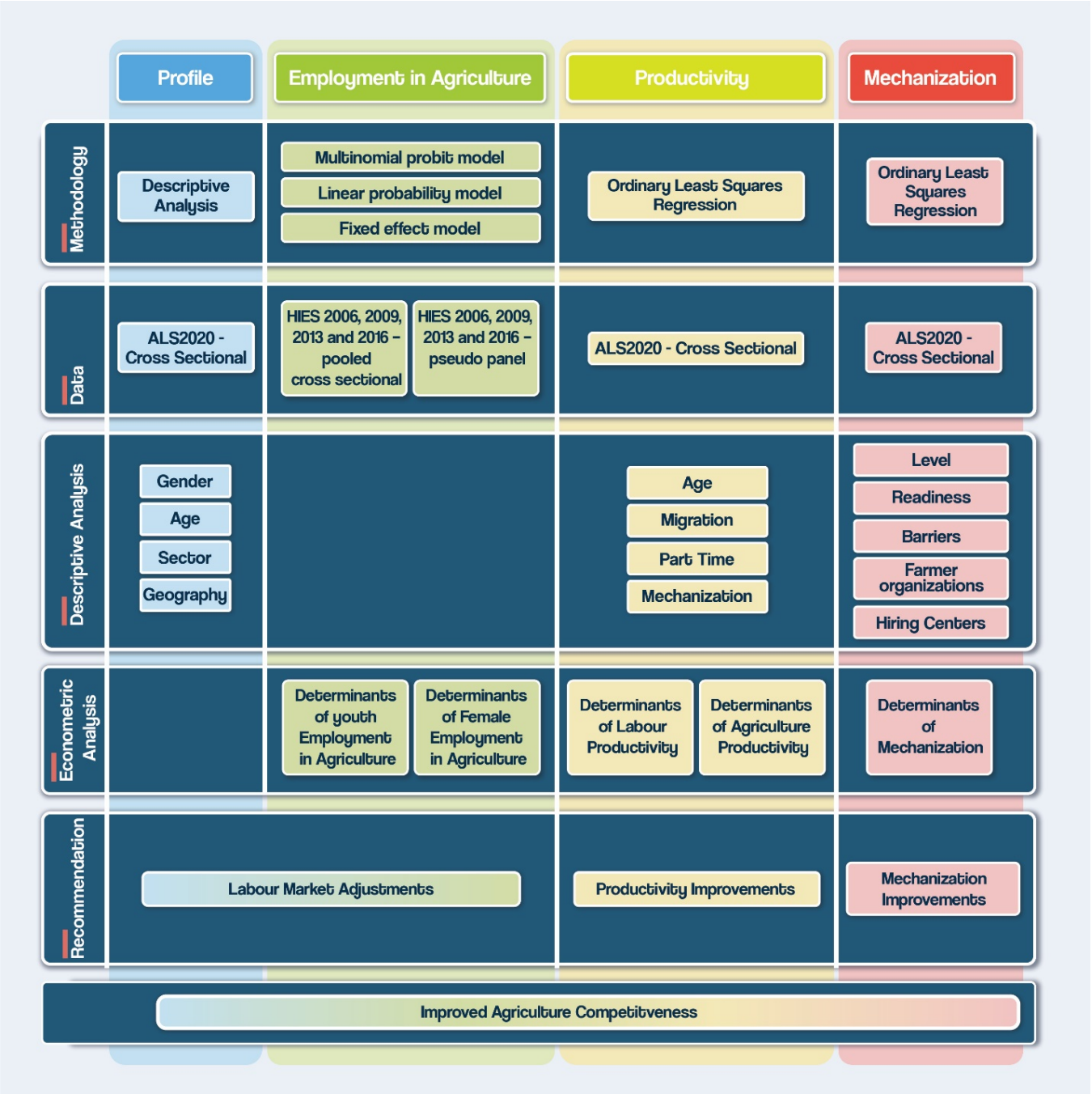
1.4 Analytical Framework

The analytical framework of the study is a Concurrent Mixed Method, where qualitative and quantitative data are collected at the same time and integrated for the overall analysis. This Concurrent Mixed Method approach adds breadth and depth to the analysis resulting in a comprehensive study, where limitation of each type of analysis– qualitative and quantitative, is compensated by the other. The quantitative data includes both primary and secondary data. The primary data source is a field sample survey conducted for this study called the Agriculture Labour Survey in 2020 (ALS2020). Secondary data sources include the last four rounds (2006, 2009, 2013 and 2016) of the Household Income and Expenditure Survey (HIES) conducted by the Department of Census and Statistics. Qualitative data is collected in Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs).

The profile of agriculture workers is developed using primary data collected from ALS2020 using a descriptive analysis methodology. In the analysis of attractiveness of agriculture employment for youth and females, the unit of analysis is individual and the outcome considered is the probability of employment in agriculture. Here two variations are adopted where initially all four rounds of HIES data is pooled together and Multinomial Probit Models are estimated to examine the determinants of employment in agriculture among alternative economic activities of non-agriculture employment and economic inactivity. Subsequently, by pooled Ordinary Least Squares (OLS) models are established for the economically active population. Finally, Fixed Effect linear probability models are estimated by creating a pseudo panel data structure with the four rounds of the HIES data by following cohorts over time. The cohorts for the analysis of youth employment is based on birth year, bi-annual birth period, and gender, identified as birth-gender cohorts. For the female employment analysis cohorts are created based on birth year. In analyzing the determinants of productivity (both labour productivity and agricultural productivity), the unit of analysis is household, thus household level cross sectional data from ALS2020 is used in an OLS regression. In the analysis of mechanization, a descriptive analysis is followed by a quantitative analysis of determinants of mechanization. The unit of analysis in the model for determinants of mechanization is the household. In all analyses the determinant includes vectors of human resource variables, capital and knowledge variable, and natural resource variables, with minor variations depending on the outcome variable considered. The findings from all quantitative analyses are triangulated with findings from qualitative data.

The remainder of this report is structured as follows. Chapter 2 outlines the policy context in the agriculture sector in Sri Lanka under early years and recent period followed by the influence of the overall public policy on agriculture. Chapter 3 covers the review of previous literature, which starts with literature on Sri Lanka, which includes a detailed analysis of agricultural labour, and the attractiveness for youth and female employment, followed by the nexus between worker out migration and part time farming in agriculture. The remainder of the literature review draws on regional experiences. Chapter 4 presents the two data sources used in the analysis and the methodologies adopted in the empirical analysis. The analysis starts with Chapter 5 which develops the profile of agriculture workers in Sri Lanka with special focus on age and gender. Chapter 6 focuses on the analysis on the attractiveness of agriculture for youth and females, while Chapter 7 focuses on productivity, followed by the analysis on mechanization in Chapter 8. Chapter 9 concludes the report with a synthesis of findings and recommendations.

Figure 2-1: Overview of the analytical framework



Source: Authors

Chapter 2 : Policy Evolution

Currently, there are several sectoral and sub-sectoral policies and strategies covering agricultural activities focused in this study. Among them, the key is the National Agriculture Policy (2007), which aims to assure food security, ensuring environmental sustainability and developing economic opportunity. Other such policies include the National Land Use Policy (2007), the National Policy and Strategy on Cleaner Production for the Agriculture Sector (2012), and the National Agricultural Research Policy and Strategy 2018-2027 (2018). Additionally, some national policy and strategy documents such as the New Trade Policy (2017), the National Policy on Sustainable Consumption and Development (2018), the National Export Strategy (2018) and the Public Investment Programme (PIP) are important (Ministry of Agriculture, 2019). The remainder of this section examines the policy evolution in agriculture before and after 2010.

2.1 Early Years

History of Agricultural Policy in Sri Lanka is coherently documented by Thibbotuwawa (2019a) as a self-sufficient economy, consisting mainly of a peasant agricultural sector with minimal international trade before the British colonial rule in 1815. During this period, the British interest to establish an export agricultural sector, made of large plantations, resulted in the Crown Land Ordinance of 1840 and a corresponding land acquisition campaign by the then government (IPS, 2004). The allocation of land acquired under the Crown Land Ordinance and the corresponding emphasis on developing plantations, led to a rapid rise in the land area used for the plantation sector. At the same time, the meagre market surplus, deteriorating prices, and stagnation in the context of growing availability of cheaper imported food, made the domestic agriculture sector laggard compared to the export-oriented plantation sector (Samaratunga P. , 2011). As a result, the export earnings from the plantation sector in Sri Lanka made an increasingly important contribution to the Gross Domestic Production (GDP) of the economy, while the contribution of the domestic agriculture sector continued to shrink (Thibbotuwawa, 2019a). This trend continued till the introduction of the Land Development Ordinance in 1935.

The underlying philosophy of the Land Development Ordinance of 1935 was rural development and the preservation of the peasantry. The strategy was essentially indigenous and was not based on any western models of the time. Although there was not much emphasis on economic growth per se, there was a greater preoccupation with

the general upliftment of the majority of Sri Lankan people, namely the peasants in their rural habitats and hence, it favoured a home-grown, egalitarian, rural development model (Land Commission, 1990). It provided for the appointment of a Land Commissioner, thereby paving the way for the establishment of the Land Commissioner's Department which was charged with the responsibility of administration, protection, alienation and development of all State lands and the provision of the administrative machinery through which the Government acted on matters pertaining to land. This attempt was further reinforced by a series of related legislation such as the Land Settlement Ordinance of 1931 and the Crown Lands Ordinance of 1947. Many large-scale irrigation projects for the rehabilitation of ancient irrigation structures, in areas such as Minneriya and Minipe, were carried out. Similarly, irrigation structures, such as the Gal Oya tank, were developed. Despite the weaknesses in the operation, a larger proportion of State lands passed into the possession of many landless families, including the middle class, through the Land Development Ordinance. However, as it was unable to keep pace with the increasing population and the concomitant demand for land, the impact of land settlement schemes in the Dry Zone based on the Land Development Ordinance had relatively little impact on the problems of congestion and landlessness in the Wet Zone villages. Nevertheless, this initiative, together with price hikes in imported food during the World War II, created a conducive environment for the growth in domestic agriculture sector in Sri Lanka (Samaratunga P. , 2011).

In the post-independence period, the domestic food production sector experienced growth, as a result of continued land development activities and support prices for rice. For instance, in the late 1960s, the Mahaweli Development Programme (MDP) and subsequently in the 1980s, the Accelerated Mahaweli Development Programme (AMDP) played a key role in land development of the country. Specifically, as part of the AMDP, nearly 320,000 acres of new lands were made available for around 90,000 farm families, to settle in the Dry Zone (Herath J. , 2006). Similarly, over one million ha of land was alienated under difference irrigation, settlement and tenure schemes (IPS, 2017). At the same time, the continuous increase in prices of imported food also contributed to this growth of the domestic food production sector in Sri Lanka (Thibbotuwawa, 2019a). During the 1960s, the government agricultural policy strategy was more oriented towards import substitution and restrictions of imports. Main strategic thrust in this period was supply side policies based on introducing 'green revolution' technologies along with irrigated land development, which were aimed at achieving 'self-sufficiency' in paddy and other major food crops. In this policy context, one specific strategy adopted is periodic price support for domestic food crops, which in turn further contributed

towards the growth of the domestic food production sector. Nevertheless, the growth in the domestic food production sector was insufficient to alleviate the country's food importation burden. Signifying the problem of import dependency of Sri Lanka in terms of agri-food, the food imports bill continued to rise both in absolute terms and relative to the export earnings (Thibbotuwawa, 2019a). The introduction of open economic policies in 1977 ended the import substitution development strategy. The subsequent trade liberalization and the adoption of export development "changed the relative price structure in the domestic agriculture sector and brought about drastic changes in food production and consumption" (Thibbotuwawa, 2019a, p. 221). As a result, by the end of the 21st century, the agricultural sector in Sri Lanka is dualistic in nature, with an export-oriented plantation sector producing tea, rubber, and coconut, and a less commercial and partially market-oriented food crop production sector producing rice, subsidiary food crops, and vegetables and fruits, predominantly as small holdings (IPS, 2016).

2.2 Recent Period: 2010-2020

During 2010-2014, the policy direction in terms of paddy and OFCs aimed at ensuring higher and sustainable income for farmers by ensuring remunerative prices for agricultural produce, farm mechanization, expanding the extent cultivated, reducing post-harvest waste, introduce efficient farm management techniques and high yielding seeds, and improving water management (Department of National Planning, 2010). During 2014-2015, the main areas of public investment in agriculture aimed to focus on developing and distributing seed and planting material, efficient use of water and fertilizer, post-harvest handling, and promoting access to microfinance, technological innovations, and extension services (Department of National Planning, 2013). Additionally, this plan included aims to develop agro-economic zones. Some notable projects implemented during this period included the commercial farm programme - aimed at providing agricultural equipment to commercial farmers on 50 percent farmer contribution basis, and the Youth Agri Mission, which aimed at encouraging unemployed youth population to engage in agriculture. Other projects and programs implemented during this period include Organic Fertilizer Production & Promotion Programme, aimed to produce and promote the usage of organic fertilizer, the Crop Forecasting Programme, and seed production programs for big onions and red onions (Ministry of Agriculture, 2014).

As a result of the change of the government in 2015, the focus of the new policy statement - the Vision 2025, introduced in 2017, aimed at promoting ICT enabled agricultural

extension services to farmers, eliminating information asymmetries and reducing transaction costs along the farmer value chain by encouraging mobile phone-based services (Department of Government Information, 2017). Moreover, the policy emphasis was also on facilitating efficiency in agricultural markets by facilitating crop production and improvement, agribusiness development, establishment of large-scale agro-enterprises, and introduction of high yield crops. The reigning government also aimed to promote private sector participation and PPPs where feasible, expedite the Agriculture Sector Modernisation Project, and transition farmers from purely subsistence agriculture to agri-business. Within this heightened policy interest to modernize the agriculture sector in Sri Lanka, there was interest to update the agriculture policy along smart agriculture and climate resilience practices for farmers (Senarathna, 2019). In keeping with these modernization efforts, Sri Lanka's E-agriculture Strategy was developed in 2016, with the objective of channelling the ICT potential of the country towards goals related to agriculture (Thibbotuwawa, 2019). In this connection, Sri Lanka has set up an e-agriculture task force consisting of officials linked to the Ministry of Agriculture (MOA) and its related departments, as well as the Telecommunications Regulatory Commission of Sri Lanka (TRCSL), Information and Communication Technology Agency (ICTA) and Telecom and ICT providers in Sri Lanka. In addition to this task force, the E-agriculture Strategy also includes a leadership committee, a steering committee to constitute the e-agriculture governance framework. Under this initiative, the Department of Agriculture (DOA), together with other relevant organisations, have launched e-agriculture programmes to disseminate agriculture information via ICT and mobile platforms, software applications, etc., to name a few.

Similarly, the policy direction during this phase also included commercialization with eco-friendly innovative technologies, mainly aimed at a sustainable drive of competitiveness of agriculture and agro-based products in the international market (Department of National Planning, 2017). In this context, the role of the government was aimed to be that of a facilitator and regulator, with minimal involvement in setting input and output prices, with greater emphasis on improving and upgrading agricultural research and development, agricultural extension, and provision and improvement of rural infrastructure. The policy direction also aimed at improving the regulatory environment to ensure fairness in competition and protection from foreign competition, and assisting the improvement of the livelihood of farmers, mainly in the form of cash transfers rather than input-based subsidies. Nevertheless, contrary to this stated policy orientation, the fertilizer subsidy program was implemented during this period. Other programs implemented to achieve these objectives include a project to improve productivity of paddy cultivation, establishment of community seed banks to increase

the availability of quality seeds of popular traditional rice cultivars and planting materials of traditional tuber crops, and productivity improvement in cultivation of specific crops, such as maize, soya, ground nut, and chili (Ministry of Agriculture, Rural Economic Affairs,Livestock, Irrigation, Fisheries and Aquatic Resources Development, 2019). These projects also focused on increasing the availability of quality seeds & planting materials, agri-village entrepreneurship development, and the "Sarupiri Gewaththak" national home gardening project. Moreover, during this time, the National Agriculture Research Policy (NARP), the Fertilizer Regulatory Act, and the Agriculture Sector Modernization Project were implemented (Ministry of Agriculture, Rural Economic Affairs,Livestock, Irrigation, Fisheries and Aquatic Resources Development, 2019).

The agriculture policy direction of the newly elected president in 2019 and government in 2020 is based on agriculture development through advanced technological innovations. Some specific areas targeted in this new policy direction include increase land productivity, modernize agriculture, promote youth entrepreneurship, revolutionize the use of fertilizer, domestic production of seeds and planting materials, modernize packaging, storage, marketing and transportation, and improve research for agricultural innovation (Ministry of Finance, 2020). Along these lines, during 2020, paddy farmers were guaranteed higher price for their products, and the importation of crops that could have been grown locally or those imported for re-export purposes were banned. Additionally, the farmers were provided with required fertilizer free of charge, encouraged to recultivate abandoned land and to produce export crops, such as pepper and cinnamon (Parliament of Sri Lanka, 2020). The future aims of the government currently in power were reiterated during the inaugural speech by the president at the inaugural session of the new parliament in August 2020 (Parliament of Sri Lanka, 2020). These include providing opportunities to generate substantial foreign exchange by providing a stable price to the farmers through value addition to agricultural products and exports, increase the production of organic fertilizer locally, ensure total organic farming in Sri Lanka in the next decade, and improve and encourage modern methods and technology for agriculture.

As seen in the foregone review over the years, the same major policy thrust aimed at achieving self-sufficiency through supply side interventions with the control of imports to manage the demand supply gap in the short run, has been pursed. This policy focus has aimed at addressing the policy priorities set decades ago and addressed partially. Meanwhile, many new challenges have emerged such as stagnating productivity, environmental destruction and growing land scarcity etc., which have not been mainstreamed yet in sufficient scale. Moreover, as highlighted by the Ministry of

Agriculture (2019, p.g. 15), a "number of national policy and strategy documents encompass activities in the agriculture sector". As per the Ministry of Agriculture (2019, p.g. 15), these are not limited to the New Trade Policy (2017), the National Policy on Sustainable Consumption and Development (2018), the National Export Strategy (2018), and the Public Investment Programme (PIP). As such, the policy focus on agriculture labour in Sri Lanka is derived through these and other general labour policies. For instance, the National Human Resources and Employment Policy for Sri Lanka and its revisions (Secretariate for Senior Ministers, n.d., p. 20) identify that "different sub sectors in agriculture pose different human resource issues, requiring different policy responses". This policy notes that there is an "observed reluctance on the part of the youth in the labour force to engage in agricultural jobs of the traditional type" (Secretariate for Senior Ministers, n.d., p. 20). Similarly, the drafted Overarching Agriculture Policy for Sri Lanka (Ministry of Agriculture, 2019) underscores that the agriculture sector struggles to attract youth with better skills, while the small scale of operation is a major constraint in adopting technology driven agriculture, particularly in crops produced and processed in larger volumes, as application of such technologies have distinct scale-economies. In this context, this draft policy notes that to remain competitive and to draw and retain high-skilled human resources, the agriculture sector must create opportunities for large operational holdings complimented by modern technology and mechanization. Echoing these priorities, the NHREP therefore, aims to promote mechanisation, modernisation and productivity improvement of agricultural jobs, with the aim to improve the youth's attraction to agricultural pursuits. Moreover, Secretariate for Senior Ministers (n.d.) recognizes that in most agricultural sub-sectors, future strategies will depend on the expansion of small-scale commercial farming. Therefore, the said policy prioritizes the importance of developing practical and entrepreneurial skills among small farm households, and especially among rural women and the youth.

Similarly, the policy framework of the government that was elected in 2020 hones in on the labour priorities through harnessing the Power of Youth by providing extensive opportunities and incentives for young entrepreneurs, and improving the Economic and social contribution of women by introducing home-based enterprise with required assistance for rural women. Similarly, to harness the knowledge and experience of senior citizens, this policy framework aims to set up a "Voluntary Service Task Force", which would enable the older generations to share their knowledge and experiences with the younger generation.

2.3 Overall Public Policy and its Effect on Agriculture

Following the foregone review of the evolution of agriculture policy in Sri Lanka, this section investigates the impact of overall public policy on the agriculture sector in the country, especially on agriculture labour. As the most part of Sri Lanka's traditional agricultural sector involves informal labour, there is no coherent policy framework pertaining to the regulation of agriculture labour of the country (except for some policies relevant to the plantations sector). However, as explained in this section, most of the policies of the government have had direct and indirect effects on agriculture labour.

Sri Lanka is well known for its public policy which is more inclined towards welfare. With regards to the social welfare policies implemented in the country over the past, the provision of free education and health services is widely accepted as the most crucial one which had long-lasting effects on the country's labour force. As noted by Godamunne (2019), up to the 1930s, free health services as well as minimum wages were provided only to the workers in the plantations sector by their employers, and the main purpose of this was to attract Indian migrants towards work in the plantations. Those workers were also assured of a quantity of rice at a guaranteed price in the Minimum Wage Ordinance. Gradually, the employers were forced to provide hospitals, schools, maternity arrangements, crèches and other amenities to resident workers. All these measures in the British agrarian policy aimed to promote commercial plantations and cash crops. However, while the agriculture policy attempted to promote private enterprise through commercial plantations and private smallholders growing cash crops, the peasant economy was largely neglected. "The land-tenure system, based on the principles of private property, disrupted traditional relationships; the shift to product specialisation led to the emergence of capitalist agricultural relations; and the peasants' tax burden was far higher than that of the more prosperous plantation economy" (Godamunne, 2019, p.g. 15).

In the post-independence period, while the land settlement programmes and land development schemes provided the farmers with the land resource to engage in agriculture, one of the most notable policies formulated in terms of agriculture labour was the 40 Youth Settlement Schemes, which were established between 1966-1969. Amidst the increasing incidence of unemployment, particularly among the educated youth, as well as the limited absorptive capacities in the traditional agriculture and other sectors, these schemes aimed to generate high incomes for the youth, and provide them with adequate incentives to remain in agriculture. The youth was assured a minimum monthly income by the cultivation of profitable food and cash crops on a scientific basis, and ancillary income sources from poultry and livestock were also envisaged. However,

this scheme was abandoned in the 1970s (Sanderatne, 2004). Nevertheless, massive public investments such as the Accelerated Mahaweli Development Project (AMDP) ensured employment in the agriculture sector for many landless peasants.

As agriculture sector has historically harboured the most of the rural and poor community of Sri Lanka, it started to receive a huge attention in the post-independence political arena, especially when designing social welfare policies. Although the education reform in the 1940s was partly driven by the need for educated and skilled labour to run public services, the contemporary political forces demanded education for all. Hence, free education was approved by the State Council in 1945 (Godamunne, 2019) . Following the 1947 constitution which abolished communal representation, the peasantry emerged as the largest group of voters and therefore, social welfare provision and the addressing of rural socioeconomic issues became the focal points for political candidates.

It is argued that one of the main reasons for not seeing a direct impact of free education on agriculture labour was the practice of promoting public sector employment by providing such employment opportunities for political loyalists which largely resulted in moving educated labour out of agriculture. By the early 1970s, unemployment, particularly among educated youth, remained high, and a significant number of these youth were from rural backgrounds, who had reached the Secondary School Certificate (SSC) level. The majority of them were the children of smallholder peasants, wage workers, and small-scale entrepreneurs who sought employment in the public sector, which provides lifetime employment, for job security and to move up the social and economic ladder (Godamunne, 2019).

According to Lakshman (2004), as large proportion of agriculture workers in Sri Lanka is engaged in self-employment, and realizing that the country's unemployment is too large to be completely absorbed by formal sector enterprises, the expansion of the informal sector and self-employment was emphasized in the employment strategies of the following years. However, a main issue in the public policy has been the disparities in the sectoral distribution of investment. In contrast to large-scale industry and modern financial services, investment in agriculture and fisheries, small industrial and other enterprises was limited (Lakshman W. , 2004). Undoubtedly, due to the slow modernization and low investment, agriculture sector continues to be traditional in terms of production technology and therefore, it receives a low value on the scale of social acceptability. Owing to this, there has been an increasing tendency among the young and educated members of the labour force to abandon agriculture under prevailing social conditions. Hence, Lakshman (2004) emphasizes that commercialization, modernization and technological transformation of agricultural practices through increased capital

formation in agriculture are needed, to utilize the full employment potential of this sector in conformity with the needs of enhanced productivity.

Chapter 3 : Literature Review

As explained in Chapter 1, the study's scope relates to the themes of agriculture labour, mechanization and productivity. As such, the literature review presented here focuses on those three themes in order to provide the Sri Lankan context for the subsequent analysis. This section firstly presents a review of existing studies on issues related to agriculture labour such as the difficulty to attract the youth and females to agriculture, worker out-migration and part-time farming in agriculture, as well as the effects of public policy on agriculture labour. It is followed by a review of studies on agriculture mechanization in Sri Lanka with regards to the history of mechanization, related policy changes, level of mechanization, readiness and barriers for mechanization, and the usage of modern technology in agriculture. Finally, it presents a review of literature on the productivity of the agriculture sector in Sri Lanka. These themes are separately reviewed to analyze the Sri Lankan and foreign contexts.

3.1 Sri Lankan context

Agriculture Labour

The agriculture sector in Sri Lanka is faced with numerous issues related to labour such as, the inability of the sector to attract youth and females, worker-out migration, part-time farming and aging etc. These are discussed in the following sub sections in detail.

Inability to attract the youth

In the case of Sri Lanka, scarcity of labour in agriculture is widely noted. Weerahewa, Thibbotuwawa, & and Samaratunga (2015) note that the Sri Lankan agriculture labour market is continuously losing young women and men. Similarly, Bamunuarachchi (2018) shows that in her sample of 342 paddy farming households, 81 percent experienced difficulty in finding agriculture labour, and the most prominent reasons behind the particular issue were the diversion of labour for technical employment and the preference to remain unemployed.

Even among the youth engaged in agriculture, the level of involvement is heterogenous. Damayanthi & Rambodagedara (2013a) show that youth participation in agriculture

differed based on the farming system, crop or geographical region. For example, in terms of chena or pulses cultivation areas, youth engagement was 100 percent, while in the case of low-country and up-country vegetable cultivation areas, and rain-fed paddy cultivation areas, the youth participation was about 60 percent. The authors point out that though the up-country vegetable cultivation is profitable, 40 percent of the youth in the sample were not involved in it due to the problem of non-availability of land and issues encountered in marketing.

Indicating the fact that not all youth engage in farm activities at the same intensity or manner, Damayanthi & Rambodagedara (2013a) highlight, about 70 percent of rural youth in their sample were engaged in agriculture related activities on some level and among them, 40 percent were engaged as full-time farmers, 26 percent were involved as part-time farmers and another 34 percent were involved in agriculture as family labourers. Further, Damayanthi, Samarasinghe, Bandara, Hitihamu, & Perera (2013b) show that among the youth in their sample, 70 percent were involved in agriculture at some level and among them, only about 28 percent were involved as full-time agricultural workers, another 24 percent were involved as unpaid family workers, while 18 percent were involved as part-time farmers. Further, 7 percent were involved in agriculture related agro-based industries or businesses.

Such low contribution by youth towards agriculture sector in Sri Lanka is attributed to various reasons, which can be grouped broadly as push factors of agricultural related occupations and pull factors of alternative occupations.

Push factors : resources, capacity and opportunity constraints

A key reason for the difficulty for youth to engage in agricultural occupations is the absence or inadequacy of required resources to carry out such activities. For example, Ranathunga (2011) shows that despite the affinity of some youth to remain in rural areas and engage in agricultural activities, they are compelled to migrate from rural to urban areas due to constraints such as landlessness, declining yield, financial issues, market access issues, and inconsistency and uncertainty associated with agricultural income. Jayatissa, Seneviratne, & Sankar (2005) emphasize that in addition to landlessness, the capacity constraints in managerial and technical skills also negatively affect youth involvement in agriculture. Highlighting another dimension of low involvement of youth in agriculture, Damayanthi & Rambodagedara (2013) note that issues in accessibility as well as availability of extension services and irrigation and marketing facilities are some factors discouraging youth from engaging in agriculture. Nevertheless, Sudarshanie (2014, p. 4) finds that in her study, although there were many factors influencing youth

participation in agriculture, "only the education level, agricultural experience, and the availability of agricultural machineries, agricultural inputs and financial facilities were significantly associated with youth participation in agriculture". Similarly, Damayanthi & Rambodagedara (2013a) quantify that 40 percent of the youth in their sample disliked to engage in full time agricultural activity, mainly due to reasons such as the lack or unavailability of sufficient land, the uncertainty of the market and low profit associated with agriculture. However, Damayanthi & Rambodagedara (2013a) also identify that cash crop cultivation sector has been attracting more youth in recent years.

In addition to the issue of landlessness, Bamunuarachchi, (2018) hones in land fragmentation, stagnation in yield, increasing input-costs, and declining profitability as factors that have contributed for those engaged in agricultural activities to move out to other areas in search of other jobs. Bamunuarachchi, (2018) further notes that in commercialized major paddy growing districts, respondents were of the view that prevailing level of mechanization in paddy farming lacks the muscle to attract the youth into paddy farming. At the same time, DailyFT (2017) shows that the unprofitability of agriculture work, resulted by the low adoption of modern technology and innovations and the lack of financial and non-financial resources for agricultural investment, and the related decline in commercial value of the agriculture sector are the other factors contributing to the decline in youth involvement in agriculture. Summing up the resource constraint experienced by the youth, DailyFT (2017) further underscores that they are of the view that "authorities are not prioritizing the commercial value of the industry, especially in its financial and marketing aspects to attract young people to engage in the sector".

Apart from constraints in terms of resources and capacities, another factor that contributes to the decline in youth involvement in agriculture is underlying socioeconomic conditions and opportunities in rural areas. For instance, in his investigation of rural to urban labour migration in Sri Lanka, Ranathunga (2011) finds that the majority of young individuals below the age of 30 years (84 percent of his sample) migrate from rural to urban areas, and the most among them (70 percent) does so due to economic issues such as unemployment, underemployment and under development in the rural sector. As such, the unavailability of opportunities in rural areas pushes the youth away towards urban areas and thereby limits their involvement in agricultural activities.

Sudarshanie (2014) finds that marital status, education level, and the availability of land and labour had a positive correlation with the satisfaction of the youth in participating in agricultural activities. In terms of future willingness of the youth to get involved in

agriculture employment, Damayanthi & Rambodagedara (2013a) found that only 58 percent of youth in their sample were willing for full-time engagement in agricultural activities. Interestingly, through further examination of these youth, the authors found that those who were in favour of full-time agriculture employment have other favorable conditions, such as long period of experiences in agriculture, sufficient labour (family labour), and basic assets such as land. Moreover, it was also revealed that this group lacked skills or proper qualifications required for other types of jobs, and had underlying reasons that compelled them to remain in the same area, such as to take care of parents or a disabled member of the family.

Push factors : mismatch between aspirations and reality in agriculture

The above discussed resource and capacity constraints applicable for the low participation of the youth in agricultural activities converge into an issue of mismatch between their aspirations and reality in agriculture. Hence, a large part of the dislike among youth to engage in agricultural activities boils down to the inability of agriculture related employment and income to align with the hopes and aspirations of the modern-day youth. Specifically, many studies have highlighted that the lack of social recognition for those involved in agriculture is a key limiting factor for young people to engage in agriculture. For instance, Damayanthi & Rambodagedara (2013) note that the lack of social recognition together with the absence of a social security system for those in agriculture discourages the youth from engaging in agriculture, while Jayatissa, Seneviratne, & Sankar (2005) highlight this issue as the "unfavourable perception towards farming". This is further exemplified in the Sri Lanka National Human Development Report of 2014, which underscores that there is a conflict between the job aspirations of the youth and their perception of involvement in agriculture. For example, approximately 52 percent of the respondents to the National Youth Survey 2013, mostly young women, indicated that they preferred government sector employment, and were not interested in agriculture mainly due to the irregular nature of income and the related lack of confidence to take such income risks. In this context, some of the youth consider migration as an alternative strategy to improve their lives (UNDP, 2014, p. ix). Similarly, Hettige & Mayer (2002) emphasizes that the high preference among the youth for white collar jobs is another reason for their low involvement in agriculture. This sentiment was also confirmed in the Report of the National Development council working group on Agricultural Policy (NDC, 1996), which highlighted the drudgery associated with farm work in Sri Lanka as a key reason for farm employment becoming unattractive to the youth. Lakshman (2004) shows that according to a survey conducted in 1997, the percent of those actually employed in agricultural and fisheries sectors was 22.43, and the percent

of the unemployed desiring an occupation in the particular sector has been only 0.86. In fact, rather than a shortage of labour, unemployment was found to be a result of the mismatch between existing labour skills and the needs of the employment opportunities that are available. "The more educated a job aspirant is, he/she appears to desire agricultural and manual jobs less and office jobs more. The educational system in the country, moreover, has been known to to distract new entrants to the labour force from manual pursuits in agriculture, fishing, animal husbandry, services, etc." (Lakshman, 2004: p.g. 282). Similarly, Damayanthi & Rambodagedara (2013a) showed that among the 40 percent who disliked to engage in full time agricultural activity, some were inclined to continue education in pursuit of better jobs. As such, the very low level of social protection, social recognition, pay, and overall sustainability associated with the agriculture sector discourages youth from continuing in the engagement of farm work (DailyFT, 2017).

The dislike of the youth towards agricultural activities only contributes to one half of the reasons for their low interest in agriculture. The other half emerges due to the mismatch between parental aspirations for their children and the potential of agriculture to meet these aspirations. In an analysis based on dry zone paddy farming areas, Bamunuarachchi (2018) shows that farmers engaged in paddy farming do not expect their children to engage in the same occupation because of the inadequate financial returns and instability associated with the livelihood. Instead, parents direct their children to engage in occupations with high prospects through higher education. This trend is aptly shown by Weeraratne & Hasebe (2011), where in their sample, the number involved in agricultural activities approximately halved in each generation, despite the fact that the first generation's occupational choice of being a farmer had a significant impact on the second generation's occupational choice of being a farmer. As such, the unfavourable perception towards farming and farmers, held by the youth, their parents, as well as by the society, is a critical factor contributing towards the decline in youth involvement in agricultural activities.

Pull factors: alternative occupations

Amidst the low potential of agricultural activities to meet the growing future aspirations of the youth and their parents, alternative employment opportunities appear more promising. Reflecting this aspect, DailyFT (2017) shows that the employment opportunities in the metropolitan areas align better with the aspirations of the youth who leave rural areas and agricultural activities. At the same time, the abandoning of agriculture sector employment by some youth, in order to engage in attractive

employment opportunities in industrial and services sectors, has resulted in other repercussions such as the emergence of a new social class engaged in regular jobs with stable income adopting to a relatively more prestigious life and lifestyle than those engaged in agriculture. Such changes serve as a factor which pulls the youth out of agriculture, in search of new types of jobs to match their emerging aspirations (Pinnawala & Herath, 2014).

Inability to attract women

Damayanthi & Rambodagedara (2013a) emphasizes that among the youth in their sample who were engaged in agriculture as a full-time activity, only 18 percent were females, and among those who are part-time farmers the share of females was only 13 percent. Even though the female engagement in full time and part time farm work was relatively low, in the case of family labour, their share has been notable. Specifically, 47 percent of those involved as family labour were females. Adding to this, Bamunuarachchi (2018) notes that when disaggregated by gender, in Sri Lanka, there was a significant drop in women's engagement in paddy farming which was, on average, one sixth of the time allocated by males in the same areas, and the contribution by female family labour was higher than that of hired female labour. The reasons for such low participation of women in agriculture too can be categorized as push factors and pull factors.

Push factors: agricultural related occupations

As noted by Lawal et. al. (2009), the extent of family labour available is highly correlated, mainly with the marital status of the farming household members. Moreover, as indicated by De Silva (2012), factors common to all females in Sri Lanka, such as discrimination in the labour market, displacement due to capital intensive production methods, higher education of women, child care activities especially among middle income families, changing preference for leisure due to increasing of per capita income, also apply for the low LFPR for agriculture sector. For instance, during the third quarter of 2019, the LFPR for females was 34.1 percent, while the corresponding rate for males was much higher at 72.9 percent (DCS, 2019). Other evidence for some of those factors contributing to women being pushed out from agriculture sector employment can be explained as follows.

Push factors : displacement due to mechanization

The adoption of capital-intensive technology, which has influenced farming practices by reducing the use of labour mainly in paddy farming, has limited the opportunities for females to involve in agricultural activities (De Silva, 2012). For instance, such displacement of females is evident in tasks such as weeding, harvesting and processing, which were traditionally done by women. Further confirming these changes in agriculture, Bamunuarachchi (2018) finds that 53 percent of the respondents of her study sample believed that the role of women in agriculture has changed mainly due to mechanization. Other factors that have contributed to the low involvement of females in agriculture are the engagement of women in private sector employment opportunities, their reluctance to engage in agriculture activities and family commitments. As a result, agricultural activities associated with harvesting and processing, which were traditionally associated with females, are now largely displaced by machinery.

Push factors: gender norms, discrimination and rights

The prevailing gender norms in Sri Lanka discriminate females in agriculture across many dimensions. This is considered a discouraging factor for women's involvement in the agricultural activities. On the one hand, they have faced an excessive burden of allocating time for household and care giving activities, while also enduring the income earning burden (FAO, 2018; DailyFT, 2017). Similarly, FAO (2018) points out the gender wage gap in agriculture, where female paid agricultural workers are paid less than the earnings of their male counterparts. Bamunuarachchi (2018) shows that female family labour contribution was higher than female hired labour contribution in all her study districts except Ampara. In Ampara, female family labour contribution was higher than female hired labour "…due to the reluctance of females in the Muslim community to work unless they belong to the low income category" (Bamunuarachchi, 2018, p.40). This is further reinforced by Gunawardana (2018) who identifies that gender norms and social surveillance were a barrier for the Muslim women to participate in livelihoods outside home.

FAO (2018) has further noted that there are large disparities in access to and control over resources like land, water and inputs as well as in access to markets and skill training, all of which are determining factors for agricultural production and livelihood associated with women. Moreover, the FAO (2018) underscores that though Sri Lankan constitution is non-discriminatory in dealing with land ownership, there are gender biases in land development ordinance and other customary laws (including the Kandyan law, Tesawalame law, and the Muslim law). In fact, there is inequality in land ownership by

females, where only 16 percent of all privately -owned land in the country belongs to women. Such discrimination in terms of land ownership in Sri Lanka has, to some extent, served as a restrictive factor in females' involvement in production of crops for consumption and commercial purpose. Specifically, the absence of land ownership restricts females from obtaining support services such as irrigation water, credit and fertilizer. Specifically, to become eligible for subsidized fertilizer, the title of the land, as well as the membership of the area farmer organization, are essential. As many women have no land titles to prove their ownership for land, especially in irrigated settlements, they are not entitled to obtain subsidized fertilizer. Similarly, due to the absence of title deeds for their land, many women are disqualified from obtaining membership in the area farmer organization. This further restricts female farmers from obtaining irrigation water from the organization that handles water distribution. Moreover, for agriculture related training programs, the Department of Agrarian Development selects participants from the members of the registered list of the farmer organizations. Here also, women who do not have land ownership become disqualified from obtaining such training (FAO, 2018).

As such, literature notes that the violation of women's right to own lands and undertake cultivation with formal access to services provided by government institutions, is one of the reasons for the decline in female involvement in agriculture over time in Sri Lanka. For example, Lakshman & et al. (2011) note that "women's traditional work in the Dry Zone chena cultivation has been curtailed by the nature of the agriculture promoted in government settlements", which undermines the women's economic status and opportunities by practices such as males being favored in receiving titles to land and access to credit (Lakshman, Ansumana, & Ruhunage, 2011, p. 5). Echoing these concerns, ADB (2015, p.g. 20) notes that "women are involved actively in the sector but have unequal access to skills, agriculture extension, and markets, or are relegated to the role of unpaid family workers without access to independent income or are agricultural workers receiving lower wages than male laborers.

FAO (2018) identifies that these issues arise due to the absence of any gender mainstreaming policies, strategies and programmes for agricultural sector in Sri Lanka. Specifically, as per FAO (2018), there are no programmes designed to enable women to access and control resources, or to promote women's active participation in agricultural operations in a manner to enable them to receive a fair share for their involvement, or to participate equally in decision making process.

Wickramasinghe (2012) highlights that unlike in the past, rural women are currently an important segment in the agriculture workforce that contributes to the national economy.

Women play a vital role in production and processing related to crops and livestock, while engaging in the rearing of children and household activities. The agricultural activities that women engage in include sowing, transplanting, weeding, harvesting, threshing, cleaning, drying, etc. Nevertheless, men's role is disproportionately visible in agriculture, giving them an advantage in terms of services such as bank credit and services as well as facilities for technological development. Therefore, Wickramasinghe (2012) suggests that in developing technologies and other agricultural development interventions, they should aim to reduce drudgery of farm women at work through the improvement of the design of tools such as increasing employment opportunities for women during the off-crop season, increase women's work efficiency thereby increasing their production and productivity, and ensure efficient use of available resources including time, skills, money, raw material, etc.

Pull factors: alternative occupations

The displacement due to mechanization, low level of productivity, inadequate income of small family farms, and discrimination experienced by female farmers have compelled women to move away from unpaid family labour and seek alternative paid employment opportunities. In the absence of off-farm employment opportunities in rural communities, two popular alternative employment opportunities for such females have been the garment industry in the export processing zones in urban areas and female domestic worker jobs abroad (ADB, 2004).

Such movement away from agricultural work is also influenced by globalization and rapid change of aspirations and life styles of the rural women, where traditional agricultural activities are often perceived as demeaning (Hettige, 2002). Hettige (2002) notes that rural women with such changed attitudes have been attracted to employment opportunities generated after 1977, especially in new industries, garment factories and overseas, in addition to hard manual work in the rural sector (Hettige, 2002). As analyzed by Erfurt (2005), the benefits accrued by rural women working in export processing zones include having a job which gives the opportunity to earn a stable income, ability to contribute to family expenditure, and the ability to save and create assets. These elevated capacities of women and the related level of empowerment have had a positive effect in different settings, such as the factories they work in, family and community. On the contrary, females' involvement in agricultural activities have not enabled females to reach such heights. Similarly, ADB (2004) highlights that female garment factory workers from rural agricultural settings, who used to earn irregular income, have now become economically stabilized and empowered.

Worker-out migration

A phenomenon running parallel to the decline in the involvement of youth and females in agriculture is their out-migration from rural areas to more urban areas. The combination of the lack of resources, uncertainty of agriculture income and the mismatch between aspirations prompt many to leave agricultural occupations. In the context of limited alternative employment opportunities in rural areas, the common choice is to move to urban areas in search of employment. As noted by Samaratunga, Jayaweera, & Perera (2012), by the mid-1980s, out of total internal migrants in Sri Lanka, 65 percent accounted for unskilled workers and a large segment of them came from the rural areas where the main occupation was agriculture. Though initially the females were the dominant among the migrants, by 2009, the out-migration of males and females became nearly equal. As found by these authors, out-migration from rural areas has created a labour shortage in rural households and areas, creating a high demand for the internally migrant labourers, and a consequential increase in the cost of hired labour. Although some households with migrants have used remittances sent by migrants to hire labour and/or purchase machinery to cultivate their agricultural land, the use of remittances has not produced significant increases in their investments in productive assets, compared to households without migrants. Hence, to attract the youth who migrate out, the authors recommend to deviate from "traditional practices full of drudgery to a modernized and formalized agriculture" that consists of social recognition (Samaratunga, Jayaweera, & Perera, 2012, p. vi).

On the contrary, Ranathunga (2011) has found that the remittances sent by the migrants, who are working in factories in urban processing zones, to their households, account for 21 percent of their household's income, and a third of such remittances is used for productive investments, that include mainly farming and education, with multiplier effects in income and employment.

Part-time farming and aging

The labour shortage in agriculture has led to the emergence of part time farmers, which has resulted in many implications. For instance, Jayatissa & et al. (2014) has found that the limited time allocated by part time farmers towards agriculture has become a crucial issue in commencing re-cultivation of abandoned paddy land. As a result, there is heightened reliance on machines for re-cultivation related activities. On the contrary, in areas where machinery could not be substituted for the labour shortage, the necessary agricultural activities such as weedicide and land preparation etc. are not properly completed, resulting in abandoning of agricultural land.

As highlighted by Pinnawala & et al. (2014), Sri Lankan farmers in the non-plantation agricultural sector are typically part-time farm operators, and around 40 percent of the income of Sri Lankan farmers is derived from off-farm employment. While the insufficient income from agriculture alone pushes them towards off farm activities, the availability of such alternative income sources also discourages them from performing a committed task in terms of agriculture. This vicious cycle has resulted in off-farm income emerging as the main source of livelihood of many of the small farmers, discouraging them to completely move away from farming.

As noted by ADB (2019), faster aging is a new trend in Sri Lanka, similar to the case of other Southeast, East Asian and developed countries. Nevertheless, Sri Lanka's experience is unique due to the speed of aging and the decline in the share of working age population. The country is aging rapidly with a share of those aged 65 and above increasing from 7 percent to 21 percent within a very shorter period from 2007 to 2045. This reflects a rapid change compared to many other countries. At the same time, the country's working age population will start declining by 2030. According to ADB (2019) this rapid aging and fall in the share of the working age population will affect the country's long-term productivity growth.

By examining the impact of population ageing on the labour market in Sri Lanka, Vodopivec & et al. (2008) observed that in agriculture sector, the share of workers reduced with their ageing. Specifically, unlike others such as self-employed and casual workers who tend to work until very old age due to poverty and until deteriorating health compelled them to stop work, those in agriculture sector stopped much earlier.

The study on economic impacts of demographic aging in Sri Lanka by Rannan-Eliya (1999) shows that "an older workforce may be expected to be less "vital" and less able to learn or increase productivity. It is also the case that older workers with families may be less willing to relocate with employment, and so an older labour force may exhibit less flexibility. However, the most productive societies today are also the oldest, so the likelihood is that investment in education and training both to impart skills and to assist workers to adjust can more than out-weight the impact of ageing on workforce age" (Rannan-Eliya, 1999, p. 15).

Mechanization

History and Policy Changes

The history of farm mechanization in Sri Lanka goes back to the late 1940s and 1950s, the period which involved accelerated settling of people in the Dry Zone under the programme of population re-settlement. At that time, mechanization meant tractorization of paddy cultivation to address labour scarcity of new settlers, who were allocated with 3 hectares of irrigated land per individual. Mechanization objectives of this time also aimed to increase productivity of the irrigated land by advancing cultivation with the start of rain fall, letting the tanks to save water for subsequent minor-season cropping (Farrington & Abeyratne, 1982).

Tractor hiring centers

In Sri Lanka, the small-farmer mechanization process started with the tractor pooling stations, initiated by using 150 tractors gifted by departing foreign military authorities in the mid-1940s (Farrington & Abeyratne, 1982). This tractorization was commenced initially with full government involvement (without a clear vision or a programme) to operate tractor pools of imported tractors to be rented at subsidized rates. These stations were opened initially at Iranamadu, Nikaweratiya, Kalmunai, Wirawila, & Nalanda. The tractors were hired out to farmers for ploughing, harrowing, and threshing by charging at subsidized rates. Since 1952, the management of these centers was undertaken by the Co-operative Agriculture Product and Sales Societies and their Unions and they tried to expand the services by importing further 241 tractors from Britain. However, these co-operative societies failed to recover the running cost, which as a result increased charge (Farrington & Abeyratne, 1982). Subsequently, their operation was handed over to both the Food Production Department and the Department of Agriculture.

After 1956, the tractor pools were closed due to their heavy losses and related failure. Subsequently, private individuals owned and hired tractors as a consequence of government subsidies and concessions for the importation of tractors. Under the Mahaweli programme of 1970s tractor ownership was promoted, where under the tank irrigation modernization project, a total of 60 four-wheeled tractors and 180 two-wheeled tractors were expected to be provided. Similarly, under the Accelerated Mahaweli Development project, another 500 four wheeled tractors and 1,000 two-wheeled tractors were expected to be provided under foreign aided subsidized credit programme. By the end of 1960s, tractor pooling centers were established island wide, mainly to introduce

four-wheeled tractors to address the cattle shortage in land preparation in agriculture. In the 1970s, these centers also introduced two wheeled tractors (Bandara, 2012).
From the mid-1960s to 1981, the official policy was private ownership of tractors under heavy subsidies and concessions for mechanization (Farrington & Abeyratne, 1982b). As such, with the liberalization of trade account and exchange rate reforms, tractor registration increased from 274 in 1971 to 2,532 in 1978. Until early 1970s, only four-wheeled tractors were imported and the importation of two-wheeled tractors commenced subsequently. Since 1980s, the new registration of four-wheeled tractors declined, mainly due to the gradual removal of incentives on tractor imports (Gunawardana & Somaratne, 2000).

Attempts for broader mechanization after1960's

After 1960, instead of mechanization referring to mere tractorizaion, it expanded to encompass increasing cropping intensity via saving of tank water through timely cultivation and reduction of staggering irrigation schemes, especially in the Dry Zone (Farrington & Abeyratne, 1982). Moreover, mechanization was also viewed as a strategy to reduce production cost, increase quality, and attract the young generation towards agriculture (Tilakaratna, 2003).

Along with the liberalized economic policies in the late 1970s, the promotion of modern technology spanned beyond paddy to reach other crops as well. For instance, import tax concessions were provided to the private sector, while the Department of Agriculture was encouraged to develop and introduce new machines and techniques, as well as to distribute machines and tools among farmers and farmer organizations at subsidized rates or free of charge. Moreover, two institutions were established under the Department of Agriculture in 1969 (Bandara, 2012). One is the Design and Testing Unit at Mahailluppallama, and the other one is the Agricultural Implement Manufacturing Center in Wattala. The Design and Testing Unit at Mahailluppallama was aimed to check the suitability of machines imported by the private sector to local conditions. Its scope expanded in 1982, to cover research on agricultural mechanization and modification of imported machines to suit local conditions etc., under the new name of Farm Mechanization Research Center (FMRC). Overtime, the FMRC sold their patents to the private sector manufacturers for commercial production and distribution (Kumara, Weerakkody, & Epasinghe, 2016). In 1973, the Farm Machinery Training Center was established in Pulliyankulama, Anuradhapura, to train farmers on the usage and maintenance of farm machinery (Bandara, 2012). Tilakaratna (2003, p.6) highlights that

"most of the agricultural machinery and equipment needed by the Sri Lankan farmers are manufactured in the country, except single axle and twin axle tractors".

Mechanization for labour shortage

Severe shortages in labour for agriculture practices necessitated the mechanizing of major activities of the paddy sector, such as harvesting, threshing, and winnowing (Epasinghe, Kumara, & Pathirana, 2010). This was fulfilled by the rapid importation of various types of machines like combine harvesters and combine threshers from countries like China, India and Japan since the mid-part of the decade 2000. The island wide availability of sales outlets and service centers operated by companies involved in importing machinery contributed to the rapid expansion in the usage of such machinery for agriculture (Kumara, Weerakkody, & Epasinghe, 2016).

Similar to the paddy sector, various machines and implements were introduced to OFC sector, to address issues of labour scarcity in activities such as land preparation, seeding, threshing and processing of OFC crops (Kumara, Weerakkody, & Epasinghe, 2016). Some examples are, the two-wheeled tractor operated three-time plough/tiller; spring loaded tine tiller; rotavator altered for earthing; four-wheeled tractor operated seeder; and multiple crop thresher (two-wheeled as well as four-wheeled tractor operated). Moreover, some crop specific equipment was introduced, such as the manual seeder and altered combine harvester for threshing maize; manual and electrical decorticators for ground nut; crop processing machine for legume; manual seeder for finger millet and sesame; a thresher for finger millet; and a paddy Agrimec altered for threshing of finger millet etc. Some of the machines were imported, while others were modified or innovated by the FMRC, private sector or farmers themselves.

By the end of the 1990s, the active involvement of the public and private sectors, as well as individuals, led to the development and production as well as importation of agricultural machines and implements used for paddy as well as OFCs. Tilakaratna (2003) quantified this strength of private sector stakeholders as 9 large-scale manufacturers, 20 medium-scale manufacturers, 40 small-scale manufacturers and 1332 village artisans. In addition, during the period from 1957 to 1998, the inventory of tractors and other implements handed over to Agrarian Services Centers were 998 four-wheeled tractors, 709 two-wheeled tractors, 20 threshing machines, 65 harvesting machines, 10,000 sprayers and 44 tractor ploughs (Pussepitiya, 1998). Recent estimates show that in major and commercialized paddy growing districts, 48 percent of the families owned four-wheeled tractors and 8 percent owned two-wheeled tractors, while 44 percent owned sprayers. However, the ownership of high-cost machines such as combine harvester and

combine processer was still negligible at 2 percent and 0.3 percent respectively (Bamunuarachchi, 2018).

In the face of labour shortage, some households with migrants have used remittances to hire labour and/or purchase machinery to cultivate their agricultural land without abandoning them. This was relatively more beneficial for those cultivating in a near commercial scale with large operational land (plot sizes over 5 acres) with access to irrigation water. Nevertheless, in areas where agricultural activities were more subsistence in nature and smaller sized lands (less than one acre) were utilized, the substitution of migrated labour with hired labour and investments in machinery were not favourable and thus, had resulted in abandoning the cultivation (Samaratunga, Jayaweera, & Perera, 2012). Further, the use of remittances for investments in productive assets such as tractors, sprayers, water pumps, was not higher in households with a migrant than in households without a migrant. This unlikelihood in the investment in agricultural equipment is attributed to the unproductiveness of agriculture (Samaratunga, Jayaweera, & Perera, 2012). Such low investment was seen by Samaratunga, Jayaweera, & Perera (2012) even in Polonnaruwa, which is a major commercially paddy growing district. As such, in order to attract a sizeable portion of remittances towards investment into agriculture equipment and mechanization, the authors recommend to increase "the profitability in the rural agricultural sector by increasing investment in research and extension on new crops and livestock enterprises for diversification of agriculture both vertically and horizontally, so that the rates of returns on investment in agriculture would be attractive" (Samaratunga, Jayaweera, & Perera, 2012, p. vi).

Role of Farmer Organizations

The initial steps for the establishment of farmer organizations in Sri Lanka were taken through the Gal Oya Water Management Project which was operationalized between 1979-1985 under a USAID fund (Giragama, Sanker, & Samarakoon, 1999). This was implemented jointly by the Irrigation Department and the Agrarian Research and Training Institute (ARTI).

The farmer organizations were developed as a bottom-up approach for planning and organization, for building organizations based on hydrological boundaries and using trained catalysts to facilitate the organization of farmers and promote self-reliance of the farming community. Uphoff and Wijayaratna (2000) shows that the system of farmer organizations established in the early 1980s in Gal Oya significantly enhanced the efficiency of rice production through its benefits in terms of social capital. The study

emphasized that during 1981-84 period in Gal Oya "young institutional organizers were recruited and trained to act as catalysts for eliciting and assisting farmer organization" (Uphoff & Wijayaratna, 2000: p.g. 1878). These youth lived alongside farm households and organized farmers cultivating using water from a common source such as a gate, a turnout or a larger distributary canal (Uphoff & Wijayaratna, 2000).

During this time the key tasks of farmer organizations were, procurement and distribution of agricultural inputs on a cooperative basis, efficient water management, adoption of innovative cultivation methods for greater productivity, development of credit and marketing skills and resolution of farmer conflicts (Giragama, Sanker, & Samarakoon, 1999). After mid-1990s, the concept of farmer organizations/companies was promoted as a mechanism to encourage farmers' participation in cooperatively managing common resources and assets, and in organizing technical and other services that can commonly benefit all members. The government has given tractors, combine harvesters and other tools to these organizations to commonly benefit by managing their operation.

Over the years, farmer organizations were expanded to all major settlement schemes and subsequently covered other agricultural settlements and the Mahaweli Development Project. A historic event in farmer organizations in Sri Lanka was the enactment of the Agrarian Services Act No. 4 of 1991. This Act enabled the registration of Farmer Organizations with body corporate status and the power to sue and be sued. At the time of the first farmer convention in 1996, Anuradhapura and Matale districts had 1,060 and 686 registered Farmer Organizations, respectively. Nonetheless, FAO (n.d) identifies that farmer organizations in Sri Lanka face challenges in terms of capacities and coordination. Moreover, it is underscored that the issues in transparency and support from allied national organizations handicap the ability of farmer organizations to maximize their efficiency.

Criticism of mechanization policies in Sri Lanka

Nevertheless, the mechanization approach adopted in post 1980s is criticized to be void of a clearly defined national mechanization policy and strategy, as well as Ministry level national mechanization programmes (Abeyratne, 1991). A key criticism is the policy inconsistency and the insufficient protection of local production of large agricultural machinery where imported raw material was taxed while imported machinery were not taxed. This penalized local manufacturers when competing with imported machines, which resulted in some local manufacturers closing their factories in 1990s (Bandara, 2012). Other notable deficits highlighted in literature include loopholes in import tariff structure and law enforcement, absence of quality standards for imported products, and

the functioning of various institutions involved in mechanization without coordinated aims and objectives (Abeyratne, 1991).

Readiness and barriers for mechanization

Despite the various attempts over the years, the level of mechanization of agriculture in Sri Lanka is limited. A key barrier identified in literature is the unavailability of machinery developed specifically for the crops and conditions in Sri Lanka. The available machinery was manufactured for use with other crops, especially in other countries and therefore, the adoption of these machines resulted in many technical issues for the farmers (Epasinghe, Kumara, & Pathirana, 2010). For instance, Ulluwishewa, Tsuchiya, & Sakai (1985) highlight that the mismatch between local field conditions and the conditions for which the tractors and implements were manufactured for, as the main reasons for the failure to adopt them in paddy land preparation in Sri Lanka.

Some literature notes that the poor adoption of mechanization in Sri Lanka is mainly due to socioeconomic factors. At the same time, it is identified that the attitudes of farming community towards the adoption of new technology also serve as a barrier. Such negative attitudes of farmers were influenced by factors such as poor awareness about the availability of machinery, issues in affordability of machines due to high cost and poor farmer income. In fact, the National Development Council (1996) reports that although tractors, threshers and transplanters were freely available in Sri Lanka, the ability of farmers to access them was limited, due to both the high cost of purchase as well as high operational cost. As such, the costs involved served as a barrier for the adoption of new technology by many small-scale farmers, at either level of purchase or hire and operate.

Other issues that inhibited the used of mechanization for agriculture, especially paddy as noted by Gamlath, Gunathilake, & Chamara (2018), include the non-availability of a machine developed for bund preparation. In the case of adopting transplanting machines, issues such as the small size of paddy fields, high cost of rice transplanting machinery, technical issues associated with their operation and problems in the preparation of seedling have served as barriers. Moreover, Gamlath, Gunathilake, & Chamara (2018) note that mechanization of rice weeding technically depends on the mechanization of transplanting. As such, in the absence of mechanized transplanting, the mechanization of weeding cannot take place. Similarly, the high price of power sprayers also led to the low level of use of power sprayers for chemical applications in Sri Lanka.

As noted by Tilakaratna (2003), other barriers to mechanization include the difficulty in promoting local machinery manufacturing industry, uncontrolled dumping of low-

quality machines and poor financing facilities for purchasing machinery by farmers. In the context of such barriers and issues in readiness for mechanization, the reduction in the use of animal power has resulted in great hardships for medium and small-scale farmers and severe energy scarcity in the field. Tilakaratna (2003) further highlights that although the mechanization helped to a great extent to achieve the objective of self-sufficiency in rice, its cost had been in terms of loss of efficiency in rice cultivation.

FAO (2018) notes a gender disparity in access to mechanization. It was noted that four-wheel tractors are hardly used by women, and that combined harvesters are exclusively used by men. Based on discussions at the Farm Mechanization Training Centre, the Institute of Post Harvest Technology of the Ministry of Agriculture, and field visits to several districts, it was evident that very few women (less than 10 percent of total trained each year for the past 3 years) are provided with training on the use of farm machinery and planting methods. The responses of women during field visits reinforced this view.

Bamunuarachchi (2018, p.12) underscores that the "agriculture mechanization process [in Sri Lanka] ought to strike a balance between available labour and the need of machines for timely operation". As shown by Thilakarathne & Thilakarathne (n.a.), in the case of paddy in Sri Lanka, mechanization complements the increase in the yield, as almost every farming operation from land preparation to rice processing has been mechanized to some level. On the contrary, Bamunuarachchi (2018) finds that in paddy sector in the dry zone in Sri Lanka, mechanization was limited only to land preparation and harvesting stages.

Nevertheless, the institutional framework in Sri Lanka complements mechanization of agriculture, where for instance, the Farm Mechanization and Research Centre (FMRC), situated in Mahailluppalama is tasked with the introduction of effective agricultural mechanization technologies which are compatible with field and socio-economic characteristics native to various regions in Sri Lanka (Kumara, Weerakkody, & Epasinghe, 2016). Quantifying the effect of mechanization, Bamunuarachchi (2018) finds that 39 percent of farmers in her sample of 342 households, remained in agriculture mainly due to mechanization.

Modern technology

Modern technologies have immense potential to develop productivity and mechanization in agriculture in Sri Lanka. As underscored by Thibbotuwawa (2019), Sri Lanka has adopted modern technology in terms of a seed and planting material management information system, a progress monitoring system for National Food Production Programme, and a QR code system for good agricultural practices (GAP)

certification programme. In addition to these already launched initiatives, the 'E-agriculture' Strategy of Sri Lanka has also identified areas of ICT with potential applications to advance existing agriculture system information collection, efficiencies and services. Some initiatives include mobile telephone based integrated agriculture advisory service, forecasting of food crop, provision of marketing information service, e-services for the registration of pesticides and pesticide information, plant protection, plant quarantine, and soil test results, e-agriculture library service, research information management system, natural resources management information services, plant genetic resources information service, weather forecasting and advisory service, land use and soil conservation mapping and e-information system, geospatial information service, and farm machinery e-information service (Thibbotuwawa, 2019; Department of Agriculture. , 2016).

In addition to these government initiatives, there are several private sector initiatives towards the adoption of modern technology in the agriculture sector. As noted by Thibbotuwawa (2019), the use of automated climate control, fertigation systems and hydroponics enable 'climate smart,' agriculture with year-round production. At the same time, the Chemical Industries Colombo (CIC) has used drones for scanning fields and distributing agro chemicals and fertilizer with minimum human involvement and wastage, while Hayleys Agriculture Holdings (HAH) together with DJI Technologies have explored aerial spraying in challenging terrains and elevations. As a telecommunication giant, Dialog has been using real-time weather data, weather forecasts and alerts to create personalised weather-related solutions to farmers.

However, CBSL 2019 states that advanced technology usage in the Sri Lankan agriculture sector is limited, not only among farmers, but also among the agribusinesses. The report highlights some key issues regarding the use of modern technology in agriculture sector as, the limitation of R&D initiatives of the private sector to a few pioneering companies, the slow adoption of new technologies by agriculture firms and farmers than expected, and the slower pace of farm investments in productivity enhancing technology as the farms are sheltered from competition. The identified reasons for the slow-paced technological adoption by agriculture firms and the farming community are, concerns over the adaptability of new technologies, limited capital to make initial investment, lack of technical education and skills, and the reluctance of tech-savvy youth to engage in farming activities. Moreover, it is identified that the availability and speed of internet connections in rural areas as well as the lack of awareness of available services also limit smart technology usage by farmers. Hence, CBSL (2019) suggests that identifying sectoral and grassroot level limitations of technology adoption, introducing policy reforms on capital allocation for technology transformation and technical education, strengthening

digital infrastructure, increasing public investment in R&D activities through the numerous agriculture related research organizations, creating a conducive environment for private sector investment, improving access to credit at concessional rates to support farmer level investments, and increasing awareness on available services, will help mitigate barriers for transformation from conventional practices to tech-based agriculture.

Level of farm mechanization and benefits

Despite its limitations the agriculture sector has started its mechanization process. By the beginning of 1990s, among all crops, rice was the most mechanized, with 49 percent of the paddy land being ploughed by tractor (Abeyratne, 1991). Nevertheless, as pointed out in the Report of the National Development council Working group on Agricultural Policy (National Development Council, 1996), compared to other countries, such as Philippines, Malaysia, Thailand and India, the level of agricultural mechanization has been low in Sri Lanka, where mechanization is largely limited to land preparation in paddy. In order to address this limitation, the same report recommends providing small farmers with improved access to credit under easy terms by letting them the opportunity to purchase machines as individuals or groups.

Epasinghe, Kumara, & Pathirana (2010) show that during 2005-2010, there were diverse types of machines and equipment that could be used for harvesting and processing of paddy in Sri Lanka. Some of them had been imported by various companies while some had been developed and introduced by the Department of Agriculture. As per Epasinghe, Kumara, & Pathirana (2010), farmers were efficiently using these machines. In fact, combine harvester and combine thresher were more popular among farmers for harvesting and processing of their crops. For instance, in the districts of Polonnaruwa, Ampara and Hambanthota, over 90 percent of farmers were using combined harvesters or combine threshers for harvesting or processing of their paddy (Epasinghe, Kumara, & Pathirana, 2010). Mahrouf & Rafeek (2003) show that using combine harvester for paddy replaces labour by 80-85 percent, decreases the cost of harvestsing by LKR 3,800 per hectare, and increases net income by LKR 7,850 per hectare. Literature also identifies that using combine harvester leads to rapid harvesting, reducing the cost of production, minimizing post-harvest losses, enhancing the income of farmers and assisting farmers to overcome labour shortage in peak harvesting periods (Epasinghe, Kumara, & Pathirana, 2010). Moreover, with its use, additional 200-300 kg of paddy can be harvested than through other methods of harvesting and threshing, and 5 percent of post-harvest

losses can be avoided when all three activities of harvesting, threshing and winnowing are done simultaneously.

The benefits of switching from tractor treading to thresher use include time saving, cost saving and increase in income. According to Prasanna, Gunaratne, & Withana (2004), the average time saved by small threshers (Agrimec machine) was 1.85 hours per hectare or 0.75 hours per acre and by combine threshers, it was 11.7 hours per hectare or 4.75 hours per acre. As a result of time saving, the net cost of saving enjoyed by farmers who adopted small threshers was LKR 454.66 per hectare or LKR 184.00 per acre, and that of the farmers who adopted combine threshers was LKR 1756.88 per hectare or LKR 711.00 per acre. After switching from tractor treading to mechanical threshing, the farmers were able to earn an additional amount of LKR 1.00 per kg due to the production of stainless high-quality paddy and reduction of head grain losses. Hence, with the adoption of small Agremec machines and combine threshers, the farmers have been able to increase their profit margin on average by LKR. 6,345.53 per hectare or LKR 2,568.00 per acre and by LKR 9,071.04 per hectare or LKR 3671.00 per acre respectively.

The study by Epasinghe, Kumara, & Pathirana (2010) has shown that as a result of using more modern technologies for harvesting and processing activities (threshing and winnowing) of paddy, the labour productivity as well as the profitability of paddy has increased. This change has been a result of the reduction of labor days to perform activities by those technologies. For example, to complete activities such as harvesting, threshing and winnowing of paddy in Ampara district with the use of Agrimec machine, 12.68 labour days per acre were required. But with use of combine harvester, mini combine harvester and combine thresher, it required only 2.98, 3.10 and 10.17 labour days per acre respectively. As a result, the total labor days required for the cultivation of paddy per acre have declined under the application of the latest technologies like combine harvester and mini combine harvester. For example, total labour days required for per acre cultivation of paddy in Ampara district with the use of combine harvester and mini-combine harvester for harvesting and processing has been respectively 16.07 and 16.67 labour days compared with 27.43 labour days required with the use of the Agrimec machine.

Similalry, in the case of Hambantota district, according to Epasinghe, Kumara, & Pathirana (2010), the labour productivity of farmers increased from 69.5kg of paddy per labour day under Agrimec machine to 71.5kg of paddy per labour day under combine thresher and 134.1kg of paddy per labour day under combine harvester. Moreover, this study also shows that compared to Agrimec machine and combine thresher, the combine harvester is the most efficient with the largest increase in labour productivity.

In the case of OFCs, despite the production and introduction of a variety of machines to mechanize various operations, their rate of adoption is not satisfactory. For instance, Kumara, Weerakkody & Epasinghe (2016) highlight that even though hundreds of farmers are aware about manual as well as electrical ground nut decorticators, only 14 percent and 15 percent of farmers in Ampara and Moneragala districts respectively had used manual decorticator, while only 7 percent and 5 percent of farmers in Ampara and Moneragala respectively had used electrical decorticator.

Productivity

As seen in the above discussion, mechanization has contributed to immense improvements in productivity in the agriculture sector. In countries where agriculture is a dominant source of employment, the level and growth of agricultural productivity become main determinants of the incomes of the majority of the workforce. Thus, increasing agricultural productivity not only helps the agriculture sector but also helps to raise real rural and urban wages via low food prices. (UNCTAD, 2015).

Green Revolution

As noted by CBSL 2019, although prioritizing plantations over subsistence farming led to the inability to meet the growing food demand during the colonial period, the Green revolution which followed in the 1960s aimed to increase the efficiency of agricultural processes through various techniques such as high yielding robust varieties, hybridized seeds, expansion of irrigation infrastructure, synthetic fertilizer, and pesticides etc. Herath (1981) notes that in 1966 a cabinet sub-committee was appointed to launch an intensive campaign for increasing the production of rice by tapping the new technologies developed under the Green Revolution. Nevertheless, the Green Revolution had not led to a breakthrough in rice production in Sri Lanka, mainly as the dry zone rice farmers were reluctant to take the 'risks accompanying the investment for the full package of inputs recommended for the new varieties' due to the drought and irrigation related uncertainties they face (Herath H. , 1981).

Similar evidence of the implications of the Green Revolution are found by Jayatilaka (1989) by examining an irrigated village and a not-irrigated village in Sri Lanka. This study shows that even though the Green Revolution has taken place in both villages, it has not increased yield as expected. The author indicates that it is unlikely that the expected "increase in agricultural production would take place as capital is invested more on entrepreneurial activities rather than on land" (Jayatilaka, 1989, p.29). Similarly,

more recent evidence also indicates that "although the agriculture sector has undergone considerable transformation and improvements in response to green revolution practices, productivity levels have been stagnant in recent years, raising concerns about food security as well as low farmer income" (CBSL, 2019: p. 60).

Institutional factors

Herath (1981) identified farm capital as a bottleneck for improving land and labor productivity in peasant agriculture during 1960's. However, the emphasis on lending for peasant agriculture resulted in a substantial progress in this front. Specifically, a New Agricultural Credit Scheme through the Peoples Bank, Co-operative Rural Banks and the Bank of Ceylon provided a comprehensive credit scheme for farmers. Additionally, institutional changes such as a guaranteed price and crop insurance for rice were introduced with the aim to provide incentives for farmers to increase output. Jayatilaka (1989) underscores that in addition to the institutional changes identified by Herath (1981), the agricultural extension work also became effective after 1973 as an institutional arrangement aimed at promoting new technology among the peasants. This came into effect after making District Agricultural Extension Officers (DAEOs) responsible of supervising the extension work in their districts and dividing each district into small units, headed by an Agricultural Instructor (AI) working with several field workers.

Liberalization of the economy

As Somaratne (1993) highlights, the liberalization of agricultural markets in 1977 contributed to agricultural productivity in terms of a conducive price and marketing structure for the increased use of yield-increasing technology and inputs by farmers, a very high adoption rate of high yielding varieties of paddy, OFCs and vegetables, and changes in food distribution policy. In fact, the trade liberalization policies of 1977 led to a greater investment in farm machinery, which contributed to a higher level of labour productivity and land productivity. Specifically, tractor imports expanded greatly, and the use of tractors and threshers led to a labour saving mechanization, which caused family labour to be displaced by hired labour. While the improvement in estate management, fertilizer application, subsidies and technological advancement in export agricultural sector are found to have contributed to agriculture productivity, land fragmentation is identified as an acute problem which has led to inefficient management of farms and thereby to low land and labour productivity.

Government interventions

There is evidence that the market interventions of the government contributed to the productivity levels in agriculture. Prior to 1977, a guaranteed price scheme was put in place by the government to ensure a remunerative income for farmers and to establish a procurement system for paddy and most OFCs. The policy changes in 1977 also included a government assured guaranteed price and a floor price for paddy and OFCs respectively. As a result, the farm gate price for paddy has prevailed at a level about 20 percent higher than the floor price in the open market during the 1980s. "This price policy indirectly helped maintain increased productivity levels by facilitating the rational selection of profitable crop enterprises" (Somaratne, 1993).

In terms of the colonization schemes implemented by the government, Sanderatne (2004) states that these schemes in the post-independence period incurred high costs whereas the productivity of land settlement was low in relation to its capital investment. In fact, given the considerably high infrastructural expenditure and traditional agricultural practices, the capital-output ratio of these schemes was extremely high, indicating that the benefit and cost ratio was low.

Productivity and employment

As noted by Yatawara 2004, traditionally, there has been a trade off between the dual goals of productivity growth and employment generation, in such a way that the rising labour productivity (i.e. growth in value added per worker) is inextricably linked with a decreasing employment. However, Yatawara 2004 states that the negative relationship between productivity growth and employment may not always take place. On the contrary, job growth can actually increase due to cost reductions and profit increases associated with labour productivity. High profits can lead to the entry of new firms and thereby increase employment, while technology driven increases in labour productivity that lead to increased relative wages will encourage greater job applications, thereby stimulating job growth while exerting downward pressure on wages in the meantime. Yatawara (2004) investigates this issue empirically by analysing aggregate data over the 1963-2000 period, where he finds a positive productivity growth in all sub-sectors of the economy and the negative relationship between productivity growth and employment creation only in the agriculture sector. However, whether the falling agriculture employment in Sri Lanka is actually due to increasing productivity, remains a debatable issue.

According to Lakshman (2004), in terms of the proportion of agriculture in employment which is consistently higher than its GDP proportion, there is low productivity in the agriculture sector in Sri Lanka. Similarly, CBSL (2019) notes that the agriculture sector in Sri Lanka is still considered to be highly labour intensive, despite the gradual decline of the share of employment. However, measuring the agriculture labour productivity in Sri Lanka by dividing agriculture GDP in LKR millions by the number of employed population in the agriculture sector of a given year, Marambe (2019) finds that the agriculture labour productivity in Sri Lanka has increased over the years from 2015 to 2018. Further, the study shows that during 2011–2014, employment in agriculture has declined despite an annual average output growth of 4.2 percent, indicating a rise in agriculture productivity. Moreover, the share of low-skilled workers in agriculture has also declined during this period (Marambe, Labour Productivity in Agriculture: A Case from Sri Lanka and Some Food for Thoughts, 2019).

3.2 International / Regional Context

A review of International literature on agriculture labour, mechanization and productivity is essential for a comprehensive study about the case in Sri Lanka, and to draw on international experiences.

Agriculture Labour

Involvement of the youth and women in agriculture

Agriculture labour involves both family and paid workers. To attract outside labour, mainly youth, well-functioning agriculture labour markets are important (Hurst, 2007). Despite the difficulty to attract, the involvement of youth in agriculture is important for sustaining agricultural productivity due to their characteristics such as resilience, resourcefulness and perseverance (Naamwintome B F, 2013). As highlighted by Kibwika & Semana (n.d), in the case of Ghana, one of the main problems faced by youth is the mismatch between the skills needed for agriculture and the life skills and education they acquire from schools. The general problems in terms of lack of markets for capital, inputs, and extension services, lack of access to and control over the basic production resources (mainly land) and related absence of freedom to decide what agricultural enterprises to engage, lack of collateral, and absence of control over the benefits of their efforts, discourage youth from involving in agriculture in Ghana.

Globally, women account for a smaller share of employment in agriculture. In the developing world, women account for 40 percent of the agricultural labour force, while in South Asia, the estimate is only 35 percent (SOFA Team and C. Doss , 2011). Similar to the youth, females in agriculture also face issues in terms of credit and extension services (Kibwika & Semana, n.d, p. 7). However, more young males than females involve in agriculture "due to the former being capable of doing more tedious work usually associated with farming, than the females" (Adeogun, 2015: p. 215).

Effects of ageing labour force

In Bihar, farmers' most and least active ages before retiring are 18 to 24 and 35 to 39 respectively, and the age at which their involvement in agriculture begins to decline is 60 to 64 (Milovanovic & Smutka, 2020). Evidence from China shows that "technical efficiency initially increases with age until reaching a maximum when the average age of household labor input reaches 45, and thereafter it decreases" (Li & Sicular, 2013, p. 357). As noted by Saiyut et al. (2017), "… the labour force aged 60 years and over increased the technical inefficiency, while the labour force aged 15-59 years reduced the technical inefficiency in Thai agricultural production" (Saiyut, Bunyasiri, Sririsupluxana, & Mahathanaseth, 2017, p. 1). On the contrary, Suphannachart (2016) finds no statistical evidence of population ageing impacting productivity.

Worker out-migration

According to Satyal (2010), in Nepal, there is an agriculture labour shortage due to internal and international out migration of the rural working age population, where absentee population of the country accounted for 15 percent in 2008. Among them 80 percent belonged to the age group of 15-44 and 89 percent of them migrated from rural areas where the prominent livelihood activity of the people is agriculture. Jaquet & et al. (2019) shows that due to subsequent labour shortage caused by migration, some lands were left unused leading to over growth and forest recovery, while other lands were turned into grazing land with consequences such as land degradation.

However, Taylor, Rozelle, & de Brauw (2003) prove that although the loss of labour due to migration has a negative effect on household cropping income (but not on crop yield), migrant remittances have partially compensated for the loss labour effect by facilitating investments majorly in self-employment and minorly in crop production. As highlighted by Paris et al. (2009), in addition to consumption smoothing, remittances ease credit constraints for investments in agriculture and serve as an insurance. The authors show

that with regards to migration from rice farming areas in Philippine, Thailand and Vietnam, remittances from internal or external migration have been used for family consumption as well as for production investment activities. However, the comparison of the yield between migrant and non-migrant families indicates no difference except in dry season in Vietnam.

Part-time farming

As shown by Tetteh (2017), the income earned from off farm work can be utilized to purchase farm inputs or to adopt new technologies, while the income earned from farming can be invested in off farm activities. In fact, many developing countries have a forward and a backward linkage between farm and off farm income. Moreover, income diversification is observed as a very important livelihood strategy among smallholders who have possibility to utilize earnings from off-farm work to improve their yield (Tetteh, 2017). In addition to the generation of income, off farm employment also has a liquidity relaxing effect with a potential increase in farm expenditure/investment. Haiguang & et.al. (2013) show that in China, while the part time farming households invested more capital and materials in farming due to the absence of financial constraints, the full-time farming households invested less labour input and farming practices focused on elderly females and labourers with comparatively low education, causing to decline the yield of crops and the benefit of agricultural land use. Similarly, in Jammu and Kashmir, only 24 percent of the farm households exclusively depend on farming while others are involved in non-farm economic activities, so that agriculture is their secondary activity. The latter households are found to use more external inputs like fertilizer and pesticides than full-time farm households, leading to increase in productivity of the part-time farmers (Peshin & et al., 2018). Shittu (2014) also finds that in Southern Nigeria, production efficiency of the farm households has enhanced significantly due to off farm income, which has increased the cultivated land area by enabling access to land via leasing (Shittu, 2014).

However, there is also a lost labor effect, resulting in a potential allocation of labour away from the farm (Tetteh, 2017). Nevertheless, in an environment where the total number of farms has been declining and the number of part-time farmers who primarily depend on off-farm income avenues have been increasing, Singh, S. P. & et al. (1981) emphasize that part-time farmers are no less efficient than are full-time farmers. Thus, "part-time farmer does not, in itself, indicate anything about the productivity of that farm unit" (Singh & Williamson, 1981, p. 66). Similarly, Lien, Kumbhakar, & Hardaker (2008) notes that there are no observed differences in farm productivity or technical efficiency between part-

time and full-time farmers. Hence, it is concluded that the policy makers should not discourage part-time farming based on productivity or efficiency concerns (Lien, Kumbhakar, & Hardaker, 2008).

Policies to improve agriculture labour

Many countries are facing challenges in attracting workers into the agriculture sector and keeping the sector attractive and sustainable. Nevertheless, some countries have been successful in promoting employment in agriculture sector. With regards to Southeast Asian countries, the common factor explaining their impressive performances in agriculture is the role played by the government in terms of defining objectives and strategies in development plans, land reforms, provision of infrastructure, stabilized food prices, public investment in human capital development through formal education, expansion of extension services, and the handling of directly selected economic activities while encouraging private investment in others (Kidane, Maetz, & Dardel, 2006). In terms of the role of the legal and policy framework, in many countries, land reforms, regulatory frameworks, and contractual arrangements have been the key drivers for achieving agricultural success through a productive labour force. Similarly, an optimal size agricultural labour force is important. Hence, in order to make agriculture a viable sector to be employed, it is critical for agriculture labour surplus countries to direct the excess labour out of agriculture, by creating off-farm employment opportunities, developing other sectors in the economy and maintaining macroeconomic stability (Kidane, Maetz and Dardel, 2006). On the contrary, for countries without a surplus of labour in the agriculture sector, other strategies have proven successful. For instance, the success stories of Thailand provide useful lessons to learn from. By the late 1980s, Thailand could no longer add more to agriculture labour or land as manufacturing and services sectors in urban areas competed for labour. Hence, agricultural yields were increased through research as well as greater usage of fertilizers. Thousands of workers left agriculture during the economic boom in Thailand and therefore, labour was substituted by rapid mechanization. This was well facilitated by the increasing availability of formal credit. Ultimately, as farm labour productivity increased, average agriculture wages rose above wages in the manufacturing and services sectors from 1991 to 2004 (Leturque & Wiggins, 2011). According to Leturque and Wiggins (2011), the rural non-farm economy in Thailand has grown to the point where it provides around half of all rural jobs, and many of those jobs are linked to prospering agriculture. Moreover, "investments in education have had an important impact on agricultural labour productivity growth in Thailand" (Leturque and Wiggins, 2011: p. 25). Thailand has promoted universal primary education since the 1960s and the average rural literacy rates reached 80 percent even before the end of the 1970s. As pointed out by Leturque and Wiggins (2011), "investments in education have had an important impact on agricultural labour productivity growth, which,

perhaps unexpectedly, was more important than that on non-agricultural employment and poverty reduction (Leturque and Wiggins, 2011: p. 25).

The developments in Thai agriculture sector led to the emergence of a group of specialized, professional farmers who are technically innovative and focused on higher-value markets. Contract farming was a typical marketing arrangement for these farmers, and their incomes grew quickly during the economic boom of 1980-1996, even when the share of agriculture in the economy was in contraction. The government facilitated the emergence of contract farming schemes by supporting interaction among smallholders as well as between farmers and private companies supplying inputs and purchasing products. In addition to this, Thailand strongly supported the emergence of a national agribusiness sector, developing several public or semi-public agribusiness companies which involved in upstream and downstream linkages (Leturque and Wiggins, 2011).

Mechanization and Productivity

Lawal et. al., 2009 highlights that the capacity of a farmer to adopt agricultural innovations and make decisions on various aspects of farming is influenced by the level of education. Hence, education is often considered as highly important for sustainable agricultural growth and development (Lawal et. al., 2009). Similarly, agricultural mechanization or the adoption of technology to replace humans with non-human sources of power in agriculture production is influenced by the level of education. Such mechanization includes the application of tools, implements and machinery, operated by manual, animal or engine (fossil fuel or electric) (Diao, Silver, & Takeshima, 2016). The concept of agriculture mechanization is closely linked to agriculture intensification, which is the "increased application of labor and other inputs per unit of land (intensified use of inputs) and more frequent cropping of land through reducing fallow periods (intensified use of land)" (Diao, Silver, & Takeshima, 2016, p. 5). In addition to the increased use of agricultural inputs, agriculture intensification is also a process of agricultural technological changes. The adoption of technology and mechanization of farm activities saves cost, time and labour due to timeliness of operations, better quality of operations and exactness in the application of the inputs. Despite these advantages, the adoption of modern technology and farm mechanization is limited.

Improvement of farm technology and mechanization is also crucial to attract workers to agriculture because most people, especially the youth, tend to move away from agriculture when it involves more manual work and unpredicted losses due to low productivity, low capitalization and technological backwardness. There is ample evidence to show the importance of R&D in this regard. The case of China provides useful lessons for the formulation of policies related to R&D. China's research reform evolved

in four phases. In the very early reform era, the number of agricultural research institutes increased and subsequently in the next phase during 1986-1998, policymakers commercialized agricultural R&D and encouraged institutes to engage in income-generating activities because of the fiscal shortages for research support and low staff salaries. The third phase during 1999-2006 included the transformation of the public R&D system and the rise of enterprise-based R&D. Public research institutes were divided into three groups as public R&D institutes which were fully funded by the government, science and technology (S&T) service institutes which were partially government funded, and technology development institutes which were incorporated into the commercialization efforts. Final phase, which began from 2007, included further funding for agricultural research and further expansion of public research institutes. Apart from R&D, there was a rapid development of extension institutions in China since 1978. Today, China's agricultural R&D system and the public agricultural extension system are the largest in the world and its R&D system covers nearly every discipline in agriculture and related. These investments have translated directly into agricultural productivity growth, which has facilitated China's agricultural growth over the past (China's 40 Years of Agricultural Development and Reform, 2018).

Taiwan's agricultural development story provides another example for the importance of R&D for agriculture productivity. In fact, the vigorous and competent activity by Japanese scientists and administrators engaged in agricultural research in Taiwan played a massive role in promoting the development of irrigation facilities and in encouraging the adoption of improved farm practices. The policy makers in Taiwan mobilized labor for road-building and irrigation projects and disseminated information concerning improved farming methods and instructions for maintenance of land improvements (Johnston, 1962). Hence, "labor productivity in agriculture increased by something like 130 to 160 per cent over the 30-year span between the decade 1901-10 and the 1930's" (Johnston, 1962: p. 271).

Most countries have also rendered market support for farmers to increase their productivity. For example, in the development of the rice sector of Guinea, some key market interventions were, enhancing market conditions, providing market information on prices and imports, and increasing producer prices through narrowing the price differential between domestic and imported rice (Kidane, Maetz and Dardel, 2006). However, in China, despite their aim to increase farmers' income and promote farm production, subsidies and market interventions in terms of price supports did not result in satisfactory outcomes. Hence, officials gradually began to shift part of the budget from subsidies towards more productivity-enhancing investments, such as land consolidation. They also started to reduce the intensity of market interventions and phase out most price distorting policies (China's 40 Years of Agricultural Development and Reform, 2018). In

the case of China, both public and private agricultural investment created the foundation for the country's steady agricultural growth and rapid agricultural transformation. For example, investment in low to mid quality land has helped to improve soil quality and raise agricultural production capacity. Farmers have also significantly increased their own investments and use of inputs, leading to investments in irrigation and agricultural machinery as well as use of chemical fertilisers and pesticides dramatically increasing since 1978 (China's 40 Years of Agricultural Development and Reform, 2018) Moreover, in China, stabilizing farmers' control and income through land contract rights provided incentives for them to invest in agriculture and stimulate land transfer among farmers, leading to increases in farm size which improved agricultural efficiency, productivity and incomes. The particular rise in agricultural productivity facilitated China's transformation from grain-dominated to more diversified agriculture because farmers were able to shift their land and labour from grain to cash crops and livestock (China's 40 Years of Agricultural Development and Reform, 2018).

Thus, when the public policy creates a favourable environment, the farmers tend to actively participate and make their own contributions to improve their productivity and technology. For example, Guinea's domestic rice production doubled in the 1990s due to the creation of an improved policy environment for private sector involvement and support for the development of private processing units through credit facilities. In Thailand, the provision of agricultural credit through institutional innovations has contributed to the development of more capital and technology-intensive agriculture since the 1980s. It ensured most of the small farmers can obtain credit and other financial services, enabling agricultural investment and progress in terms of productivity (Leturque and Wiggins, 2011).

Implications of out-migration, ageing and part-time farming on agriculture mechanization and productivity

Some existing literature underscore the implications of out-migration, ageing and part-time farming on agriculture mechanization and productivity. Li & Sicular (2013) show that inefficiency of older farmers is due to lack of management skills, poor adoption of new technologies, reluctance to expand the farm and accumulate capital, and risk aversion. Similarly, Guo & et al. (2015) show that intention of abandoning agriculture by some old farmers is related to their declining productivity caused by lower investments on inputs like fertilizer, seeds etc. On the contrary, Suphannachart (2016) highlights that "the improvements in health and longevity lead to farmers' experiences in agriculture and adoption of machinery and new technology, enabling them to continue in agricultural activities" (Suphannachart, 2016, pp. 10-11). It is found that rather than ageing, the other factors like land- labour ratio, capital labour ratio, research budget-labour ratio and educational level are positively influencing agricultural labour productivity.

Satyal (2010) notes that out-migration from rural areas in Nepal is leading to lower productivity in agriculture. Migration has created a shortage in agricultural labour force leading to a decline in local production. At the same time, foreign remittances have increased the demand for food and raised food prices. Nevertheless, in the context of the associated increase in domestic wages and inability to increase labour productivity had led to the abandoning of agriculture (Pant, 2013). In terms of remittances, Khanal & et al. (2015) show that in Nepal, a major portion of remittances have been used for consumption purposes while only very small portion, 5 percent, have been invested in agriculture, causing a declining productivity. Hence, investment in agriculture and income from agriculture have been higher in non-migrated households than migrated households. Similarly, Singh, Singh & Jha (2012) show that in Bihar, allocation of remittances for agricultural input could have further increased if proper infrastructure facilities were available in the rural areas for faster dissemination of modern technology to increase agricultural productivity.

However, the story of China is different in this regard. China's agriculture has become more specialized since the 1990s and mechanization began recently as non-farm employment increased significantly. The fundamental reasons behind the improvement of the country's rural economy have been the rise in agricultural productivity and diversification and the booming growth of other sectors in the economy. Gaining off-farm employment opportunities allowed farmers to work part-time on the farm and the rise of urbanization, manufacturing and construction sectors provided an even stronger impetus to move off the farm. Since the mid-2000s, off-farm wages have been rising and as more households began to work full-time off the farm, they began to rent out their lands. Those who stayed were the ones who rented those lands and they started specializing in farm activities, paving way for a steady increase in farm size and increasing pressure to mechanize (China's 40 Years of Agricultural Development and Reform, 2018).

In the case of the Philippines Velosa (2011) finds that remittances have increased the fraction of farms involved in high value commercial crops while decreased the fraction of farms engaged in crop diversification, increased the mechanical technology adoption among rice farmers and become a source of insurance and investment finance that promotes agricultural development. Duc Loc (2015) suggests that remittances in Vietnam led to a shift from rice to other crops, leading to an increase in land productivity, while the absence of remittances after migration resulted in decreasing diversification as well as labour productivity. Similarly, Wang, Wang, & Pan (2011) highlight that the negative-labour drain effect of non-farm income activities is set off by the positive investment

inducing effect, which greatly contribute to the growth of agricultural productivity. These authors find that non-farm activities largely increase agricultural capital stock and agricultural productivity. Evidence from Pakistan and Bangladesh show mixed effects of labour out-migration on agriculture mechanization and productivity. For example, for a labour incentive crop – cotton, migration has negatively affected productivity despite the use of remittances to purchase inputs, while for the less labour intensive crop – wheat migration has a positive impact on the productivity, as the remittances contributed to timely purchase of input (Imran & et al., 2016). Evidence from Bangladesh, show that international migrants, who are generally better off and participating for high return employments, are applying modern technology while the internal migrants who are poor and participating for low return jobs, do not apply modern technology resulting for low productivity (Mendola, 2008).

Diiro & et al. (2013) find a positive and significant effect of household off-farm income on the adoption of improved maize varieties. "A one percent increase in off- farm income earned increased the probability of adopting improved maize varieties by about 0.4 percent" and one percent increase in off farm income led to a 0.3 percent increase of hectares planting improved maize varieties (Diiro, 2013, p. 5). However, Vietnam, Nguyen (n.d.) finds mixed results with regards to the impact of part time farming on productivity. Farmers in Southern Vietnam have their production unaffected due to part time farming, while in Northern Vietnam farmers were hiring labour to substitute for family labour, investing more capital and adapting into less labour intensive farming activities. The author concludes that "non-farm employment is mere a substitute than a complement to rice production" (Nguyen, non- dated, p. 1). Similarly, in examining the linkages among agricultural total factor productivity, farm size and farm household participation in the off-farm labour market for the Southeastern region of the United States, Yee & et al. (2004), reveal that the off-farm work and productivity are negatively related (Yee, Abearn, & Huffman, 2004).

Finally, it is important to note that some international literature highlights the problems encountered in measuring labour productivity. Doss (2018) highlights that regardless of gender, measuring labour inputs is challenging. Labour is often measured in days worked, and in estimating productivity, farmers are required to recall how many days were spent working on each task during the previous season, and it involves the implicit assumption that "a day's work is a useful measure of input and that the contribution of each day's work is roughly equal. These measures rarely account for hours worked or effort expended" (Doss, 2018, p. 40). Moreover, "for a variety of reasons, including social norms, skills and physical capabilities, there may be differences in the labour provided by men and women" (Doss, 2018, p. 40). In this context, men's and women's labour are

treated as separate inputs in an agricultural production function, where often household output value is regressed on a vector of inputs, including men's and women's labour. There is mixed evidence on the gender gap in labour productivity as some studies find no gender gap while other do find that the marginal product of female labour is lower than that of male labour (Doss, 2018).

Chapter 4 : Data and Methodology

4.1 Data

The analysis in this report is based on both primary and secondary data sources. Primary data consists of quantitative data collected in a sample survey conducted in 2020, as well as qualitative data collected from Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs). Secondary data sources of the study are the micro-data sets of the last four rounds (2006, 2009, 2013 and 2016) of the Household Income and Expenditure Survey (HIES) conducted by the Department of Census and Statistics, Sri Lanka.

Primary data

Household survey

The primary data collection for the sample survey was conducted in 11 districts from February 12, 2020 to March 1, 2020. The shaded rows in Table 4-1 indicate districts sampled into the survey. The selection of districts for the survey was based on multiple criteria.

1. Represent dynamics in agriculture labor:

In order to capture the dynamism in agriculture labour and labour shortages, districts with wide variation in the share of employment in agriculture were selected. Here, the range of 24-56 percent employment in agriculture was captured by the selected districts. Specifically, districts such as Badulla, Monaragala, and Anuradhapura represent districts higher than national average of 26 percent, while Jaffna and Kilinochchi, represent districts with lower than national average, in terms of share of workers employed in agriculture (see column 2 in Table 4-1).

2. Represent crop diversity:

Districts were selected for the survey to represent all broad crop types covered in the scope of this study. As such, the sample includes districts important for paddy cultivation such as Anuradhapura, Polonnaruwa and Ampara, while Badulla is included to represent vegetable cultivation. Matale is selected for its importance in cultivation of spices, while Monaragala is included due to its cultivation of a wide cross section of crops including fruits, vegetables and other OFCs (see column 3-6 in Table 4-1).

3. Represent ethnic diversity

In order to represent ethnic diversity, districts with a majority of Sinhala speaking population as well as districts with a majority of Tamil speaking communities were selected. This criterion also aims to address the representation of minority communities.

4. Represent variation in agro-ecological zones

The districts selected covers all three zones in terms of rainfall namely wet, intermediate and dry zones. In terms of elevation, the districts selected represent all three categorizations in terms of up country, mid country and low country. As such, the selected districts represent the agro-ecological zones of intermediate zone low country, dry zone low country, intermediate zone mid country, wet zone mid country and intermediate zone up country (see column 7).

5. Cover the geographic scope of larger ASMP

Finally, all 11 districts selected for the survey overlapped with the scope of the larger ASMP. In sampling, districts with high involvement in plantation agriculture were excluded due to being beyond the scope of this study.

Within these districts, the geographic locations were randomly selected first as Divisional Secretariat Divisions (DSDs) within districts, and second as Grama Niladhari Divisions (GNDs) within DSDs. Within a selected GND, field work was started from a randomly selected location, and every third house was visited for the survey. In the event of a house not meeting the recruitment criteria for the survey, the subsequent houses were visited until meeting the recruitment criteria and after each successful interview, the third household was visited.

However, by drawing a sample directly proportionate to the size of the population employed in agriculture would result in drawing very small samples from some districts, and would limit the possibility of arriving at meaningful estimates at the district level (see column 8 in Table 4-1). In order to address this limitation, the district samples were restricted within the range of $43 < n < 209$. This resulted in increasing the sample sizes in Kilinochchi, Mullaitivu and Vavuniya and capping the sample size in Anuradhapura and Badulla. The corresponding adjusted sample household size for each district is depicted in column (9) in Table 4-1 while the total number of individuals surveyed from each district is presented in column 10.

The total of 1020 households in 11 selected districts are distributed proportionate to the population in agriculture employment. At the national level, in 2017[2], there were 791,316

[2] Latest available National Level data from Labour Force Survey 2017 (DCS, 2017) at the time of sampling.

persons involved in agriculture and a sample of 1000 household works out to 0.13 percent. Hence, from each district, close to 0.13 percent of the agriculture households were sampled. As such, the number of households sampled from each district is broadly proportionate to the population employed in agriculture to arrive at a total of 1000 households. Additionally, the survey also collected information about hired labour involved in agricultural activities of these households.

The survey involved a structured questionnaire with close-ended questions, on modules covering characteristics along the themes of demographics, employment, land, inputs and output of crops, labour inputs, mechanization, technology, hazards, credit, and income. The survey questionnaire was developed in consultation with the Agriculture Sector Modernization Project team at the Ministry of Agriculture. Enumeration of the survey was carried out both in Sinhala and Tamil, based on the requirements of the selected locations. In this context, due to the coverage of nearly half of all districts in Sri Lanka with a sample of 1020 households with 3543 household member, and another 5985 hired agricultural workers[3] the ALS2020 is a nationally representative, rich quantitative data source focusing on agricultural labour in Sri Lanka.

Collection of qualitative primary data

The quantitative data of the primary survey was complemented with KIIs involving 22 individuals involved in agriculture sector and 5 FGDs involving 46 individuals. The respondents to the qualitative data collections were selected based on maximum variation sampling technique, where a wide cross section of stakeholders with diverse expertise and exposure were interviewed. The areas of expertise represented by KII respondents included agriculture related academic research, agrarian service centres, training centres, farmers organizations, public and private technology developers and agrarian research centres, private sector agri-businesses, and informal sector agri-businesses.

For the FGDs, participants were selected based on the fulfillment of recruitment criteria of involvement in agriculture. Additionally, participants were selected to represent both genders and diverse age groups. Both FGDs and KIIs were carried out based on discussion and interview guides developed, respectively. The FGD guide covered the themes of labour in agriculture, extension and other services, mechanization and modern

[3] There may be multiple counting of hired workers as more than one households may have reported information about a given hired worker who may work for multiple farms in the area.

technology, and cost of production. The KII guides broadly covered the themes of agriculture labour, labour productivity, and mechanization and modern technology, and the guides were customized based on the expertise of the respondents.

Table 4-1 District-wise characteristics of agriculture

	2017 employed in agriculture		2017 Paddy producti-on targets	2017 production targets			Agro-ecological Zones	No of households proportionate to population in agriculture	Adjusted sample	
	No.	%	(Mt)	Vegetab-le (t)	Fruit (t)	OFC (t)			No. HHs	No. individuals
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Total	2,140,185	26.1	5,078,217	1,616,255	856,777	810,826		1000	1020	3543
Colombo	24,100	2.5	15,540	15,079	5,370	268	WL			
Gampaha	28,976	3.2	48,390	11,525	35,226	768	IL			
Kalutara	64,957	12.9	61,045	14,766	14,707	813	WL			
Kandy	117,394	22.2	77,245	70,684	26,477	3,833	WM			
Matale[1]	70,222	36.2	120,315	43,382	3,251	34,936	DL, IL, IM, IU & WM	89	89	266
Nuwara eliya	213,489	64.3	22,665	307,737	11,902	6,903	WU			
Galle	106,934	26.1	58,495	8,635	18,214	323	WL			
Matara	117,409	34.2	93,670	11,283	22,664	330	WL			
Hambantota[2]	78,928	32.2	260,200	104,155	46,455	10,373	DL			
Jaffna	48,234	24.2	26,230	37,163	31,827	75,538	DL	61	61	287
Mannar	12,245	33.2	105,895	12,264	1,881	9,060	DL			
Vavunia[3]	23,957	32.7	102,490	30,234	16,708	18,684	DL	18	43	125
Mullativu[4]	14,032	40.6	70,585	37,634	9,625	19,102	DL	30	45	135
Kilinochchi	8,880	24.8	89,665	26,180	11,194	7,581	DL	11	43	127
Batticaloa[5]	45,051	28.2	288,705	18,949	5,878	15,918	DL	57	57	194
Ampara[6]	62,043	29.5	604,430	47,982	20,494	63,806	DL	78	78	170
Trincomalee[7]	33,103	25.4	267,920	35,974	55,458	25,325	DL			

Kurunegala[8]	203,041	29	491,775	51,872	59,120	23,303	IL			
Puttalam	83,291	26.5	132,025	76,236	48,145	41,824	IL, DL			
Anuradhapura[9]	173,920	46.1	537,567	103,989	4,484	185,986	DL	220	200	615
Polonnaruwa[10]	50,315	34.3	270,325	9,651	7,610	7,791	DL	64	68	247
Badulla[11]	196,864	54.5	111,320	236,553	7,842	48,059	IL	249	208	872
Moneragala[12]	97,798	51	213,440	115,472	134,946	103,654	IL	124	128	505
Ratnapura[13]	195,777	40.2	65,630	65,963	37,070	8,390	WL			
Kegalle	69,224	20	55,145	19,850	47,247	673	WL			

Notes: (1) District production targets reported in paddy, vegetable, fruit and OFC columns of this table are excluding production targets of respective Mahaweli systems under each district, as mentioned below:

[1]Mahaweli system G (Paddy: 42,340 Mt, Vegetable:3500 t, Fruits: 5307 t, OFC: 3641 t)

[3,4,9]Mahaweli system L (Paddy: 6100 Mt, Vegetable:135 t, Fruits: 1529 t, OFC: 1496 t)

[5,10]Mahaweli system B (Paddy: 195,545 Mt, Vegetable: 2997 t, Fruits: 13,079 t, OFC: 3010 t)

[6,10,11]Mahaweli system C (Paddy: 237,025 Mt, Vegetable:4194 t, Fruits:10,218 t, OFC: 6989 t)

[7,10]Mahaweli system D (Paddy: 3195 Mt, Vegetable:479 t, Fruits: 674 t, OFC:342 t)

[8,9]Mahaweli system H (Paddy:192,165 Mt, Vegetables: 49,767 t, Fruits: 36,561 t, OFC: 34,984 t)

[6,11]Rambakenoya (Paddy: 12,600 Mt, Vegetable: 2167 t, Fruits: 1441 t, OFC: 1841 t)

[2,12,13]Uda Walawe (Paddy: 118,395 Mt, Vegetable: 24,142 t, Fruits: 102,115 t, OFC: 4,251 t)

(2) WL: wet zone, low country IL: Intermediate low country WU: Wet upcountry
DL: Dry zone, low country IU: intermediate zone up country IM: Intermediate zone mid country
WM: Wet zone mid country

Source: Authors' calculations based on Labour Force Survey 2017; Annual Report CBSL (2019); and Crop production targets (*http://www.agrimin.gov.lk/web/index.php/en/downloads/statistics-news)*

Secondary data

Secondary data for this study is from the most recent four rounds of the Household Income and Expenditure Survey -2016, 2012/13, 2009/10 and 2006/7. The HIES is conducted by the Department of Census and Statistics (DCS). In its each round the HIES micro-data covers an approximate sample of 25,000 covering all 25 districts in the country representative at the national level.

The HIES is a yearlong sample survey which is conducted in 12 consecutive monthly rounds and an island wide representative sample of equal size is enumerated in each monthly round to capture seasonal and regional variations of income, expenditure and

consumption patterns. The data from HIES 2012/13 and HIES 2016 were nationally representative covering all 25 districts, while the survey for 2006/7 excluded districts in Northern Province and Trincomalee district, and 2009/10 excluded Mannar, Kilinochchi and Mullaithivu districts. In 2016 the survey was carried out from January to December 2016, while in all other rounds, the survey period of 12 consecutive months spanned across two adjoining years.

HIES consists of a demographic schedule, which includes information of all household members about their economic activity, while the other schedules include education, health, detailed schedules on expenditure and income, inventory of durable goods, debt, access to facilities, and housing information including exposure to natural hazards. The analysis in the study mainly relies on demographic and income data, which is disaggregated as income from paid employment, income from agricultural activities which focuses on paddy, other seasonal crops, , income from other agricultural activities, income from non- agricultural activities, and income from other cash receipt,. The study uses HIES data for the analysis of attractiveness of agriculture due to it wider coverage and inclusion of both agricultural and non-agricultural households, facilitating the analysis of preference for agriculture.

4.2 Methodology

The overall methodology of the proposed study involves a Concurrent Mixed Method, where qualitative and quantitative data are collected at the same time and integrated for the overall analysis with secondary data. The Concurrent Mixed Method approach adds breadth and depth to the analysis resulting in a comprehensive study, where limitation of each type of analysis, qualitative versus quantitative and primary versus secondary, is compensated by the other. The analysis is further strengthened by the review of existing literature.

In developing the profile of agriculture labour force, a descriptive analysis with univariate and bivariate analyses are conducted using primary data from the ALS2020. Detailed profile of agricultural households, workers involved in agriculture as the primary activity and workers involved in agriculture as the secondary activity are presented in Chapter 5. In addition to the main analysis, supplementary tables based on HIES2016 data are also presented as an annexure.

The investigation of how to improve attractiveness of agriculture for youth and female workers in Sri Lanka, is based on a pooled cross-section dataset and a pseudo panel data set created by pooling HIES data of four survey years: 2016, 2012/13, 2009/10 and 2006/7.

The unit of analysis in the pooled dataset are individuals, while the unit of analysis in the pseudo panel data set for youth is birth-gender cohorts and birth cohorts for female analysis.

The sample construction is shown in Table 4-2. For each of the youth and female analyses, the initial analysis focus on pooled data set consisting of all individuals in a Multinomial Probit Model (MNP), where the three alternative outcomes available are economic inactivity, employment in agricultural activities and employment in non-agricultural activities. The next analysis focuses on economically active individuals in the pooled dataset with a linear probability model using Ordinary Least Squares (OLS) methodology for the two outcomes of employment in agricultural activities versus employment in non-agricultural activities. Finally, the pseudo panel data is used for the economically active cohort level analysis with a fixed effect mode for the choice of employment in agricultural or non-agricultural activities through a linear probability model. The pseudo panel analysis is able to give more unbiased estimates than the pooled analyses, since it follows a cohort of individuals over time, which allows to control for unobserved cohort specific characteristics.

Table 4-2 Sample construction for youth and female econometric analysis

Data set	Youth				Female	
	Pooled Full sample	Economically Active sample			Pooled Full sample	Economically Active sample
		All	Male	Female		
No of individuals - 2016	13,075	8,031	5,291	2,740	23,890	8,842
No of individuals - 2012/13	13,117	7,409	5,113	2,296	24,185	8,070
No of individuals - 2009/10	12,508	6,955	4,946	2,009	23,395	7,777
No of individuals - 2006	12,594	6,331	4,483	1,848	23,607	7,900
Total number of individuals	51,294	28,726	19,833	8,893	95,077	32,589
Total number of cohorts	-	176	88	88	-	88
Average cohort size	-	163	225	101	-	370

Source: Authors' calculations

Pooled Analysis

The birth years considered for this analysis is limited to 1977-1987 to reflect the 19-29 year-old individuals in HIES 2006 who become 29-39 year olds in HIES 2016. Multinomial Probit and linear probability (OLS) methodologies are applied, where the dependent variable in this analysis is an indicator variable for youth/females are employed in agriculture or not. For this purpose, the definition for of the agriculture labor force is those engaged in agriculture industry work in the areas of (1) crop agriculture and (2) mixed farming (both crop and animal production) as per the Sri Lanka Standardized Industrial Classification (SLSIC) industry codes. Due to scope of the study being limited to paddy and other food crops (OFCs), those involved in the plantation (tea, rubber and coconut) sector have been omitted from this group. Similarly, animal production is also not considered (although it is classified as an agricultural activity) unless the individual is engaged in animal production simultaneous to crop agriculture (mixed farming).

The independent variables chosen for the analysis are demographic variables such as age, age squared, marital status, ethnicity, education level; household level variables such as household non-agriculture income, family members income, household agriculture profit, household size, presence of young children, share of elders, share of females, presence of migrants in household, presence of debt in household, access to personal transport (ownership of at least one vehicle), access to information (ownership of a phone); and agriculture related variables such as household heads' involvement in agriculture, agriculture subsector (paddy, vegetables, other cereals), part-time farming, agriculture cultivation area, ownership of agricultural land by household, distance to agrarian centre, agriculture mechanization score [4], average agriculture and non-agriculture income in district, and household natural disaster experience. Dummies for HIES survey year, belonging to youth age group 19-29 and district are also included.

Pseudo Panel Analysis

The cohorts for the pseudo panel analysis of youth employment is based on birth year, bi-annual birth period, and gender cohorts (identified as birth-gender cohorts) across 2016, 2012/13, 2009/10 and 2006/7 HIES data sets. The birth years considered for the analysis is limited to 1977-1987 to reflect the 19-29-year-old individuals in HIES 2006 who become 29-39-year-olds in HIES 2016. With eleven such birth cohorts, two bi-annual birth periods, and two gender groups across four datasets (11*2*2*4) results in potentially 176 cells of cohort mean data. The choice of birth-gender cohorts defined in this manner are

[4] Score from 1-5 of the the number of agriculture equipment owned by household

stable cohorts due to the inability for individuals to switch neither birth year, bi-annual birth period, nor gender across survey years. Furthermore, the sample is restricted to economically active youth.

Based on the above configuration, 176 potential cells would include mean values of the individuals in respective variable for each cohort. The variables would be of three types:

• Continuous variables, i.e. including age, age squared, household non-agriculture income, family members income, household agriculture profit, average agriculture and non-agriculture income in district, household size, share of elders, share of females, agriculture cultivation area, distance to agrarian centre, agriculture mechanization index score would be the mean value for individuals in each cell (cohort).

• Dummy variables, i.e. HIES survey year, youth age group 19-29, would indicate that a given characteristic is possessed by everyone in the cell or by no one in the cell.

• Proportional variables, i.e. marital status, ethnicity, education level, presence of young children, household heads' involvement in agriculture, agriculture subsector (paddy, vegetables, other cereals), part-time farming, presence of migrants in household, presence of debt in household, ownership of agricultural land/vehicles/mobile phone by household, household natural disaster experience, would be the share of individuals processing the said characteristic.

The dependent variable in this analysis would be a proportional variable (Yit) constructed as the share of youth employed in agriculture relative to total youth, for cohort i at time period t, and i=1,…N and t=1,…,T.

Those falling under the definition of youth are in a specific age group and thus in a unique phase in their lives. They are often starting their work life, beginning to be independent and income earners, and thus often not mature and experienced compared to those in subsequent age groups. Thus, certain traits such as attitudes towards occupations, and expectations about employment, which are often unobserved, tend to influence their behavior in the labour market and their preferences for certain jobs. Moreover, these attitudes tend to change when they progress towards the latter end of the age group defined as youth. As such, if these unobserved determinants are not controlled for, the determinants models via an ordinary least squares method becomes biased. To ensure identification and overcome such omitted variable bias, an appropriate strategy is to adopt the Fixed Effect methodology using pseudo panel data from HIES four rounds of data collection, to estimate the following equation. Fixed effect models are based on three assumptions for identification to be valid. They are unobserved heterogeneity is time invariant and cohort specific, it is additive, which allows the time invariant cohort specific

unobserved heterogeneity such as attitudes, denoted as α_i appear in the linear model as depicted in Equation 1 below, and that unobserved heterogeneity is correlated with regressors.

$$y_{it}=x_{it}\beta+\alpha i+\varepsilon_{it} \qquad \text{Equation 1}$$

Here X_{it} is a vector of characteristics that includes the continuous, dummy, and proportional independent variables discussed above for cohort i at time t. Given the identification strategy and its possibility to arrive at causal interpretations, the vector of β coefficients would indicate the effect of each variable on the share of youth employed in agriculture net of cohort fixed effects. For instance, by understanding the causal effect of ownership of agricultural land on the outcome, appropriate land policies can be introduced to attract youth into agriculture employment. Similarly, the impact of education and ownership of agricultural equipment on youth employment in agriculture can be identified and required policy measures can be recommended to improve youth employment.

If, the unobserved heterogeneity is random rather than being fixed, the error terms would be biased. In order to test the presence of fixed effects and the validity of the methodology a Hausman Test would be conducted.

Similar to the case of modeling youth in agriculture, the case of females in agriculture is also modeled using a pooled data in a MNP model for all females, and linear probability model for economically active females. Next using the pseudo panel data structure a fixed effect model is estimated on economically active females. In this analysis Equation 1 would be adopted after changing of the outcome variable as the proportion of females in agriculture defined as the share of females employed in agriculture out of total females. The same definition as in the youth analysis applies for defining those participating in agriculture work.

The cohort structure for the analysis of females in agriculture is comprised of 22 two-year age group cohorts, for those born between the years 1945-1988, in the 2016, 2012/13, 2009/10 and 2006/7 HIES data sets. As per this construction, in the 2006/7 survey, the youngest cohort is age 18-19 and oldest is 60-61 years. After following these cohorts for 4 rounds of HIES, the said oldest cohort would now be 70-71 years, while the youngest cohorts would have aged to 28-29 years. As per this configuration of birth cohorts across four survey years, the data structure would comprise of 88 potential cells for analysis (22*4).

Additionally, data from KIIs and FGDs would be used to add qualitative dimensions to quantitative findings and to triangulate findings. All qualitative data collected via KIIs

and FGDs would be analyzed under key themes emerging from data. Findings from quantitative and qualitative data are triangulated to arrive at conclusions.

The analysis of productivity involves a descriptive analysis and a regression analysis for determinants of productivity using ALS2020 data. In analyzing the determinants of productivity, household level cross sectional data from ALS2020 is used in an OLS regression as seen in Equation 2. Given that farmers considered in this analysis are involved in producing multiple agricultural outputs using many agricultural inputs literature dictates the adoption of a common unit of measurement for outputs and inputs. FAO (2017, pp 40, 42), notes that "putting a monetary value on the respective output allows aggregating the output of different crops and products", while "inputs also must be aggregated, generally by converting them to monetary units". As such, the outcome variable of the analysis of agricultural productivity is defined as the ratio of agriculture outputs to agriculture inputs, while in the labour productivity analysis, it is the ratio of income from agriculture to man hours of agriculture labour used. For each of the productivity analyses, the productivity calculation thecash costs are considered, with the exception of family labour, for which the cost is calculated by using imputed values with average wage rate in the area by DSD division, age groups and gender.

$$Productivity_i = \beta X_i + e_i \qquad \text{Equation 2}$$

where i = indicates i^{th} household.

The analysis of farm mechanization in Sri Lanka involves a detailed descriptive analysis using quantitative and qualitative data from ALS2020. Additionally, a household level agriculture mechanization score is calculated to aggregate multiple variables that represent mechanization into a single score, that is easier to interpret. Here, each mechanization variable s assigned an equal weight and the total is summed to arrive at the mechanization score. The mechanization score arrived in this manner is regressed as a OLS model on independent variables to arrive at its determinants (similar to Equation 2).

Chapter 5 : Profile of Agricultural Households and Workers in Sri Lanka

This section investigates the basic characteristics and related information of individuals involved in agriculture. As identified through the review of literature, apart from wages, multitude of other interrelated factors contribute to an individuals' decisions to supply labor at various points in their life. These other factors that affect the labour supply decision in a utility maximization setting mainly include returns to education, skills and experience, nature of work, stage in life and other household, socio-economic and cultural characteristics.

Hence, an understanding about the profile of agriculture workers is crucial to identify the factors that affect the labour supply decisions in agriculture and thereby formulate strategies to improve the attractiveness of agriculture for employment. As such, the following section presents a detailed profile of agriculture households in line with some important indicators highlighted in the literature review for their potential implications on agriculture labour supply, with special emphasis to the age and gender profile, feminization, ageing, outmigration, part-time farming, and geographical regions, as outlined in the scope and tasks of the study.[5]

Initially, the analysis focuses on all members of agriculture households, to understand the overall household characteristics. The second part focuses on individuals involved in agriculture, to discern characteristics specific to the agriculture labour force. The analysis of the agriculture labour force is disaggregated into two components - one focusing on those self-reported to involve in agriculture as their primary economic activity while the other focuses on those self-reported to involve in agriculture as their secondary economic activity. This disaggregated analysis aims to bring out the differences between two groups.

The entire analysis of the profile is based on primary data collected by the authors in 2020, referred to as the Agriculture Labour Survey 2020 (ALS2020). The sample comprises of 1020 agricultural households, consisting of 3,543 individuals[6], of which

[5] The scope of the study is outlined in the Terms of Reference (TOR) provided by the Agriculture Sector Modernization Project of the Ministry of Agriculture, Rural Economic Affairs, Irrigation and Fisheries and Aquatic Resources Development in the Contract Agreement (No.LK-MOA-PMU-31829-CS-QCBS).

[6] See Chapter 3 for a detailed information about the ALS2020.

1,671 are involved in agriculture. Among them, a majority of 1,328 are involved in agriculture as their primary economic activity, while the remaining 343 are involved in agriculture as their secondary economic activity. Utilizing this data source, the profile of agricultural households and workers are developed adopting a descriptive methodology. As an annex, more tabulations along the same indicators are presented using Household Income and Expenditure Survey (HIES) 2016. The analysis of both data sources is not presented side by side due to definitional issues. Nevertheless, for indicators where data is not available in ALS2020, information is presented using on HIES2016, subsequent to indicating the associated caveats.

5.1 Profile of Agricultural households

In this sample of 1020 agricultural households in the ALS2020, the average household size was 3.5 members and up to 98 percent of households comprised 6 members or less. In terms of composition, while 29 percent of the total 3,543 agricultural household members were heads of households, 25 percent were wives of the head of the household, indicating the larger number of male headed households. In fact, less than 1 percent were husbands of the head of the household. In terms of children within the household, a larger share were males, where sons of the head of the household accounted for 23 percent, while daughters accounted for 17 percent (Figure 5-1). As such, there is a significance of nuclear families among agriculture communities.

The majority of the agricultural household members were Sinhala (75 percent) while Tamils account for 21 percent. Muslims and Burghers accounted for 4 percent and 0.1 percent, respectively. Similar patterns could be identified with the religious representation where Buddhists accounted for 74 percent, followed by Hindus accounting for 21 percent, while those following Islam and Christianity/Catholicism accounting for 4 percent and 0.7 percent, respectively.

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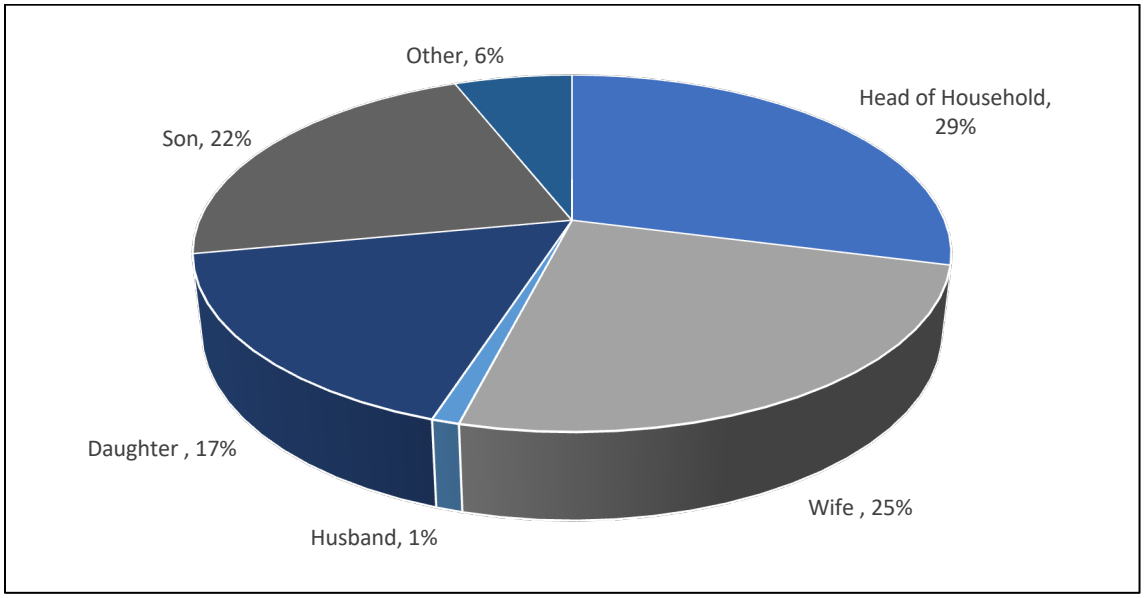
Figure 5-1: Composition of agricultural households - 2020



Source: Authors

In terms of gender composition in agriculture households, data reveals a near equal split, with a share of 51 percent of males, more equal to the national picture. This shows that there is no gender bias in the availability of labour for agricultural work, within these households. With regards to the age group levels, the highest share was in 30-55 years age group[7] (41 percent), followed by below 19 years (30 percent) (Table 5-1). When age groups were disaggregated by gender, male shares were higher in all age groups, except for 30-55 years. As seen in the population pyramid below, when disaggregated by 5-year age groups, there is a near equal gender split in the age group of 20-95 years. The shape is somewhat barrel-shaped for 20-60 years.

Table 5-1: Age by gender of household members

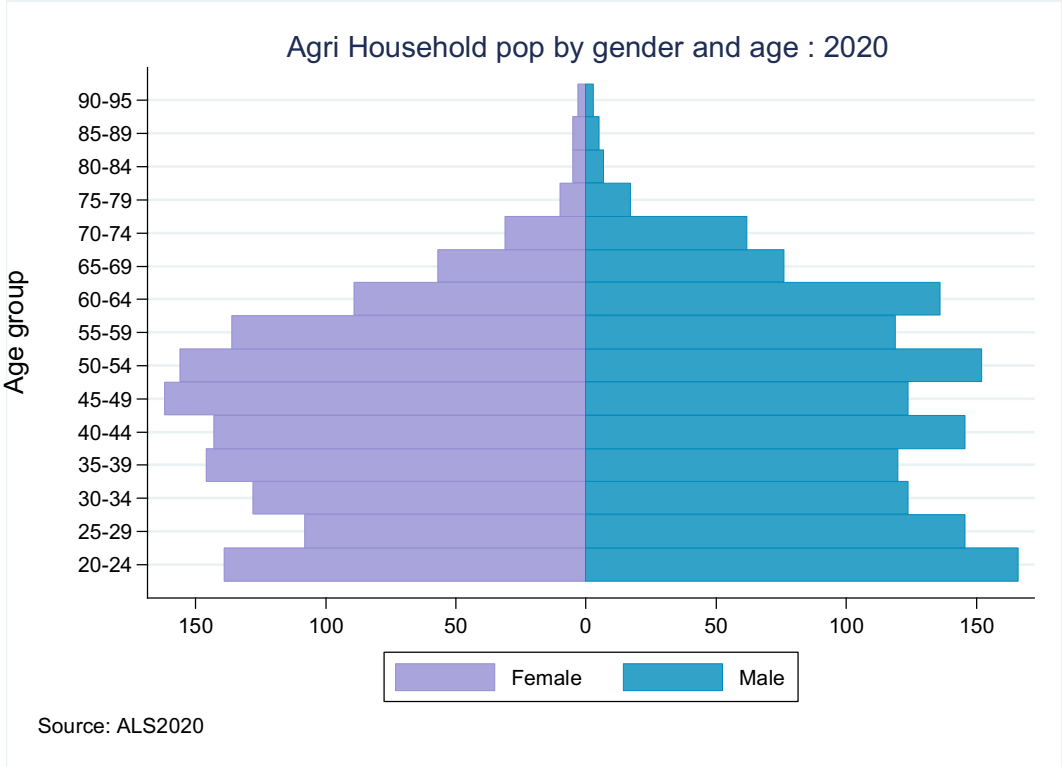
Age group	Sex (% within age group)		Age group (% of total)
	Male	Female	
Below 19 years (%)	51	49	22
19-29 years (%)	56	44	17

[7] The age groups are defined in this manner as per the scope of the study which focuses on youth, and to a lesser extent on older individuals.

30-55 years (%)	47	53	41
Over 55 years (%)	57	43	20
Total (in absolute value)	1,719	1,824	3,543

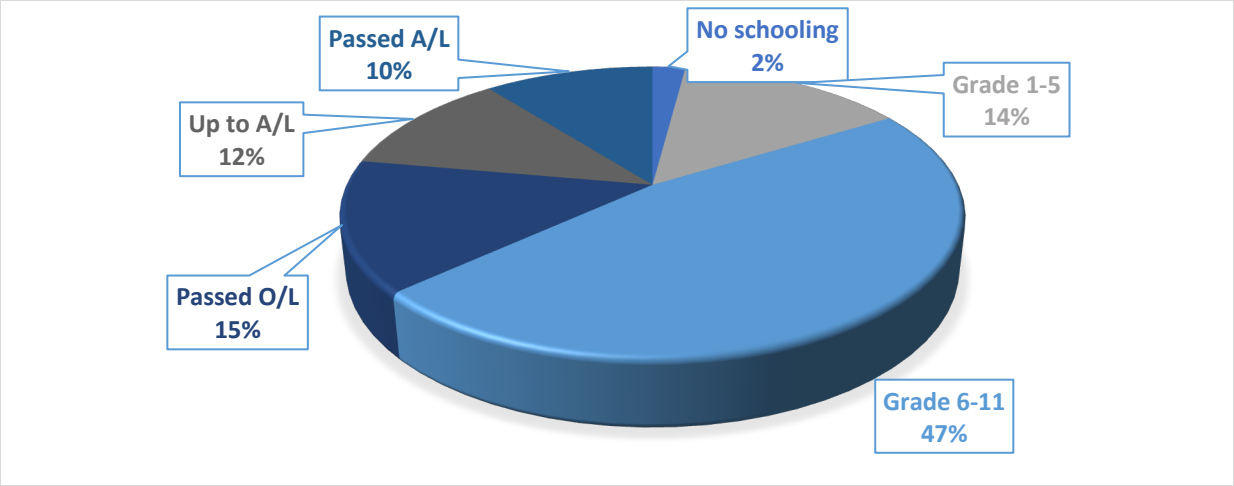
Source: Authors

Figure 5-2 : Agricultural household population by age and gender : 2020



Among children in the ages of 5-17 years, 85 percent were currently schooling. As depicted in Figure 5-3, among the adult household members (equal or above 18 years of age) 2 percent have not gone to school, while 14 percent and 47 percent of the individuals have gone up to grades 1 to 5 and grades 6 to 11, respectively. In this sample 14 percent has passed the O/L exam, while 12 percent and 11 percent studied up to A/L and passed A/L, respectively.

Figure 5-3: Schooling of Agriculture Household Members in ALS2020



Source: Authors

The average area cultivated by a household in this sample was 349 perches, while, 74 percent of these households owned their land, 7 percent had shared land ownership, and another 2 percent have encroached the land. Another 14 percent of the households had leased in the land they cultivate. Moreover, 72 percent of the households used one land for cultivation, while 18 percent used two lands. In terms of the terrain of the main land used for agriculture, 76 percent were flat land, 23 percent were with a slope, while only 2 percent accounted for a steep slope and undulated lands for the cultivation (see Table 5-2).

Table 5-2: Agricultural land characteristics

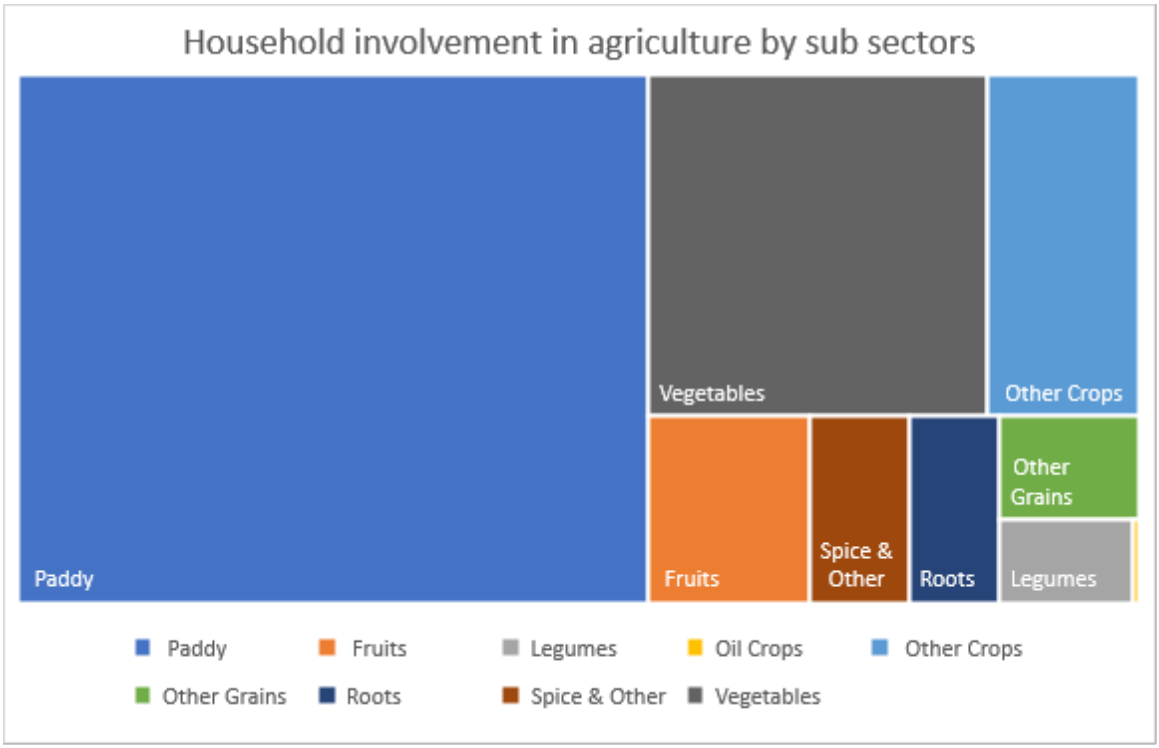
Variable	Value
Average cultivated land area	349 **(in perches)**
Ownership	
Fully owned by household	74%
Shared ownership by household	7%
Encroached	2%
Leased in	14%
Terrain	
Flat	76%
Slop	23%
Steep slope and undulated lands	2%

Source: Authors

Subsectors within agriculture

Of these agricultural households 48 percent were involved in paddy cultivation only, while 44 percent were involved in OFC only. Around 8 percent of the households were involved in both crop types. Paddy was the cultivation in which most of the farmers were engaged, followed by vegetables, other crops and fruits.

Figure 5-4: Household involvement in agriculture by subsectors



Source: Authors' illustration

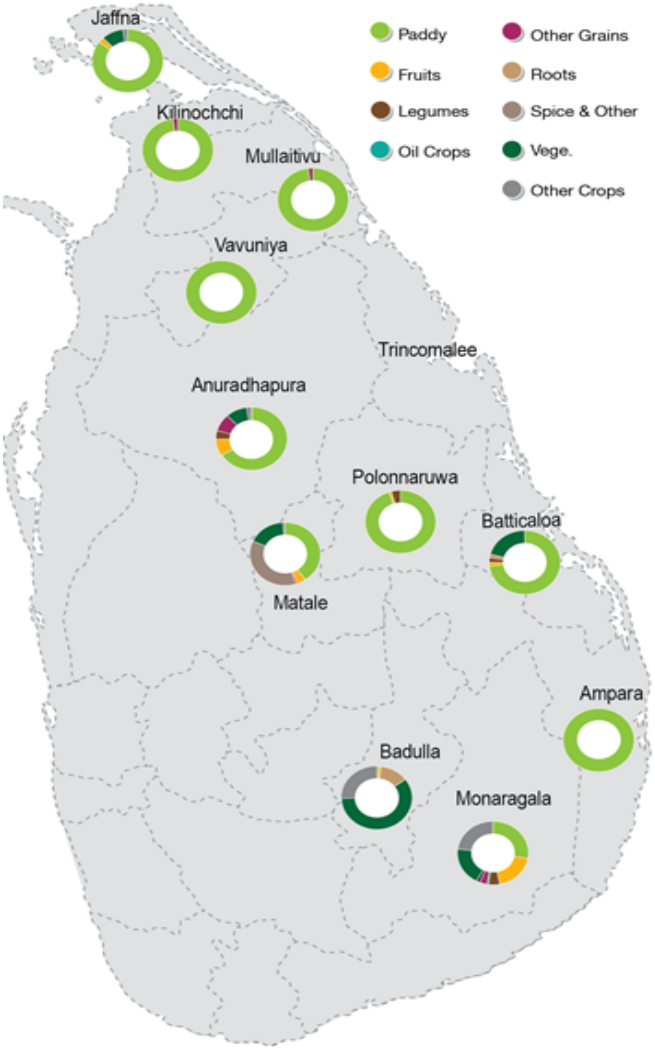
Note: 'Other crops' refers to crops other than those depicted in diagram. OFCs are all crops depicted in the diagram other than paddy.

Geographic location

In terms of the geographical distribution of crops, Ampara and Vavauniya were involved in paddy cultivation only, while Kilinochchi and Mulaitivu involved mainly in paddy and other grains. Polonnaruwa district was mainly involved in paddy, with 4 percent of the households reported to have cultivated legumes and another 1 percent reported to

have cultivated fruits. In Jaffna, in addition to paddy, the responding households also cultivated vegetables (10 percent) and fruits (3 percent) and other crops (2 percent). In Batticaloa, 74 percent of the households were involved in paddy cultivation, while the share involved in vegetables was 21 percent. Additionally, in Batticaloa, 2 percent of the households cultivate roots, legumes and fruits, each. In Anuradhapura, in addition to paddy (67 percent), households were also involved in vegetables (10 percent), fruits and other grains (9 percent each), and legumes (4 percent). In Matale district, the share of households involved in paddy was only 40 percent, while 36 percent of the households were involved in cultivation of spices, 17 percent in vegetables, and 4 percent in fruits. Matale was the only district in the sample where spices were cultivated. In Monaragala, 28 percent of the households cultivated paddy, while 23 percent cultivated other crops. The share of fruits and vegetable cultivations in Monaragala were 19 percent each. At the same time, Monaragala was the only district in the sample where households cultivating oil crops (1 percent) were interviewed. In the case of Badulla, the highest share of households were involved in vegetable cultivation (59 percent), followed by 25 percent in other crops and 13 percent in roots. Among the households in Badulla, paddy and fruits cultivations, each accounted for only 1 percent (see Table 5-3).

Table 5-3: Geographical distribution of crops - ALS2020



Source: Authors

Full time and part-time farming

In this analysis individuals involved in agriculture as their main economic activity are identified as full-time farmers, while those involved in agriculture as the secondary activity are considered part-time farmers. When defined in this manner, this sample has 1,328 (37 percent) full time farmers among all household members, while 11 percent or 343 individuals are part time farmers.

Of all household members 13 percent were engaged in non-farm economic activities as their main economic activity, while a large proportion claimed to be full-time students - 18 percent (this includes children as well), and 4 percent were unemployed (see top panel

Table 5-4). Among the total agricultural household members, 74 percent did not engage in any secondary economic activity, while 8 percent engaged in non-farm economic activities as the secondary work. As such, in the terms of their full-time and part-time activities, agriculture was dominant in these households.

Nevertheless, in terms of the types of alternative occupations they involve in, among the 449 who were involved in agriculture as part-time farmers, the majority were engaged in other activities as skilled workers (59 percent), followed by those in clerical or teaching occupations (12 percent) and unskilled work (10 percent) (see bottom panel in Table 5-4). Similarly, when considering those part-time farmers, their other occupations included skilled work (39 percent), agriculture[8] (7 percent) and clerical or teaching occupations (6 percent) (see bottom panel in Table 5-5).

Table 5-4: Main Activities of agricultural household members - 2020

Main Activity	Number	%
Farming/ Agriculture	1,328	37
Student	645	18
Housewife	522	15
Non-farm economic activity	**449**	**13**
Doing nothing	314	9
seeking for and available for work	133	4
Unable to work /retired/other	152	4
TOTAL	3,543	100
Main activity: Non-farm economic activity – Main Occupations		
Skilled Worker	263	59
Clerical / Teacher	52	12
Unskilled Worker	43	10
Businessperson	27	6
Junior Management	7	2
Executive	3	1
Junior Executive	2	<1
Other	52	12
Total	449	100

Source: Authors

[8] This is in the situation where both primary and secondary employment are in agriculture.

Table 5-5: Secondary Activities of agricultural household members - 2020

Secondary Activity	Number	%
No Secondary activity	2,259	74
Farming/ Agriculture	**343**	11
Non-farm economic activity	243	8
Housewife	143	5
Other	74	2
	3,062	100
Secondary activity: Farming/ Agriculture – *Main* Occupations		
Skilled Worker	135	39
Agriculture	24	7
Clerical / Teacher	22	6
Business	14	4
Unskilled Worker	14	4
Executive	2	1
Junior Management	1	0
Other	131	38
TOTAL	343	100

Source: Authors

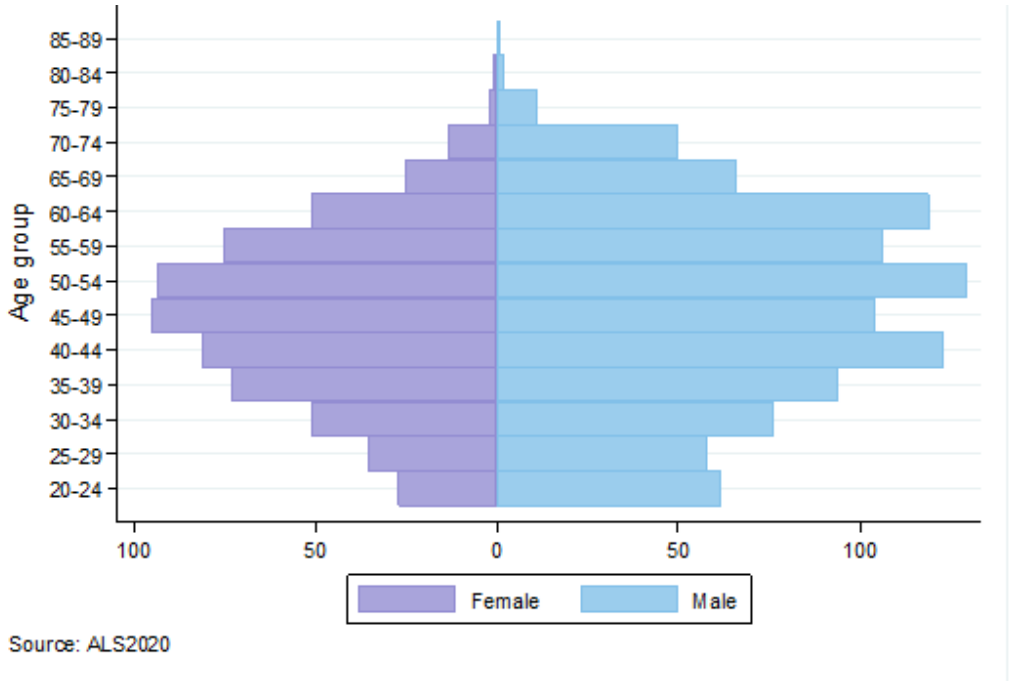
The ALS2020 survey also collected data about why some individuals are not involved in agriculture. Among the reasons as to why one is not involved in agriculture, 29 percent reported due to being involved in further studies and 22 percent reported lack of time due the current occupation. Another 11 percent indicated that they do not like to be engaged in agriculture, while 5 percent are not involved due to their parental preference and influence towards other employment/activity. Over another 4 percent indicated reasons including risks and uncertainties in agriculture, its labour incentive, strenuous, and time-consuming nature, and insufficient income. In similar vein, qualitative findings also revealed that attitude, insufficient income and parental influence may lead to distract especially youth from agriculture sector and mechanization/ agriculture modernization is an ideal approach to attract youth to agriculture sector. For instance, a KII stakeholder[9] highlighted that "I think whole mechanization process is a best approach to attract youth to agriculture sector. Because of this new technology and mechanization, they may involve in agriculture."

[9] Private sector official interviewed on 16/02/2021

Age, Gender and (de-)feminization in agriculture

Among those involved in agriculture as full-time or part-time farmer in these agricultural households, the gender and age disaggregation is depicted in the population pyramid below. Contrary to the previous population pyramid of all household members, here a clear bulging is seen in the male side of the pyramid.

Figure 5-5: Age pyramid of those involvement in agriculture - ALS2020



In addition to family labour agriculture also relies on hired labour, and ALS 2020 collected detailed information of hired labour, over and above the information collected from the 3543-household member covered in the 1020 households. As such, in terms various agricultural activities information on the use of family versus hired labour was collected. Based on such activity wise data collected, in addition to the 1635 family worker[10] there were another 5985 hired workers[11] involved in agriculture in these areas.

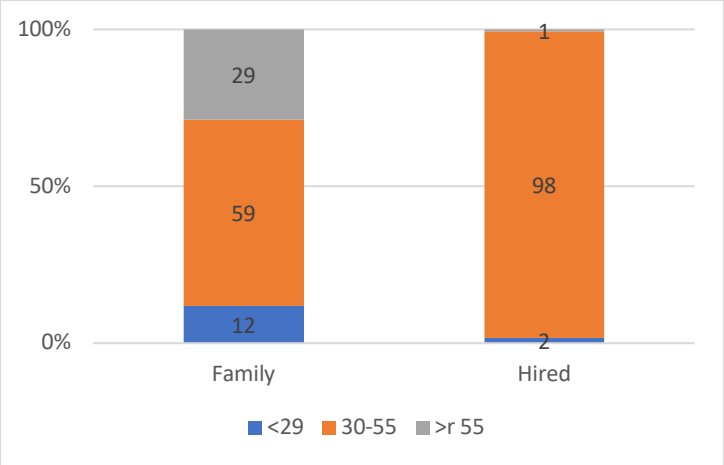
[10] The total number of family workers in full time and part time is 1671, while the total number of family workers when counted based on activities is 1635. The discrepancy of 36 is due to reporting errors across the two schedules in the survey.

[11] There may be multiple counting of hired workers as more than one households may have reported information about a given hired worker who may work for multiple farms in the area.

Hired and Family labour by age group

Hired and family workers in agriculture are dissimilar. As seen in Figure 5-6, in the case of family labour even though there is a clear majority among 35-55 year old worker, the composition also includes over a third of older workers and 12 per cent of youth workers. On the contrary, when hired workers are considered, 98 percent are in the age group of 35-55 years while only 1 and 2 percent are in older and youth workers, respectively.

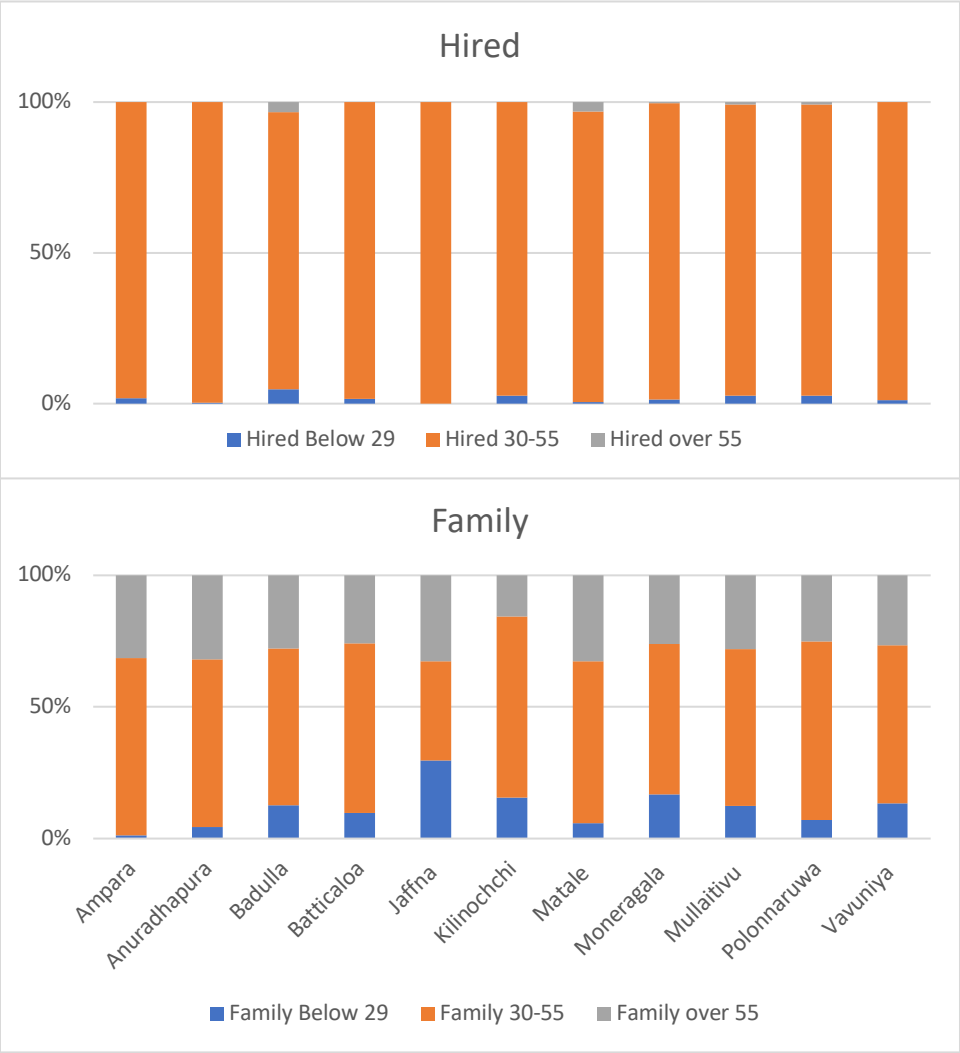
Figure 5-6: Age distribution of family and hired workers



Source: Authors

When the age distribution of hired and family workers are disaggregated by districts also, the significance of the 35-55 year old age bracket among hired workers is seen (see top panel in Figure 5-7), while the involvement of other age groups are minute. Nevertheless, when family labour is considered a reasonable mix of 35-55 year old and older workers are seen across all districts. It is interesting to note that Jaffna has the highest involvement of youth workers which accounts for a substantial 30 percent. This is consistent with the relatively low youth unemployment rate in the Northern province observed in Labour Force Survey (DCS, 2019). In the other extreme Ampara has the lowest share (1 percent) of youth family workers involved in agriculture. This is in line with provincial statistics from the Labour Force Survey, which shows that Eastern province is one of the provinces with the lowest share of youth among unemployed population (DCS, 2019). In terms of older workers also Jaffna together with Matale has the largest share of older family workers, which is 30 percent. The share of older workers in all districts range between 25 to 33 percent, except for Kilinochchi, which is 16 percent.

Figure 5-7: District disaggregation of age of hired and family workers



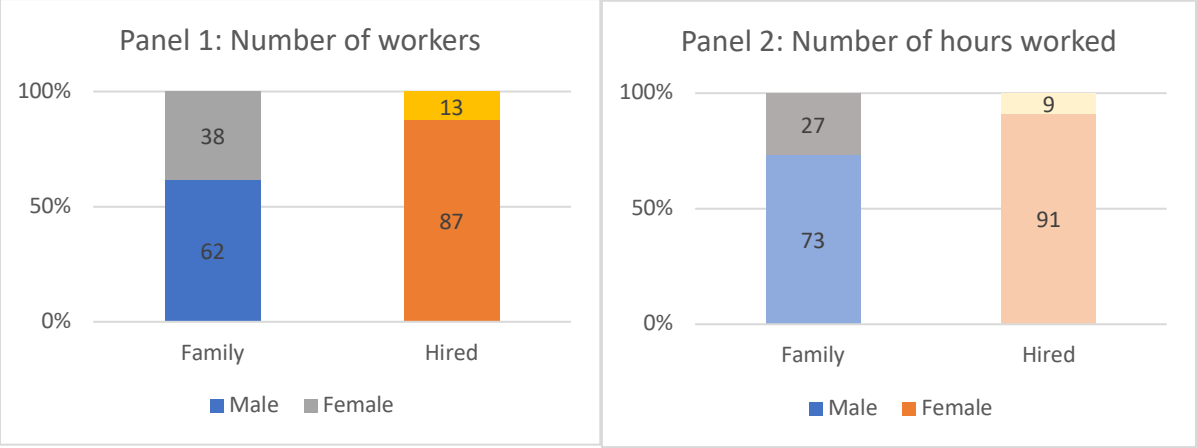
Source: Authors

Hired and Family labour by gender

When the number of family and hired workers used in agriculture is disaggregated by gender a distinct difference is seen in these two types of workers, where the share of females in family labour is much higher than among hired labour. Specifically, as shown in the left panel in Figure 5-8 the share of female workers among family workers was 38% while the corresponding share among hired workers is only 13%. This reflects the preference or greater ability for females to work in own agricultural pursuits rather than in outside farms, possibly due to the capacity to manage both household responsibilities

and agricultural work as often highlighted in literature. Similarly, this could also be due to the relatively lower wages earned by hired female workers compared to hired male workers. The average wage of a female workers in this sample is LKR 1009.61, while the corresponding wage rate for males is LKR 1313.58. As such, this gender wage gap in agriculture also may be contributing to discourage females from working in agriculture for a wage.

Figure 5-8 : Gender in family vs hired workers



Source: Authors

Within the 11 districts considered for the study there is significant variance in terms of the proportions of male and female workers. As seen in left panel in **Table 5-6**, in Batticaloa neither family nor hired female workers were reported, while in Kilinochchi and Vavuniya female labour was only among family workers and no females were reported as hired workers. Literature points towards there being social restrictions for Muslim women to engage in livelihoods outside the home (Gunawardana,2018) which has affected participation in these districts. Despite being a nearby districts with similar ethnic profiles Mullaitivu and Jaffna have reported both family and hired female workers, though the proportion of hired labour is much smaller. On the contrary, the share of family female workers in these two districts are among the top 3 districts with 20% and 16%, respectively. As such, the involvement or not of female labour is not necessarily a cultural/ethnic reason as Tamil farmers across these four districts have females' involvement in agriculture at very extreme levels. In Moneragala, the share of female hired labour is almost equal to the share of male family labour, while in Badulla equal shares of males and females of family workers contribute to total workers. There

is district wise variation in the use of family vs hired labour by gender, possibly driven by a combination of crop types, environmental conditions for farming and cultural aspects.

In contrast to the number of workers engaged in agriculture, when the number of hours actually worked in agriculture are considered the distribution of effort in agriculture by family and hired workers by gender shows a slightly different picture, as seen in the right panel in Figure 5-8. Specifically, in the right panel the share of involvement of females among family and hired workers is lower than before. Nevertheless, the male dominance in the sector is retained.

Some differences are also seen across district disaggregation as depicted right panel in Table 5-6. For instance, in Kilinochchi and Vavuniya, when hours worked is considered, male family workers make a larger contribution, where in Vavuniya 65 percent of the hourly contribution towards agriculture is made by hired male workers, while in Kilinochchi their contribution is 55 percent. Even though not reflected in terms of number of workers involved in agriculture (left panel), when the number of hours contributed is considered in right panel of Table 5-6 in Batticaloa male family workers make a 99% contribution. The next highest contribution of male family workers is seen in Ampara district. Similarly, in the case of family female labour also, the right panel shows a larger contribution than in left panel. For instance, in Mullaitivu and Badulla the female family contribution in hours are 38 and 35 percent, in contract to 20 and 19 percent seen before, respectively. Moreover, the contribution of hired females is much lower in the right panel than in the left panel. For instance, in Anuradhapura female hired labour accounts for only 10% of all labour hours in the district. Similalarly, in Matale, the contribution from female family workers is larger than that of hired male workers. These results show that it is important to consider the actual number of hours involved in agriculture rather than the person level involvement or not in agriculture.

Table 5-6: District wise disaggregation of hired and family labour by gender

	% of No. of workers involved in agriculture				% of No of hours involved in in agriculture			
District	family Male	hired Male	family female	hired female	Family male	Hired male	Family female	Hired female
Ampara	14	85	1	1	64	35	1	0
Anuradhapura	14	59	7	20	43	29	18	10
Badulla	19	46	19	17	40	19	35	5
Batticaloa	9	91	0	0	99	1	0	0
Jaffna	22	61	16	1	59	12	28	1
Kilinochchi	4	92	4	0	25	55	20	0
Matale	16	59	13	11	51	21	26	2
Moneragala	15	62	7	15	41	44	14	2
Mullaitivu	23	55	20	2	49	10	38	3
Polonnaruwa	15	67	8	10	51	33	14	2
Vavuniya	2	97	1	0	22	65	13	0

Source: Authors

Migration and remittances

In addition to income from sources discussed above, some agricultural households receive remittances sent by internal or international migrants. In fact, 23 percent of the agricultural households received internal remittances and the average annual internal remittances received was LKR 429,344. To overcome the underrepresentation of international migrants in ALS2020, here we also considered migration and remittances using HIES2016 for the definition of agricultural households in HIES2016). In the HIES2016 secondary data, 5 percent of the agricultural households consist of at least one international migrant while 14 percent consist of at least one internal migrant. Moreover, around 6 percent of the agricultural household are reported to be receiving an international remittance income, while 11 percent receive internal remittances.

Wages, Income and borrowing

The average daily wage of agricultural workers in ALS2020 is LKR 1274.32, while the male average daily wage is LKR 1313.58 and the female wage rate is LKR 1009.61. The age and gender disaggregated wage rates are depicted in Table 5-7 below. After disregarding the single observation for female youth reported in the table, the highest

daily wage rate is earned in agriculture by male over 55 years, which is LKR 1359. The lowest daily wage is earned by over 55 year old females, which is LKR 950.

Table 5-7: Average wage of agriculture workers by gender and age group

	Mean	Std, Dev	No. of observations	Min	Max
Male_Less29	1206	357	42	350	1500
Male_30_55Yrs	1316	364	1158	350	6000
Male_55Yrs	1359	125	27	1200	1500
Female_Less29	1500		1	1500	1500
Female_30_55Yrs	1010	218	171	600	2000
female_55Yrs	950	151	10	800	1300

Notes: average wage based on those earning positive agricultural workers
Source: Authors

The annual average agriculture income of these households was LKR 118,104, while corresponding non-agricultural income was LKR 429,344. In terms of the financial position of the households, the sample revealed that the majority of the agricultural households have not borrowed during the last two years. Specifically, 60 percent of the households in the sample were not indebted during the last 2 years. Among those who have borrowed, the sources borrowed from included Samurdhi bank, where 14 percent of the 1020 households have borrowed from, while 10 percent have borrowed from government commercial banks. Moreover, 6 percent of agricultural households were indebted to farmers (Govijana) banks and 4 percent to regional development banks (see Table 5-8). It is important to note that some households indicated borrowings from multiple sources.

Table 5-8: Indebtedness of households by entity (Primary Data)

Credit Sources	% of Households
Government commercial Banks	10
Private commercial banks	3
Private financial institutions	2
Regional Development Bank	4

Farmer (govijana) Bank	6
Samurdhi Bank	14
Cooperative Rural Bank	1
Sanasa Bank	1
NGO's	0
Community Organizations including death donation society	2
Private money Lenders including traders.	1
Supply agriculture products on credit basis	0.4

Source: Authors

In terms of the issues faced when borrowing from these sources, 36 percent of the households indicated that details of farm assets were requested, while 21 percent indicated the issue of overdue loans. Other issues highlighted by the responding households included farmers age (27 percent), and the need to show a stable income source (28 percent).

Reflecting the somewhat low level of understanding among agricultural households about the availability of credit for agriculture related mechanization and the adoption of advanced technology, about 8-16 percent of the responding households indicated that they do not know if the lending institutions in the formal sector would offer credit for these purposes. Nevertheless, 44-87 percent of the households indicated that credit is available from such institutions for mechanization and/or adoption of modern technology for agriculture purposes.

5.2 Profile of Labour in Agriculture as primary activity

This agriculture labour profile consists of two types of individuals involved in agriculture. The first type of individuals considered is those involved in agriculture as their main activity. There were 1328 individuals in the ALS2020 who reported agriculture as their primary economic activity the analysis on them is presented in this section.

62 percent of those involved in agriculture as the primary activity are heads of the household (HoH), and 26 percent are spouses of the HoH. Further, 10 percent account for children of the HoH, out of which 8 percent are sons while daughters accounted for only 2 percent (see Table 5-9). The low involvement of adult children of the HoH in agriculture further confirms less popularity of agriculture among the second generation. In terms of marital status of those involved in agriculture as their main activity, primary data reveals that 90 percent are married and 7 percent are never married, while 3 percent are widowed divorced or separated.

Table 5-9: Marital status and relationship among those involved in agriculture as major activity

Marital status	%	Relationship	%
Married	90	Head	62
Never Married	7	Spouse	26
Widowed/divorced /separated	3	Children	10
		Other	2

Source: Authors.

When it comes to the ethno-religious composition of those involved in agriculture as the major activity, data shows that the majority are Sinhala, followed by Tamils and Muslims (see Table 5-10). Mirroring ethnicity, in terms of region, Buddhists accounted for the largest share, followed by Hindu and Islam, while the share of Christians was the lowest.

Table 5-10: Ethnicity and religion of those involved in agriculture as major activity

Ethnicity	HIES Secondary Data 2016	ASMP Primary Data 2020	Religion	HIES Secondary Data 2016	ASMP Primary Data 2020
Sinhala	87	74	Buddhist	86	74
Tamil	11	20	Hindu	9	19
Muslim	2	6	Islam	2	6
Other	0	0.2	Christian	2	1
Total	100	100	Total	100	100

Source: Authors.

Gender and age

In terms of those who are involved in agriculture as their major activity, there is a clear dominance of males, in contrast to the near equal gender split seen in agriculture household members' profile. For instance, the primary ALS2020 data shows that the majority (66%) involved in agriculture are males (see Table 5-11). This underscores the low involvement of females in agriculture as their major

economic activity. The average age of those involved in agriculture as the major activity in the ALS2020 sample is 49 years, while the corresponding figures, when disaggregated by gender are 50 years for males and 47 years for females.

Under the age disaggregation 57 percent account for the age group of 30-55 years, as the key age group in agriculture. Similarly, the age group of over 55 years is the second largest age bracket, accounting for 34 percent of those involved in agriculture as the main activity. The age group of 19-29 accounts for 9 percent, while those below 19 years account for the smallest share of less than 1 percent. In terms of the gender split among age groups, overall, the dominance of males is seen. Nevertheless, the proportions diverge in the two data sources. The shares of male across all age groups range within 61-74 percent.

As such, two key patterns are observed - the disproportionately low involvement of females and youth in agriculture as a major economic activity. Moreover, it is important to note that despite the less popularity of agriculture among the youth in Sri Lanka, yet this cohort is consistent with the rest of the age cohorts in terms of gender preferences for agriculture.

Table 5-11: Age and gender of those involved in agriculture as major activity

	Male	Female	Total	
Av. Age (yrs)	50	47	49	
Share (%)	66	34	-	
	% in age group		% of total in age group	Av. Age (yrs)
Below 19 (%)	67	33	0.9	16
19-29 (%)	65	35	9	25
30-55 (%)	61	39	57	44
Over 55 (%)	74	26	34	64
Total			100	

Source: Authors.

Gender and age in education

The majority (36 percent) of those engaged in agriculture as the major activity are educated up to grades 6-11. The second largest group, which accounts for over a third is those schooled up to grades 1-5. A significantly larger share (21 percent) has studied up

to or passed the 12th grade A/L examination. 2 percent indicate no schooling (see Table 5-12).

Among all these involved in agriculture as their major activity, 79 percent have had an education of 10th grade or less. This might serve as a limiting factor in terms of the adoption of modern technology and equipment in their agricultural activities. This is further evident when level of schooling is disaggregated by gender and age groups. The majority of the individuals who have schooled up to grade 1-5 (65 percent) are males. On the other hand, this group comprise mainly those of 30-55 years of age while over 55 years of age bracket can be considered as the second majority which strengthen the above argument of limitation in technology adoption. Hence, the concentration of agriculture labour among the relatively lower educated and elderly rather than the young and educated, is further evidence of this limiting factor.

Table 5-12: Schooling level of those involved in agriculture as major activity (in %)

Level of schooling	Total	Gender		Age group (in yrs)			
		Male	Female	> 19	19-29	30-55	55 +
No schooling	2	73	27	3	13	47	37
Grade 1-5	34	65	35	0.4	10	53	31
Grade 6-10	36	75	25	0	3	54	43
O/L	6	50	50	0	19	65	16
Grade 12	15	55	45	3	12	62	23
A/L	7	59	51	2	19	46	33
Tertiary							
Total	100	66	34	1	9	57	34

Source: Authors.

Gender and age in agricultural activity

In a detailed analysis of the types of agricultural activities that workers are engaged in, it becomes evident that almost equal proportions are involved in all the four activities (land preparation, plant management, water management, and harvesting & post harvesting). In all these agricultural activities, the majority involved are males and, the highest and second-highest contribution to all these activities are from those in the age groups of 30-55 years and over 55 years, respectively.

Table 5-13: Agricultural Activity breakdown

Activity	Total	Gender			Age group (in yrs)		
		Male	Female	>19	19-29	30-55	55 +
Land Preparation	26	67	33	2	8	59	30
Plant Management	25	68	32	0	6	58	36
Water Management	25	77	23		8	50	42
Harvesting & Post Harvesting	24	69	31	0	7	62	31
Total	100	70	30	1	7	57	35

Source: Authors.

Geographic location

When considering the geographical breakdown of ALS2020, the survey was conducted in 12 divisional secretariats of 11 districts. The geographical breakdown of (primary) agriculture workers is shown in Table 5-14 below. Reflecting sampling[12], a majority are from Badulla (23 percent) and Anuradhapura (23 percent). Further, proportion distribution of Monaragala, Jaffna and Matale are 12 percent, 10 percent and 8 percent respectively. In contrast, Vavuniya, Mullaitivu and Batticaloa have the least share of sample distribution which are 4 percent, 3 percent and 2 percent respectively.

Table 5-14: District-wise breakdown

District	Number	Percent
Matale	103	7.76
Jaffna	128	9.64
Vavuniya	52	3.92
Mullaittivu	41	3.09
Killinochchi	54	4.07

[12] See Chapter on data and methodology.

Batticaloa	26	1.96
Ampara	86	6.48
Anuradhapura	304	22.89
Polannaruwa	73	5.5
Baddulla	307	23.12
Monaragala	154	11.6
Total	1328	100.00

Source: Authors.

Subsectors within agriculture

In ALS2020 primary data shows that the majority of agricultural workers are involved in cultivating paddy (78 percent), followed by 27 percent cultivating vegetables. The other types of crops cultivated by those involved in agriculture as their major activity include fruits (6 percent), other grains (5 percent), legumes (4 percent), roots (4 percent), and spices (3 percent). Further, in all the crop varieties the majority involved are males, except in the case of other crops, which has an equal contribution by both genders. With regards to the age, individuals who are in the age of 30-55 years can be identified as the major contributor to all crops, except for roots. Here the highest contribution is made by those over 55 years of age (49 percent).

Table 5-15: Agriculture sub sectors by age and gender

Agriculture Products	Number	%	Male (%)	Female (%)	>19 (%)	19-29 (%)	30-55 (%)	55 + (%)
Paddy	547	43	78	22	1	6	57	36
Legumes	45	4	80	20	2	9	51	38
Oil Crops	1	0.08	100	-	-	-	100	-
Vegetables	336	27	62	38	0.6	10	61	28
Roots	45	4	73	27	-	4	47	49
Fruits	71	6	79	21	-	1	58	41
Spices	34	3	68	32	-	-	56	44
Other Crops	126	10	50	50	-	9	56	35
Other Grains	62	5	68	32	-	8	58	34
Total	1267	100	70	30	0.6	10	61	28

Source: Authors.

5.2.1 Profile of Labour in Agriculture as a Secondary Activity

There were 343 individuals involved in ALS2020 who have reported agriculture as their secondary economic activity, and this section covers this segment of workers involved in agriculture.

In the case of other demographic characteristics also, regardless of agriculture being the major or minor economic activity, similar features are evident. Specifically, Sinhala Buddhists account for the largest share followed by Tamil Hindu. The share accounted for by Muslim - Islam is the lowest.

Table 5-16: Ethnicity and religion of those involved in agriculture as secondary activity

Ethnicity	ASMP Primary Data 2020	Religion	ASMP Primary Data 2020
Sinhala	62	Buddhist	62
Tamil	37	Hindu	37
Muslim	1	Islam	1
Total	100	Total	100

Notes: may not add to 100 due to rounding.
Source: Authors.

Gender and age

In this group of those involved in agriculture as a secondary activity, a larger share (61 percent) consists of males. This male dominance is consistent with the previously discussed group – those involved in agriculture as their main activity. The average age of the group is 41 years, while the gender disaggregated average ages are 40 and 43 years, for males and females, respectively. Among those who consider agriculture as their secondary activity, those in the age group of 30-55 years are 66 percent of the group, while 60 percent of them are males. The age group of over 55 years is the second largest age bracket and it accounts for 15 percent of those involved in agriculture as the secondary activity group. In the over 55 age group, males account for 55 percent. Among those in the secondary activity group 14 percent are aged 19-29 years and among them 69 percent are males. Lastly, 5 percent of the secondary activity group comprise those below 19 years of age, while among them a majority are males. The average ages disaggregated by

age group are as follows, 24 years in the youth age bracket of 19-29 years, 43 years in the 30-55 age bracket, and 62 years in the over 55 age bracket.

As the overall pattern of larger share of males that was seen in the previous analysis on agriculture as a major economic activity, is also evident here, where agriculture is considered the minor activity. Similarly, the pattern of those in the prime ages of 30-55 being mostly involved in agriculture, followed by elderly (over 55 years) and youth being least involved as a major activity are also seen among those involved in agriculture as a minor activity. As such, these descriptive analyses indicate that the lower popularity of agriculture among youth and women is not conditional on agriculture being the main economic or secondary/part-time activity.

Table 5-17 : Age and gender of those involved in agriculture as secondary activity

	ASMP Primary Data 2020			
	Male	Female	Total	
Av. Age (yrs)	40	43	41	
Share (%)	61	39	-	
	% in age group		% of total in age group	Ave age in yrs
Below 19 (%)	67	33	5	14
19-29 (%)	69	31	14	24
30-55 (%)	60	40	66	43
Over 55 (%)	55	45	15	62
Total			100	

Source: Authors.

Gender and age in education

In this segment of agricultural workers, 32 percent have schooled up to grades 1-5, while 21 percent have schooled up to grades 6-11 (see right panel in Table 5-18). Though females account for a lower share than males in each schooling bracket, yet, the gender split within education groups is somewhat even. For instance, among the individuals who have schooled up to grades 1-5 and grades 6-11, 63 percent and 64 percent are males respectively.

In terms of the age and schooling, as per ALS2020 data in this group, those with no schooling or less than the 5th grade are included in the 30-55 years age bracket, while the youth bracket (19-29 years) accounts for about third of those studied up to the 12th grade.

Moreover, in this sample, there is male dominance in every educational group. At the same time in the two extreme educational groups - no schooling and 12th grade, there are more females in agriculture.

Table 5-18: Schooling level of those involved in agriculture as minor activity (in %)

Level of schooling	ASMP Primary Data 2020					
	Total	Gender		Age group (in yrs)		
		Male	Female	19-29	30-55	55 +
No schooling	15	54	46	22	70	8
Grade 1-5	32	63	37	15	70	15
Grade 6-10	21	64	36	3	69	29
O/L	16	62	32	12	75	13
Grade 12	16	57	43	33	59	8

Source: Authors.

Gender and age in sub sectors and activities

Similar to those involved in agriculture as their major economic activity, among this group of individuals who consider agriculture as their secondary activity, paddy is the most popular (45 percent) crop. Vegetables are the (31 percent) second most popular variety, while fruits (4 percent), roots (4 percent), legumes (3 percent), other grains (3 percent), and spices & other (1 percent) are other crop varieties engaged in by this group. In this data, except for other grains and roots, with regards to all other varieties male involvement is higher than that of females. Nevertheless, in the case of cultivation of vegetables, there is large involvement of females (46 percent).

A notable feature is the highest involvement of those in age group of 30-55 years (78 percent) in the cultivation of other grains, which shows that the production of this particular product is hardly supported by the youth and elderly groups. In terms of specific activities in agriculture, most individuals, among those involved in agriculture as a minor activity are involved in land preparation (30 percent), while the lowest involvement is in water management (17 percent). As depicted in **Table 5-19**, all these activities are mainly carried out by males. Despite being lower than males, the involvement of females is highest in harvesting & post harvesting activities (46 percent), while the lowest female engagement is seen in water management (28 percent). In terms

of age disaggregation with regards to crops, for each agricultural activity, the most involved group is the age group of 30-55 years.

Table 5-19: Agriculture products and Activities

Crops	Total	Gender		Age group (in yrs)			
		Male	Female	>19	19-29	30-55	55 +
Paddy	45	66	34	8	18	63	11
Vegetables	31	54	46	6	14	67	14
Fruits	4	64	36	-	-	73	27
Legumes	3	63	38	13	13	75	-
Other Crops	10	68	32	-	14	75	11
Other Grains	3	44	56	-	11	78	11
Roots	4	45	55	9	9	64	18
Spice & other	1	100	-	-	-	50	50
TOTAL	**100**	**61**	**39**	**6**	**14**	**67**	**14**
Activity							
Land Preparation	30	64	36	8	11	63	17
Plant Management	29	58	42	6	18	61	14
Water Management	17	72	28	2	14	72	12
Harvesting & Post Harvesting	23	54	46	4	10	75	10
Total	**100**	**61**	**39**	**6**	**14**	**67**	**14**

Source: Authors.

Other activities and income

By definition, this group of individuals are involved in other economic activities alongside farming activities. In the case of ASMP primary data, these individuals are mainly involved in non-agriculture activities as skilled workers (65 percent). Additionally, 21 percent are involved as clerical workers/teachers, 13 percent as entrepreneurs and 12 percent as unskilled workers.

Chapter 6 : Youth and Female Labour in Agriculture

Labour plays an important role in the agriculture sector in Sri Lanka. However, as highlighted in the review of literature in Chapter 3, the sector faces a rising scarcity of labour. Weerahewa, Thibbotuwawa, & and Samaratunga (2015) note that the Sri Lankan agriculture labour market is continuously losing young women and men. Low participation of youth and females in the labor force is not unique to the agriculture sector. This is reflected in the decreasing unemployment rates by age seen in Sri Lanka in recent years, along with a low female labor force participation (40 percent) for the overall economy. In 2016-2018 (both years inclusive) the highest average unemployment rate of 20.5 percent was for the age group of 15-24 years, while for the 25-29 years age group the rate was 9.7 percent. For the age groups of 30-39 and 40 years and above the unemployment rates were 2.7 and 0.8 percent, respectively. In the case of females, they account for the larger share (74 per cent) of economically inactive population and a higher unemployment rate of 7.4 per cent in 2019 (DCS, 2019). Within such a context, this chapter explores the determinants of participation in agriculture sector for females and youths, in order to understand what policy measures can be adopted to draw more youngsters and women into agricultural employment.

6.1 Estimation

In this analysis we consider working age individuals have three alternative choices for economic activity. They are to be (i) economically inactive, (ii) economically active in agriculture, or (iii) economically active in non-agriculture. The push and pull factors of each alternative and the individual and household level factors influence one's choice among the three alternatives.

As extensively discussed in previous chapters, the theoretical framework of analysis of the attractiveness of agriculture for employment is based on the neoclassical theory of labour supply, where individuals allocate their time endowment between leisure and labour to maximize utility. In the calculation of utility maximization, multitude of interrelated factors contribute to an individuals' decisions to supply labor at various points in their life as they evaluate the expected return to market work relative to non-participation.

As per the job search theory, individuals would supply labour only if the market wage offered is higher than their reservation wage. In 2019, the agriculture sector earnings were relatively lower than those in industry and services sectors. For instance, the mean monthly wage among monthly salary earners in the services sector (LKR 43,378) is double that of the agriculture sector (LKR 21,852), while this gap is lower among daily wage earners. Yet, the mean daily wage in the agriculture sector is the lowest, which renders it relatively less attractive on the wage front. Literature shows that immature and inexperienced new entrants to the labour market have very high expectations and high reservation wages, which inhibit them from accepting most employment offers available in the market. Nevertheless, with maturity and greater length of time spent unemployed, such high reservation wage are decreased along with their adjustments to their expectations as per the reality in the Sri Lankan labour market. Similarly, empirical evidence in Sri Lanka suggests that relatively low opportunity cost for education promotes those with higher ability to acquire more years of education.

In addition to wages, other factors that affect the labour supply decision in a utility maximization setting include returns to education, skills and experience, nature of work (white collar or blue collar work), stage in life and household characteristics such as household size and structure, income and other remunerations etc. Along with these, as per literature and KIIs, the agriculture sector in Sri Lanka has many of factors that discourage workers to engage in the field, which are identified as "push factors" in technical labour economics contexts. Nevertheless, in an agricultural setting where employment is more informal than formal, the so called 'push' factors operate in a more intuitive manner. Those with high levels of education, skills and experience are less likely to resort to engage in agriculture due to its low average productivity and related low earnings, especially in the context of high dependency of agriculture income on favourable weather conditions. Due to this inherent uncertainty and risk structure of agriculture, those with higher returns to education are more likely to move away from agriculture. The relatively lower level of risk and uncertainty due to weather and natural disasters in non-agriculture activities serve as pull factors away to these jobs. Similarly, such low income earning capacity and hard work involved in agriculture discourages more educated and skilled individuals from engaging in agriculture. At the same time those who are depending on parents, with no dependents themselves, are more likely to be economically inactive with higher reservation wages.

In the case of females, cultural characteristics of the patriarchal society in Sri Lankan add a disproportionate burden on females for care and domestic activities whilst bearing the income earning burden as well. As such, females prefer for economic inactivity or economic activity that enable them to balance home and work-related activities in a

seamless manner. Thus, for females, agriculture possesses pull factors in terms of ability to combine household work schedule with agricultural work schedule and the possibility for part-time farming (Wickramasinghe, 2012).

Moreover, literature indicates that children's occupational choices have a strong positive correlation with parents' (Black & Devereux, 2011). At the same time, there is a tendency for parents' preference and expect their children to do better than themselves. In the case of parents involved in agriculture in Sri Lanka, there is a strong parental preference of farmer parents for their children to not be engaged in agriculture (Bamunuarachchi, 2018). The socio-economic situation of the household would also influence the decision to involve in agriculture. For instance, in well off families in rural areas, young adults and females can afford to be economically inactive. At the same time, as heard during KIIs, there is an emerging trend of youth from well off/urban families using rural land inherited from parents to cultivate crops as a part-time endeavor. Awareness about sustainability, good food habits, growing your own food etc., has created a new attraction toward agriculture.

Furthermore, lack of access or restricted access to land restricts farmers from mechanizing their activities, and inadequate poor transportation networks limits them from connecting to the agriculture supply chains. At the same time, credit constraints and attitudes of farming community towards use of new technology limits them from expanding or increasing productivity by mechanization or adopting modern technology (Kumara, Weerakkody, & Epasinghe, 2016).

As such, in modeling attractiveness of agriculture for youth and females above characteristics and determinants are considered as follows. To account demographic characteristics, the maturity and stage in one's life the variables age, age squared and marital status are included, while years of schooling is included to account for education. To account for cultural factors ethnicity is included, while household structure and related care burden – especially on females, is controlled by household size, and shares of females, elders and children less than 5 years. To capture the effect of parental influence on one's economic activity an indicator for head of the household's involvement in agriculture is included, based on the assumption that head of the household is a parent of the youth in the youth analysis or husband in the female analysis. To account for socio-economic situation of the household, annual household income, family members income, remittances, presence of internal and international migrants in households and an indicator for indebtedness are included in the models. Part-time farming - proxied based on the receipt of income from farming among other sources, is included to account for the flexibility in agriculture as well as the possibility of earning a

lower income from agriculture. As such, those earning income from farming and other activities are identified as part time farmers, while others not earning any income or only earning income from farming are not considered as part time farmers.

To control for factors that discourage employment in agriculture in terms of land issues an indicator for land ownership and the extent of agricultural land is included, while indicators for flooding, drought and wild animal attacks control for uncertainty and risk involved in agriculture. Additionally, the agriculture sub-sector involved by the respondents' household members is included to understand the relative attractiveness of sub-sectors. The household ownership of vehicle variable is used to account for access to transport to connect with agricultural supply chains, while the household ownership of mobile phone controls for networks and links in alternative economic activities as well as modern technology use in agriculture. The agriculture mechanization index reflects the level of mechanization in agricultural activities and related ease in carrying out these activities. Distance to the closest agrarian service center accounts for support from government services. To account for district effect dummies are included for district. The other dummies included are for belonging to youth age group 19-29 and HIES survey year.

Although this report focuses mainly on the supply-side, employment levels in agriculture are also influenced by demand side factors. Tacco, Davidova and Bailey (2012) suggests that the demand for agricultural labour depended on the agricultural output and is therefore in turn determined by the production function of the household. This includes technology, expected profits and relative prices of other inputs. In the case of Sri Lanka, the agriculture sector contribution to the national output has decreased while that of the industry and service sectors have increased over the years. In 2006 the contribution of agriculture to GDP was 12.3% whereas by 2016 it had fallen to 7.1% (CBSL, 2007, 2017). With the expansion of the non-agricultural sectors, it is likely that there is a higher labour demand within these sectors, drawing workers away from agriculture.

According to the standard theory of demand, the price which in this case is the wage rate is also major determinant of the demand for labour. As seen by the average wage rate in the agriculture sector of the country, throughout the period 2006-2016, it's clear that both monthly wage workers and daily wage workers in this sector received the lowest wage rate in relation to the other sectors (DCS, 2013, 2016). In addition, the Sri Lanka Labour Demand Survey, confirmed that the highest labour demand is associated with the occupations commonly seen among the industry and services sectors such as machine operators, security guards and marketing and sales related workers (DCS, 2017).

In line with this shift towards a more industry and services based economy, agriculture employment has also decreased throughout the years. However, this is a gradual decline as seen indicated by the mere 5% decrease from 2006 to 2016 (LFS, 2006, 2016), which suggests that labour markets are slow to respond to macroeconomic trends. On the other hand, there are also those who are engaged in both agricultural and non-agricultural employment (See Appedix 1 Table 1). These individuals may be doing so to mitigate the risk of engaging in agriculture alone.

Apart from these, general education and traininging level, size of agricultural households and farms, and seasonal trends can also be considered some of the factors that have an impact on the demand for agricultural workers (Tacco, Davidova and Bailey, 2012). Several of these determinants are represented through variables including argricultural profit, average non-agricultural income in the district and education level that have been included in the analysis.

Error! Reference source not found. depicts summary statistics for variables in these attractiveness models, at individual sample level.

Table 6-1: Summary Statistics

	EA youth				EA females			
Variable	Obs	Mean	Std. Dev.	% share	Obs	Mean	Std. Dev.	% share
Age	28,711	29.35	4.60	n/a	32,526	42.09	11.15	n/a
Sinhala	28,711	0.70	0.46	70	32,526	0.76	0.43	76
Marital Status								
Never Married	28,711	0.34	0.47	34	32,526	0.14	0.35	14
Married	28,711	0.63	0.48	63	32,526	0.71	0.45	71
Widowed/D/Separated	28,711	0.02	0.15	2	32,526	0.14	0.35	14
Education								
No schooling	28,711	0.02	0.27	2	32,526	0.06	0.23	6
Grade 1-5	28,711	0.08	0.27	8	32,526	0.17	0.38	17
Grade 6-10	28,711	0.50	0.50	50	32,526	0.37	0.48	37
O/L	28,711	0.11	0.31	11	32,526	0.09	0.28	9
Grade 12	28,711	0.06	0.24	6	32,526	0.06	0.23	6
A/L	28,711	0.18	0.38	18	32,526	0.18	0.39	18
Tertiary - Dip/Deg/ Phd	28,711	0.05	0.23	5	32,526	0.07	0.26	7
Household size	28,711	4.84	1.85	n/a	32,526	4.49	1.73	n/a
Child age<5 in household	28,711	0.48	0.50	48	32,526	0.28	0.45	28
Share of elders in HH age>65	28,711	0.06	0.12	n/a	32,526	0.07	0.15	n/a
Share of females in HH	28,711	0.50	0.17	n/a	32,526	0.55	0.19	n/a
HH head in agriculture	28,711	0.09	0.29	9	32,526	0.12	0.32	11

Non-agriculture HH income	8,665	1,433,648	10,200,000	n/a	10,222	1,526,779	25,700,000	n/a
Household in debt	28,711	0.47	0.50	47	32,526	0.49	0.50	48
HH owns vehicle	28,711	0.46	0.50	46	32,526	0.39	0.49	39
HH owns mob.phone	28,711	0.75	0.43	75	32,526	0.69	0.46	69
HH remittance income	28,711	10,998	67,964	n/a	32,526	15,692	91,405	n/a
Foreign migrant in HH	28,711	0.01	0.08	1	32,526	0.01	0.08	1
Internal migrant in HH	28,711	0.09	0.28	9	32,526	0.14	0.35	14
Part-time farming	28,711	0.05	0.21	5	32,526	0.04	0.19	4
Paddy	28,711	0.04	0.19	4	32,526	0.04	0.20	4
Other Cereals	28,711	0.00	0.07	<1	32,526	0.01	0.09	1
Vegetables	28,711	0.01	0.10	1	32,526	0.02	0.13	2
HH owns agriculture land	28,711	0.25	0.43	25	32,526	0.29	0.45	29
Area cultivated - perches	28,711	42.06	499.15	n/a	32,526	46.65	467.68	n/a
Agri. mechanization index	28,711	0.11	0.45	n/a	32,526	0.12	0.47	n/a
Distance to agrarian - km	28,711	6.92	6.61	n/a	32,526	7.07	6.69	n/a
HH agri profit	28,711	10,288	56,251	n/a	32,526	10,702	48,709	n/a
District average agri income	28,711	75,989	48,199	n/a	32,526	78,346	48,339	n/a
District average non-agri income	28,711	1,535,972	1,338,105	n/a	32,526	1,541,295	1,396,745	n/a
Flooding	28,711	0.03	0.18	3	32,526	0.03	0.16	3
Drought	28,711	0.02	0.14	2	32,526	0.02	0.14	2
Wild animals	28,711	0.02	0.15	2	32,526	0.02	0.16	2

Source: Authors
Note: n/a = not applicable

Regression Diagnostics

Several statistical tests were carried out to ensure that the assumptions associated with the regression analyses were upheld. Tests were performed to ensure that these models were correctly specified, did not consist of a concerning level of heteroscedasticity, multicollinearity, or problematic extreme data points. The normality of the residuals was tested although this is not a strictly necessary condition for point estimation. Additionally, the Hausman specification test was conducted for the pseudo panel models to determine whether the fixed effects or random effects technique was most appropriate. It should be noted that testing has not been carried out for serial correlation within the pseudo panel model as the data consist of different individuals observed at each of the time periods. Therefore, the residuals would remain uncorrelated given that they are uncorrelated within a given point in time.

The Tukey and Pregibon link test as well as the Ramsey specification test were performed on all three model types and the results indicated that some relevant variables may have

been omitted from the analysis. However, due to the general difficulty in accounting for all variables within a regression, and report reviewer's requirement to reduce variables, it was not possible to include further explanatory variables. In terms of identifying and removing irrelevant variables, hypothesis testing was carried out using test statistics and probability values associated with explanatory variables. Likelihood ratio tests, and information criterion were used in a similar manner for the Multinomial Probit (MNP) model. Goodness of fit measures including R^2 were also used to assess the impact of variables on the explanatory power of the model in the case of the pooled OLS models and pseudo panel models. Accordingly, though initially considered, the variables foreign migrant, information index, average agricultural income of the district and attacks from wild animals were removed from the final analysis presented here.

The rationale for considering the presence of a foreign migrant in the household was to both account for the shortage in labour and the inflow of remittances. An explanation as to why this variable did not indicate a major additional explanatory power could be that international labour migration would already be captured by the household remittances related variable. Similarly, the use of a mobile phone is more likely to be an indicator of the socioeconomic status of the household. This factor would be represented by other variables such as the ownership of a vehicle. The average agricultural earnings in the district may also be unlikely to contribute significantly to the model as the household agricultural profit level tends to act as a gauge of the lucrativeness of agriculture for household members, while the dummy variable for the districts would control for the variation among the districts. On the other hand, young people and women in the labour force may not perceive wild animal attacks as a sufficiently concerning issue to deter them from agricultural employment .

The data was screened for extreme values which may disproportionately affect the estimation using scatter plots (Refer Annex). As a result of the disparity in the distribution of certain variables such as non-agricultural household earnings and land area cultivated, some outliers were identified. The extreme values that were influencing the estimates were eliminated from the regression models while those that did not were retained. In terms of the assumption of homoscedasticity, as the pooled OLS regression consisted of linear probability model, its residuals were heteroscedastic by nature. The modified Wald statistic for groupwise heteroskedasticity was used in the case of the pseudo panel models and this too indicated that the variance of the residuals was not constant. Assessing the presence of heteroscedasticity within the MNP models was somewhat problematic since a straightforward method of testing is currently unavailable. However, since this issue has been present among the remaining models, this is likely to be the case

in the MNP models as well. To mitigate the impact of heteroscedasticity, robust standard errors have been employed across all models.

Variance inflation factors were used in testing for high levels of correlation among the explanatory variables. Excluding the dummy variables which generally tend to indicate some level of multicollinearity due to their correlation with alternative options, the test suggested that a concerning level of multicollinearity was not present. Kernel density estimation graphs (Refer Annex) were used to assess the normality of residuals. The highly peaked distributions of residuals associated with the pooled OLS models indicated some level non-normality. Although linear probability models tend to violate this condition by nature, it is possible to alleviate this issue with the use of large samples as in the case of the current study. The assumption of normality was violated to an extent within the pseudo panel models as well, where the top portion of the graphs tended to be flat. Deviance residuals were used in the case of MNP models, and these more closely resemble a normal distribution. Overall, given that this condition affects inference and is not an essential assumption for point estimation estimation was pursued.

In testing for the appropriateness of the fixed effects or random effects technique for the pseudo panel models, the Hausman specification test suggested that the random effects technique may be more appropriate. The theoretical basis underlying the pseudo-panel models, however, require the assumption of fixed effects where the individual effect is assumed to be correlated with explanatory variables. If this condition is not upheld, correlation is not assumed between the observations and each cross-section would be considered independent. In this case, the authors have proceeded to use the fixed effects estimation as required by the pseudo panel models.

Therefore, compared to the preliminary models considered in the previous version of the report, a more streamlined set of variables have been used in the final model considered for analysis, in keeping with the results of the diagnostic tests and the project reviewers' feedback.

6.2 Results

In presenting results, initially models for attractiveness of agriculture for youth are considered, followed by the analysis for females in **Error! Reference source not found.**. In both the youth and female analyses, first a Multinomial Probit Model (MNP) is estimated using pooled cross-sectional data for the three alternative outcomes (columns 1 and 6). In these MNP models an individual faces one of three choices – to participate in agriculture, non-agriculture work or remain inactive. While the base category considered

is economic inactivity, the estimates reported are for equations for activity in agriculture (column 1) and estimates for activity in non-agriculture are not reported in the interest of simplicity and space. Nevertheless, full model estimates can be provided upon request from the authors. A detailed discussion of the methodology of analysis is available in Chapter 4.

Next, the linear probability models (OLS models) are estimated by limiting the sample to economically active youth/females facing two choices - to participate in agriculture or not (columns 2 and 7). Finally, linear probability estimates corresponding to the pseudo-panel cohort analysis using fixed effect models are presented in columns 3-5 for youth and column 8 for females, where the outcome variable is the cohort share of youth/females in agriculture. In order to control for unobservable characteristics such as soft skills, motivation, experiences etc., fixed effects models are estimated with pseudo-panel data for the sub-sample of economically active individuals. These pseudo-panel cohort analysis models establish causality, while the previous models only provide correlation between variables.

Youth Participation in Agriculture

When considering the influence of demographic variables on youth's participation in agriculture employment, age has become statistically significant in the MNP and Pooled cross sectional OLS model. When faced with the three choices of economic inactivity, employment in agriculture and employment in other economic activities, age has a positive correlation with agriculture employment (see column 1). This indicates that rather than being economically inactive, older youth are more likely to take up agriculture. This finding is consistent with existing literature on Sri Lanka, which shows that at younger ages there is higher economic inactivity and unemployment. As per latest available national Labor Force Survey data, youth in the age group 15-29 recorded the highest levels of unemployment at 21.5 per cent, in 2019 (DCS, 2019).

But when the sample is restricted to only those economically active and a choice between agriculture or non-agriculture employment is considered, as seen in Column 2, age has a negative coefficient, while the age squares is positive. This shows that when type of economic activity is considered youth are less likely to take up agriculture as they mature, but this decline in preference slows down with as they age. However, there may be an increased inclination for agricultural work among the older female youth. This may be due to the ability to ensure their household and caregiving commitments while engaged in agriculture. Moreover, in the absence of any statistical significance for age on the

Pseudo panel cohort models, the age squared variable has returned statistically significance in all three columns 3, 4 and 5. Nevertheless, the influence of age squared on choice of employment is disregarded here, as age and age squared have to be analyzed in tandem.

Table 6-2: Combined Regression Results

	Youth					Female		
	Mutinomial Probit Models (Panel 1)	Pooled cross-section OLS Models	Pseudo panel Cohort Models			Mutinomial Probit Models (Panel 1)	Pooled cross-section OLS Models (Panel 2)	Pseudo panel Cohort Models
	1	2	3	4	5	6	7	8
Sample	pooled MNP	EA	EA	EA	EA	pooled MNP	EA	EA
Group	All Youth	All Youth	All Youth	Youth - Male	Youth - Female	Female	Female	Female
Age	0.192*	-0.012***	0.063	0.076	0.120*	0.180***	-0.000	-0.008
Age squared	-0.002	0.000***	0.000**	0.000*	0.001**	-0.002***	0.000	-0.000
Married	-0.617***	0.003	-0.011	-0.030	0.078	0.155	0.007	0.041
Widowed/D/Separated	-0.626	-0.018**	0.179	-0.053	0.020	0.308	0.000	-0.096
Sinhala	0.421***	0.006	-0.226	1.431*	-0.572	0.809***	0.009	-1.873
Grade 1-5	1.152**	0.025	0.030	-0.359	-0.012	-0.075	-0.002	0.008
Grade 6-10	1.038**	0.012	0.096	0.203	-0.036	-0.328*	-0.016	0.061
O/L	0.487	0.002	-0.025	-0.100	0.066	-0.609***	-0.031***	-0.044
Grade 12	0.049	-0.003	0.118	0.155	0.054	-0.634***	-0.036***	0.070
A/L	0.276	0.006	0.077	0.086	0.067	-0.430**	-0.031***	0.051
Tertiary - Dip/Deg/ Phd	-0.359	-0.005	-	-	-	-0.531	-0.049***	-
Household size	-0.009	0.001*	0.000	-0.018	0.008	-0.064***	0.000	-0.061*
Child age<5 in household	-0.104	-0.003	0.069*	0.037	0.178**	-0.287***	-0.005	-0.013
Share of elders in HH age>65	0.526	-0.003	0.161	0.268	0.463*	0.443	0.002	0.081**
Share of females in HH	-0.723***	-0.012	-0.310**	-0.308	-0.429**	0.347*	-0.006	-0.133
HH head in agriculture	1.428***	0.193***	0.356***	0.078	0.379**	1.476***	0.239***	0.266

Non-agriculture HH income	-0.000	-0.000	0.000	0.000	0.000	-0.000	-0.000	-0.000*
Household in debt	0.185**	0.001	-0.001	-0.004	-0.122*	0.099	-0.008**	-0.043
HH owns vehicle	-0.234***	-0.009***	-0.037	0.142*	-0.104*	-0.164**	0.004	-0.155
HH remittance income	-0.000***	0.000**	0.055*	-0.038	0.073	0.000	0.000	0.060
Internal migrant in HH	-0.391**	-0.015***	0.050	0.093	-0.151	0.909	-0.008	0.031
Part-time farming	3.196***	-0.044***	0.120	-0.431*	0.287	1.427***	-0.061***	0.382*
Paddy	-	0.672***	0.004	0.013	-0.07	3.455***	0.576***	-0.016
Other Cereals	-	0.591***	-0.006	-0.072*	-0.045**	3.476***	0.528***	-0.034
Vegetables	-	0.885***	0.013	-0.046**	0.019	-	0.838***	0.006
HH owns agriculture land	0.261***	0.005	-0.022	0.205	-0.006	0.134*	0.002	-0.010
Agriculture cultivation - perches	0.000	-0.000	0.000	-0.000	0.000	0.000	0.000*	0.000
Agriculture mechanization index	0.175***	0.020***	0.055	0.012	0.179	0.163***	0.024***	-0.097
Distance to agrarian centre - km	0.017***	0.001***	-0.003	0.001	-0.001	0.022***	0.001***	-0.001
HH agri profit	0.000	0.000	0.071	-0.122	-0.013	0.000	0.000	0.272***
District average non-agri income	-0.000**	-0.000***	-0.004**	-0.009***	0.000	-0.000	-0.000***	0.000
Flooding	0.303	0.002	0.306*	-0.008	0.495*	0.575***	0.012	0.274
Drought	0.229	0.024	0.131	0.198	-0.132	-0.024	0.022	0.422
hies_year=2009	0.276*	0.010*	-0.208*	-0.184	-0.541**	0.158	0.004	-0.001
hies_year=2012	0.451***	0.014***	-0.477**	-0.535	-1.065**	0.446***	0.006	0.063
hies_year=2016	0.461**	0.010*	-0.782**	-0.896	-1.690**	0.877***	0.017***	0.096
Constant	-7.573***	0.156***	-1.385	-3.291**	-2.737	-8.072***	0.014	2.589
R^2		0.547	0.765	0.84	0.799		0.519	0.961
Observations	14,623	8,665	176	88	88	25,640	10,222	88

Source: Authors

Notes: (1) * $p < .1$, ** $p < .05$, *** $p < .01$. (2) All monetary variables are in LKR and all incomes are annual values. (3) District dummies are included (although not displayed) as controls in all models except in the pseudo-panel models, in order to maintain required degrees of freedom in a small sample size panel.

In terms of marital status, relative to never married, those who are married and widowed/divorced/separated have a lower probability to be involved in agricultural activity and instead be economically inactive as seen in column 1. It is possible that

because of the existing or once existing support of a spouse it is a more desirable choice to remain inactive than join the agriculture labor force. Nevertheless, among economically active youth, relative to never married youth, widowed, divorced or separated youth in column 2 have a 0.018 lower probability to be employed in agriculture as opposed to non-agriculture employment. The reason for this could be that they need more income to support self and/or family due to lack of support from a spouse. However, in contrast to these findings, Nnadi & Akwiwu, (2008) have identified positive influence of marriage on intensity of youth's participation in rural agriculture, reasoning the fact that youth males who are heirs and having ownership of land resources have increased their concern for household welfare and food security following the marital responsibilities and conviction over time of the importance of agriculture in rural livelihood. Nevertheless, Maina & Maina, (2012) have identified through their study, that there is no impact of marital status on youth engagement in agriculture or related activities and suggesting that youth with at least secondary education and males (both married and unmarried) and residing in households with a large number of adults are less likely to engage in agriculture or agriculture related activities. In the MNP model, in the case of ethnicity, relative to all other ethnicities being Sinhalese is associated with a higher probability to be involved in agriculture.

Among dummy variables for level of education, as per MNP, youth in the lower levels of educational attainment are more likely to be involved in agriculture. Specifically, relative to those with no schooling, youth educated up to 10^{th} grade are more likely to be in agriculture, than being economically inactive. This shows that education up to 10^{th} grade can motivate youth to be employed in agriculture as opposed to economic inactivity. These results can be interpreted as follows: significance of youth participation in agriculture at primary/middle school education levels implies that youth might make the choice to quit schooling at this stage, in order to participate in agriculture activities. Youth with different aspirations for white-collar jobs will instead, continue in schooling and their choice to engage in agriculture will decline as education level increases. Specifically, many studies have highlighted that the lack of social recognition for those involved in agriculture is a key limiting factor for youth to engage in agriculture. For instance, (Damayanthi & Rambodagedara, 2013a) note that lack of social recognition together with the absence of a social security system for those in agriculture discourages youth from engaging in agriculture, while Jayatissa, Seneviratne, & Sankar (2005) highlight this issue as the "unfavourable perception towards farming". This explains why the results are significant for youth participation at lower education levels.

With regards to household level variables such as household size, presence of young children and presence of elders greater than 65 have statistically significant positive

correlation with employment in agriculture. Consistent with the surplus labour hypothesis, as seen in column 2 each additional member in the household is associated with a 0.001 higher probability. Similarly, as noted by Nnadi & Akwiwu, (2008) the positive relationship between household size and youth participation in agriculture is resulted based on the fact that "household with more residents would have greater blocks to overcome higher food security and social needs". Hence the rational consciousness of enormous family and food security requirements may cause the youth to involve in agriculture mostly in rural economies. In the case of having children less than 5 years, the impact on employment in agriculture is a 0.069 increase in the cohort share among all youth and 0.178 increase in cohort share among female youth. In the case of female youth this finding confirms that agriculture employment allows mothers of young children to cope with work and the care burden they bear. This corroborates with Damayanthi & Rambodagedara (2013a) finding that the share of female engagement in agriculture as family labor is notable. This finding of females' involvement in the overall care and specifically childcare burden in households, while being involved in agricultural activities is further reinforced with the statistically significant -0.429 coefficient in column 5 for female youth. This finding shows that having more females, possibly to take over the care burden in the household frees up young females to pursue non-agricultural employment. Similarly, in the MNP model in Column 1, an increase in the share of females in the household is associated with a decrease in youth probability in agriculture employment, relative to being economic inactivity, while in the case of pseudo panel cohort models, the corresponding decline in cohort share for all youth is -0.310 . In the case of all youth this could also mean that the higher the number of females in household, who are more likely to be economically inactive or in agriculture to balance their care burden in the household, needs to be supplemented with more income from youth by engagement in non-agricultural employment. In the case of presence of elderly in the household, each additional 1% of elders is associated with a 0.463 increase in female youth share in agriculture (see column 4). Similar to the presence of children, this also shows the care burden on females which can cause them to prefer agricultural employment over other forms of work.

Further, the household head being engaged in agriculture is a pull factor for agriculture sector participation as indicated by positive significant coefficients across most models. For instance, in the case of column 1, this coefficient indicates a positive relationship with probability of employment in agriculture relative to the base category of economic inactivity. This means that, when the head of the household is in agriculture, relative to being unemployed, youth from such households are more likely to be in agriculture employment. For all youths, the increase in the share of cohort youth with head of the

household engaged in agriculture increases the cohort youths share in agriculture by 0.356. This is the opposite effect to what is noted in the literature on parents engaged in agriculture and them having different aspirations for their children. Specifically, Bamunuarachchi (2018) shows that farmers engaged in paddy farming do not expect their children to engage in same the occupation because of the inadequate financial returns and instability associated with the livelihood. Instead parents direct their children to engage in occupations with high prospects through higher education. This trend is aptly shown by Weeraratne & Hasebe (2011), where in their sample the number involved in agricultural activities approximately halved in each generation, despite the fact that first generation occupational choice of being a farmer has a significant impact on the second-generation individual being a farmer. Despite what is noted in the literature, this study finds that youth participation in agriculture is encouraged by head of household in agriculture (similar to what is noted for females, in the section), and this is likely to do with these youth already having the family background in agriculture work, and access to land, equipment, skills and other resources.

With regards to household debt, column 1 indicates a positive coefficient, while column 5 depicts a negative coefficient. In the MNP model, relative to the base category of economic inactivity, youth from households already in debt are more likely to be involved in agriculture, rather than being economically inactive, possibly due to the economic hardship at home necessitates their economic activity in agriculture. Nevertheless, when the sample is disaggregated by gender, and economically active female youth are considered they have a 0.122 lower cohort share engaged in agricultural employment when the household is in debt. This is possibly due to the lower income earned in agricultural employment being insufficient to finance debt, females from such households are thus less likely to pursue agriculture and instead seek higher paid non-agricultural activities, even though such jobs may require them to be employed further away from home and family.

The ownership of a vehicle has multiple mechanisms to influence participation in agriculture. On the one hand, the statistically significant negative coefficients seen in column 1 indicates that relative to the base category - economic inactivity, those in households with vehicles are less likely to be involved in agriculture and prefer be economically inactive, as such ownership of vehicles is likely to reflect the socio-economic position of the household, which is more likely to be able to afford to support an economically inactive youth. On the other hand, when the economically active youth are considered in Column 2, the negative coefficient in the pooled cross sectional OLS model is likely to reflect the physical and information connectedness of the household, which serves as a conduit to seek employment in non-agriculture employment. This trend is

confirmed in literature where affluent youth abandon agriculture to engage in employment opportunities created in industrial and service sector resulting in repercussions such as emergence of a new social class engaged in regular jobs with stable income adopting to a relatively more prestigious life and lifestyle than those engaged in agriculture (Pinnawala & Herath, 2014).

When it comes to the receipt of remittances and the presence of internal migrants as seen in column 1, youth from such households are less likely to be involved in agricultural activities and instead are more likely to be economically inactive. This is consistent with the socio-economic position of a household and its ability to afford to support economically inactivity youth, as discussed before. However, among those who have already decided to work, receiving remittances shows a positive correlation with the probability of youth being employed in agriculture. One the one hand, it is possible that this is due to agricultural households being more likely to receive remittances since they earn relatively low, inconsistent income in relation to non-agricultural households. On the other hand, it could be that the support from remittance income encourage youth to engage in the agriculture despite its uncertain income.

When the economically active youth are considered in column 2, the negative coefficient (-0.015) on the indicator for the presence of an internal migrant from the household reflects that such a youth is less likely to seek employment in agriculture sector but seek non-agricultural work. This could possibly be due to the shortage of labour associated with migration, making agricultural activity unproductive or difficult for such household members. Similarly, as noted by Martín, Nori, & Bacchi, (2017) households with migrants, engage less intensively in agriculture activities than non-migrant households since they enjoyed higher income and own more assets which ultimately lead to under cultivation or abandoning their farmlands. Thus, households with migrant workers have less dependency on agriculture and local natural resources for subsistence.

For economically active youth as seen in column 2 and 4, part time farming/ earning income from multiple sources including agriculture, corresponds to a lower likelihood to identify themselves as engaged in agriculture. This shows that when faced with the choice of selecting between agriculture and non-agriculture work, the effect of part-time farming/ earning income from multiple sources including agriculture is insufficient to swing the choice towards agriculture. Nevertheless, as seen in column 1, relative to economic inactivity, part time farming has a positive correlation to be identified as being engaged in agricultural activity. As such, the capacity to engage in agriculture as part time activity while earning incomes from other sources encourages youth to associate themselves as farmers.

Next, agriculture specific determinants are considered. With regards to indicators for types of crops cultivated, households cultivating paddy, other cereals, and vegetables, compared to other food crops, are likely to have a higher probability to have their youth involved in agriculture by 0.672, 0.591 and 0.885, respectively. Nevertheless, when unobservable are controlled for in the pseudo panel cohort models the coefficients become negative, reflecting that male youth from households cultivating other cereals and vegetables are less likely to be involved in agriculture and more likely to pursue non-agriculture activities. Damayanthi and Rambodagedara (2013a) point out that though vegetable cultivation is profitable, 40% of youth in their sample were not involved in it due to the problem of non-availability of land and issues encountered in marketing.

The ownership of land is considered a pull factor for participating in agriculture in the literature – one of the key difficulties in joining the agriculture labor force is when the key resource of land is unavailable. The results corroborate this since there is a clear significant and positive effect of household land ownership on youth participating in agriculture, as opposed to being economically inactive, as seen in column 1. When only economically active male youth are considered, the findings show that there is a 0.205 higher probability for their engagement in agriculture as opposed to non-agricultural activities. When considering corroborating literature, it is found that youth are more satisfied with participating in agricultural activities, if there was an availability of land (Sudarshanie, 2014). Furthermore, Ranathunga (2011) shows that despite the affinity of some youth to remain in rural areas and engage in agricultural activities, they are compelled to migrate from rural to urban areas due to several constraints, of which landlessness is a key factor. Hence, the importance of access to land to encourage youth participation is underscored.

When it comes to agriculture mechanization, a significant positive effect is found for youth engagement in agriculture. This score reflects that as household ownership of agricultural equipment contributes to higher mechanization of agricultural activities increases, which are likely to attract youth to partake in agricultural work as opposed to economic inactivity as seen in column 1. Column 2 reflects a further dimension for economically active youth that the pull towards agricultural employment is greater than towards non-agricultural employment, when the household has a higher agriculture mechanization score. Related to this, DailyFT, 2017 shows the unprofitability of agriculture work due to low adoption of modern technology and innovations and the related decline in commercial value of the agriculture sector, are factors contributing to the decline in youth involvement in agriculture.

The distance to agrarian services center shows that further away youth are, they are more likely to be engaged in agriculture. As seen in column 1, when youth further away from agrarian services centers have a higher probability to be engaged in agricultural activity rather than being economically inactive. In the case of column 2 this reflects that among economically active youth, those further away from agrarian services centers have a higher probability to be engaged in agricultural activity rather than being employed in non-agricultural employment. In the case of this latter finding, rather than reflecting the expected connectedness to the agrarian service, this indicator might be reflecting the general proximity to town centers, where commercial activity is presence. As such, lower economic activity further away from town centers may be pulling youth into agriculture employment.

The average non-agriculture household income in the district reflects the availability of commercial activities in the district and alternative employment opportunities. As seen in most models a higher average non-agriculture income is linked to lower involvement in agricultural employment of youth. Specifically, in terms of male youth each additional increase in average district non-agricultural income by LKR 10,000, the share of male youth involvement in agriculture decreases by 0.009. In the case of all youth, this decline in share is 0.004. This effect is possibly due to availability of alternative employment opportunities. In the case of column 1 the small yet negative coefficient indicates that higher average non-agriculture income is associated with lower involvement of youth in agriculture relative to economic inactivity, possibly due to previously discussed financial capacity of households to support an economically inactive youth.

In terms of indicators for natural disasters in the pseudo panel models for all youth in columns 3 and female youth in column 5, flooding has a positive impact on share of employment in agriculture by 0.306 and 0.495, respectively. One possible explanation is the limited economic activities and related lack of employment opportunities in non-agriculture sector due to natural disasters may compel youth in these areas to pursue agricultural activities. Another explanation could be that the youth residing in rural areas where agricultural activities tend to be carried out are more likely to experience flooding as they live in proximity to water bodies and have poor quality infrastructure. Nevertheless, Sehgal, Singh, Chaudhary, & Jain, (2013) have identified climate change and related natural disasters as a main problem which make youngsters lose interest in agriculture. Hence, this may be possibly heightened due to higher degree of risks and uncertainties resulted from such climate change impacts and natural catastrophes on agriculture and related activities (Som, Burman, Sharma, Padaria, & Paul, 2018).

In the case of year dummies, the positive coefficients in column 1 shows that, the probability of agricultural employment as opposed to economic inactivity increased in each survey year relative to the omitted survey year of 2006. In the case of the economically active youth considered in column 2, the positive coefficients indicate that the probability of employment in agriculture as opposed to non-agriculture increased relative to the omitted year. With regards to the pseudo panel models, the negative coefficients for all youth and female youth models indicate that during each survey year, the preference for agriculture employment declined relative to 2006. As seen in columns 3 and 5 the absolute value of the coefficient increases over the years indicating that the popularity for agriculture declined over the years from 0.208, to 0.477, to 0.782, in 2009, 2012 and 2016 respectively. One possible reason for this is the end of the war in 2009 and the increased economic activities and related employment activities making agriculture less attractive to youth.

Female Participation in Agriculture

When considering demographic variables, the statistically significant positive and negative coefficients of age and age squared, respectively, in column 6 indicates that there is a higher tendency for females to engage in agriculture as opposed to economic inactivity as they get older, but this probability decreases at a greater rate towards the upper age limit. These findings are somewhat consistent with existing literature. For instance, Humpert & Pfeifer, (2013) indicate that employment increases with age among younger females until the age of 30-35 years, declines among middle age individuals and increase again for older individuals. As such, declining of employment may be resulted from middle age women due to the role of motherhood and thus, age effect on employment is larger for women than men (Humpert & Pfeifer, 2013). Nevertheless, no similar statistical significance is evident for the Pooled OLS model or the Pseudo Panel model. Marital status does not have any statistically significant relationship with choice of employment in agriculture as per any model. In terms of ethnicity, being Sinhala has a positive association with agricultural employment as opposed to economic inactivity, but no relationship is seen in other models.

In terms of education, in the MNP model, most educational categories beyond 6th grade are correlated with lower probability to be employed in agriculture, relative to economic inactivity. This pattern reflects the phenomenon present in Sri Lanka of low female labor force participation (around 30 per cent) despite high levels of female enrollment in universities/higher education. When considering the literature on this pattern, as noted by De Silva (2012), factors common to all females in Sri Lanka including their high

education levels (along with women facing discrimination in the labour market, changing preference for leisure due to increasing of per capita income, etc.), applies to the low female labor force participation rate in the agriculture sector.

In the case of column 7, where employment in agriculture as opposed to non-agriculture employment is considered, those educated upto O/L are associated with a 0.031 lower share for agricultural employment, while those with Tertiary education ranging from Diploma/Degree/ Phd, have the largest decline in share (0.049). This is consistent with literature on increasing returns to education, where those with education dislike engaging in agriculture. For instance, Bamunuarachchi (2018) finds that most prominent reasons for this given by her sample were the diversion of labour for technical employment and the preference to remain unemployed.

In terms of household characteristics, the household size is negatively associated with female employment in agriculture. In the case of the column 6 larger households are correlated with lower probability for female employment in agriculture as opposed to economic inactivity. Similarly, each additional child is correlated with a lower probability for female employment in agriculture as opposed to economic inactivity. These two findings are consistent with the literature that highlights that greater care burden at household discourages females from employment. The international literature finds that "in most societies, women are responsible for most of the household and child-rearing activities as well rearing of small livestock, although norms differ by culture and over time" " (SOFA Team and C. Doss , 2011, p. 16) Similarly, in column 8 the causal impact of an additional child on female employment in agriculture is -0.013, while each additional household member has a causal impact of decreasing share in agriculture by 0.061 in favour of non-agriculture employment. This is likely to be in search of greater income earned by non-agriculture sector in order to be able to support a larger family. This is evident from the fact that the annual average agriculture income of these households was LKR 118,104, while corresponding non-agricultural income was LKR 429,344.

In the case of the influence of head of household in agriculture, findings in columns 6 and 7 show that this leads to a higher probability for female involvement in agriculture. For instance, in the case of the MNP model in column 6 a female from a household in which the head of the household is already in agriculture, has a higher probability to be engaged in agriculture instead of being economically inactive. Similarly, in the case of the Pooled OLS model for economically active population in column 7, this correlation is a 0.239 higher probability for female involvement in agriculture as opposed to non-agriculture employment. This is possibly due to family influence and knowledge, experience and exposure gained over the years, which makes it easier for a female to involve in

agriculture. For instance, Bamunuarachchi (2018) shows that the female family labour contribution was higher than female hired labour contribution in all her study districts. This finding shows that it is important to focus on attracting females in agricultural households into agriculture as they are more likely to involve in the sector than others. When considering household income, in terms of non-agriculture income, a small yet statistically significant negative causal impact is seen in Column 9. This shows that higher non-agricultural income discourages females from participating in agricultural employment as opposed to non-agricultural economic activity. This finding is consistent with international literature, which identified that in South Asian countries, including Sri Lanka, there is a considerable shift in female employment from agriculture to non-agricultural economic activities, especially to service sector (Najeeb, Morales, & Lopez-Acevedo, 2020). As seen in column 7, if a household is in debt, this lowers the share of females engaged in agriculture by 0.008. This pattern shows that lower income earned in agricultural employment is insufficient to finance debt, meaning that females are thus less likely to pursue agriculture and instead seek higher paid non-agricultural activities. For females, the ownership of vehicles is associated with lower likelihood of engaging in agriculture employment as opposed to inactivity. Ownership of vehicles is likely to reflect the socio-economic position of the household, which is more likely to be able to afford to support an economically inactive female.

In all three models, the involvement of females in part time farming is associated with mixed results with regards to the probability for employment in agriculture. Based on column 6, part-time farming/ earning income from multiple sources encourages females to identify themselves as farmers as opposed to being inactive. Similarly, column 8 shows a positive relationship where engaging in part-time farming increases the probability of female participation in agriculture relative to non-agriculture employment. Nevertheless, in column 7, part-timing farming is associated with lower likelihood for females to be engaged in agriculture, as opposed to non-agriculture employment.

With regards to the type of crop, relative to the omitted category of food crops other than those included in the model (such as fruits, tubers, roots), farming paddy, other cereals and vegetables are associated with higher probability for involvement in agriculture. In the case of column 7 the associated increases are 0.576, 0,528 and 0.838, respectively. Unlike in the discussion for youth, there seems to be less variation in linkage between type of crop and participation in agriculture for females.

In the case of ownership of agricultural land and mechanization score there are statistically significant positive impact on probability for female employment in agriculture as opposed to economic inactivity as seen in column 6. At the same time, each

additional perch of land cultivated marginally increase the probability of a female to be employed in agriculture instead of non-agriculture. Similarly, greater ownership of agricultural machines indicated by the mechanization score is correlated with a 0.024 higher probability for employment in agriculture instead of non-agriculture and in agriculture instead of inactivity as shown in column 7. Moreover, these results indicate that access to land and mechanization are effective pull factors for female participation in agriculture. Encapsulating this positive relationship, the literature points towards this high level of discrimination that females face pertaining land ownership/mechanization resource access and how this has discouraged their participation in agriculture. For instance, (FAO, 2018) notes that there are large disparities in access to control over resources like land, water and inputs as well as to access to markets and skill training, all of which are determining factors for agricultural production and livelihood associated with women. The same study further finds that there is inequality in land ownership by females in Sri Lanka, where only 16 percent of all privately-owned land in the country belongs to women. Such discrimination in terms of land ownership in Sri Lanka has served as a restrictive factor in females' involvement in production of crops for consumption and commercial purpose. Specifically, the absence of land ownership restricts females from obtaining support services such as irrigation water, credit and fertilizer.

The distance to an agrarian service center is positively associated with female employment in agriculture. As shown in column 6, this greater probability is over economic inactivity, while column 7 shows the greater probability relative to non-agricultural activity. This result is more likely capturing the distance from towns/urban center, which relates with the idea that women from more rural areas are more likely to be engaged in agriculture than those is an urban setting.

Interestingly, households with higher profit from agriculture have a causal impact with females in that household involving in agriculture. Specifically, a LKR 10,000 increase in agriculture profit is associated with increasing probability of female employment in agriculture by 0.272 as opposed to being employed in non-agricultural activities. This ties with the previously discussed finding on non-agriculture income discouraging agriculture participation; it seems that if agriculture is in fact profitable, then this has the potential to draw females. Similarly, females from districts with higher average income in non-agriculture by LKR 10,000 are associated with a small (less than 1) decline in their probability for employment in agriculture instead of non-agriculture.

With regards to natural hazards, flooding shows a positive correlation the probability of female employment in the agriculture sector as opposed to economic inactivity. Similar

to the effect discussed for youth, explanations for this could be either related to the limited economic activities/lack of employment opportunities in non-agriculture sector due to natural disasters, that compel females in these areas to pursue agricultural activities or the fact that flooding is more likely to take place in rural areas with water bodies and poor infrastructure.

6.3 Synthesis of Findings

Based on the models presented in this chapter the combined key findings on factors that encourage and discourage agriculture sector participation of youth and females are as follows:

- There is a clear negative relationship between education level and agriculture sector participation, for both youth and females. Lower educated youth tend to be employed in agriculture, while females at high levels of education would rather be inactive than participate in agriculture employment.

- Although models show mixed results for the effect of part-time farming on agriculture participation, it has the potential to draw both youth and females to engage in agriculture. Particularly for youth, the part-time farming options can be more attractive than the full-time farming option, over and above remaining outside the labor force. This is because there are flexible opportunities at different stages of the agriculture value chain that can be leveraged, other than primary level farming.

- Land ownership is a very strong pull factor for agriculture sector participation (relative to both inactivity or non-agriculture employment) where the results consistently show evidence of this for both youth and females. In addition, this strongly corroborates with the literature on land access as a key pull factor for agriculture sector participation, as it is the main resource/constraint.

- There is some evidence that the presence of supplementary incomes such as remittances/non-agriculture income in the household acts as a disincentive for to participate in agriculture in relation to inactivity. On the other hand, remittances appears to enourage economically active youth to participate in agriculture. The effect of remittances is present only for youth, whereas the effect of non-agriculture household income is present for females.

- There is strong evidence from this study, which corroborates with available literature, that mechanization and accessibility of agricultural equipment help attract youth and females to the sector due to the capacity of mechanization to minimize the drudgery and hard work that serve as a deterrent in attracting these groups.

- In terms of demand, belonging to a district with high non-agriculture income may indicate higher demand for non-agricultural work in relation to agricultural work. Therefore this shows a negative impact on employment in agriculture. Profitability is another pull factor for employment in agriculture, for particularly for females. However, the literature points towards the importance of profitability as a pull factor for both youth and females.

6.4 Recommendations

Recommendations to attract youth and women to agriculture based on the above findings are as follows:

- Education: Take measures to attract youth and females at higher education levels. With advances in agricultural technologies, it is possible to create high skilled jobs in the agriculture sector for youth and females with higher education levels. Incentives should focus on the up-skilled and flexible nature of such jobs, outside of the traditional farming image, in order to attract youth/females.

  To this end, the government should consider commencing a special training course on modern farming, for youth and females who are interested in engaging in agriculture as their livelihood. Further, as a practical application, they should be provided with initial capital as concessionary credit to establish commercial farmers. (For example, Korea has a degree programme on practical agriculture for youth interested in making agriculture their livelihood. All expenses are borne by the government and after completion those graduates are provided various facilities to engage in agriculture. If they don't they have to pay back all the cost borne by the government.

- Attitudinal shift: Changing attitudes of youth and females about agriculture through various measures; eg. Include agriculture to the school curriculum so that all students get some practical exposure to agriculture, and promote concepts such as cultivation of their own foods, consumption of organic vegetables and food.

Further, farming should be promoted as an honorable occupation via conducting competitions to select best farmer at district, provincial and national levels under different categories like student, youth, government or private sector employee, adult farmer etc. Granting certificates, financial or other gifts and opportunities to travel into some other countries to learn experiences on agricultural development, will also provide incentive to participate in the sector.

- Land ownership: Steps to streamline the land acquisition process should be taken. Particularly for youth, the transfer of land from parents provides the main capital resource required to begin an agricultural venture. While this is a fairly straightforward procedure for privately owned deeds, access to permits for more affordable publicly owned land plots such as those under the Mahaweli Development Authority, and the eventual transfer to owner's name can take up to one year or more, based on KII findings. In order to attract youth, in particular, this process should be streamlined at the Divisional Secretariat level. For women, the discriminatory practices in land ownership pertaining to women, as noted in the analysis, should be rectified. Specifically, the absence of land ownership restricts females from obtaining support services such as irrigation water, credit and fertilizer. To become eligible for subsidized fertilizer, the title of the land, as well as the membership of the area farmer organization, are essential. As many women have no land titles to prove their ownership for land especially in irrigated settlements, they are not entitled to obtain subsidized fertilizer. Similarly, the absence of title deeds for their land many women are disqualified from obtaining membership in the area farmer organization. This further restricts females' farmers from obtaining irrigation water from the organization that handles water distribution. Moreover, for agriculture related training programs, the Department of Agrarian Development selects the participants from the members of the registered list of the farmer organizations. Here also women who do not have land ownership become disqualified from obtaining such training (FAO, 2018). As such, authorities need to take a more flexible approach for females, and use alternative means of determining eligibility for the above resources, such as maybe family ownership of land and tenure in agriculture sector.

- Part-time farming: Measures to reframe the image of agriculture work as a part-time activity that can be adopted by anyone, rather than the traditional image of 'farmer tilling the field' should be promoted among youth and females. For youth, steps to encourage home-gardening, and school-gardens should be taken so that this idea is instilled from a young age. This should be followed up by flexible

opportunities for contract farming, where youth can be engaged in agriculture work, while being based in more urban-full-time jobs. For females, part-time farming opportunities can be leveraged at household level where home-maker females will be able to engage in agriculture work whilst engaging in domestic activities. New technologies to cultivate using protected housing allows for growing of crops inside own home, which is convenient for females who may have mobility issues.

- Targeted interventions: Target youth and females in households that do not have supplementary income sources such as remittances and encourage them to get involved in part-time agriculture activities as discussed above, to earn a supplementary household income. Furthermore, females already in agriculture households should be encouraged to participate in agriculture as household background and support will be present, thus aiding as a pull factor.

- Mechanization: Based on KIIs, technologies such as protected gardening, hydro/agro-ponics that are not subject to weather related risks, and can be carried out in vicinity of home, will act as incentive for youth and females.

- Agriculture profitability: Profitability is an almost obvious pull factor – and agriculture profitability can be increased by combined implementation of the above recommendations.

Chapter 7: Productivity

Productivity is a key consideration in improving competitiveness. The Sri Lanka Overarching Agricultural Policy of 2019 (Ministry of Agriculture, 2019, p. 20) underscores that "one of the underlying causes for poor performance and weak global competitiveness in the agricultural sector is the low productivity of farming operations". As such, it is important to investigate the determinants of productivity in agriculture. In this Chapter the agricultural productivity (AP) as well as agricultural related labour productivity (LP) are analyzed. The chapter starts with a descriptive analysis of productivity followed by estimation, results and discussion of quantitative analysis.

The farmers considered in this analysis are involved in producing multiple agricultural outputs using many agricultural inputs are considered. For such situations, literature dictates the adoption of a common unit of measurement for outputs and inputs. FAO (2017, pp 40, 42), notes that "putting a monetary value on the respective output allows aggregating the output of different crops and products", while "Inputs also must be aggregated, generally by converting them to monetary units". As such, here AP is calculated as the ratio of the value of agriculture outputs to value of agriculture inputs. The input costs considered here are mainly cost of labour, seeds, fertilizer, chemicals, and transport. Labour productivity is calculated per hour by considering all labour used in production including unpaid family labour, and arriving at the ratio of the value of agriculture outputs to number of labour input hours used. As described in detail in Chapter 4, the analysis is based on data from ALS2020. In calculating productivity ratios mainly cash costs are considered, with the exception of family labour, for which the cost is calculated by using imputed values with average wage rate in the area by DSD division, age groups and gender. As such, for perennial crops the costs borne in previous years are not considered, as only the cost incurred during the last years is considered.

As seen in Table 6-3 the mean LP of the sample is LKR 420.95 per man hour while its standard deviation was 434.57. The range of values was between 0.06 and 2162.16. The average agriculture productivity for the sample is LKR 0.94 per unit of output, with a standard deviation of 0.78, with a minimum value of .0002383 and a maximum of 3.88.

Table 6-3 Summary Statistics

	Labour Productivity* (LKR per man hour)	Agriculture Productivity**
Mean	420.95	0.94
Std. deviation	434.57	0.78
Minimum	0.06	0.00
Maximum	2,162.16	3.88
25th percentile	117.19	0.36
50th percentile	277.78	0.75
75th percentile	554.91	1.29
Observations	955.00	966.00

Notes: *After excluding extreme values sample restricted to values less than 2176.74 ; ** after excluding extreme values sample restricted to values less than 4.
Source: Authors

The higher standard deviations are result of the the large number of observations being converged at the lower end of the productivity distribution along with a considerable amount of sporadically placed observations stretching the right tail. A similar pattern is seen when disaggregated by crops as seen in Table 6-4 below. Labour productivity is highest in spices, while the lowest is legumes. In terms of agricultural productivity paddy, fruits, other crops and spices are productive, while the rest are unproductive.

Table 6-4 The crop wise disaggregation of productivity estimates

	Labour Productivity * (LKR per man hour)			Agriculture Productivity *		
	Mean	Std dev	Obs	Mean	Std dev	Obs
Paddy	482.16	426.83	534	1.03	0.66	541
Fruits	781.84	943.23	59	2.18	2.67	59
Legumes	196.80	222.30	33	0.45	0.40	33
Other crops	449.70	462.47	98	1.04	0.95	97
Grains	295.55	289.83	42	0.73	0.63	42
Roots	457.32	445.13	35	0.85	0.62	34
Spices	14236.34	47173.88	30	37.79	106.62	30
Vegetables	245.78	284.76	237	0.57	0.57	236

Notes: *Values beyond the 95th percentile is excluded.

7.1 Descriptive Analysis

This section provides descriptive statistics of productivity by key agricultural labour variables, namely aging of labour force, worker out-migration, and part time farming, and by mechanization. Given that productivity is calculated at the household level, as agricultural output is reported at household level, when disaggregating productivity by age groups, family versus hired labour, and primary employment versus secondary employment in agriculture, the degree/intensity of each variable reported in each household is considered. For instance, in the case of age groups the share of agriculture workers used by the household in the age group of 29 years or less is considered. Similarly, the share of agriculture workers in the age group of 30-55 years and over 55 years are calculated separately for each household. Subsequently, for each age group the shares are grouped into 0-25%, 26-50%, 51-75% and over 76%. Therefore, households with 0-25% of the workers in the age group of less than 29 years age group, indicates the lowest degree of using workers in this age group, while over 76% indicates the highest degree of using workers in this age group. Similarly, the intensity of family labour, hired labour, involvement in agriculture as primary occupation and involvement in agriculture as secondary occupation are calculated.

Aging and productivity

In terms of labour productivity, clear pattern is evident, where the highest average labour productivity is seen in the households employing the largest share of 30-55-year-old workers (see Table 6-5). Similarly, households employing smaller share of over 55 years farmers have the second highest labour productivity, while the third highest average labour productivity is among the households that employ the smallest share of youth farmers. This provides some preliminary evidence that farmers in 30-55 age group have a higher labour productivity, and using smaller share of relatively young and older farmers are associated with higher average productivity. Nevertheless, within all three age groups, the highest average productivity (see last column in Table 6-5) is among households that employ the smallest share from the respective age group. As such, descriptive data does not show a cohesive link between aging and productivity.

Table 6-5 Productivity by degree of aging among agriculture workers

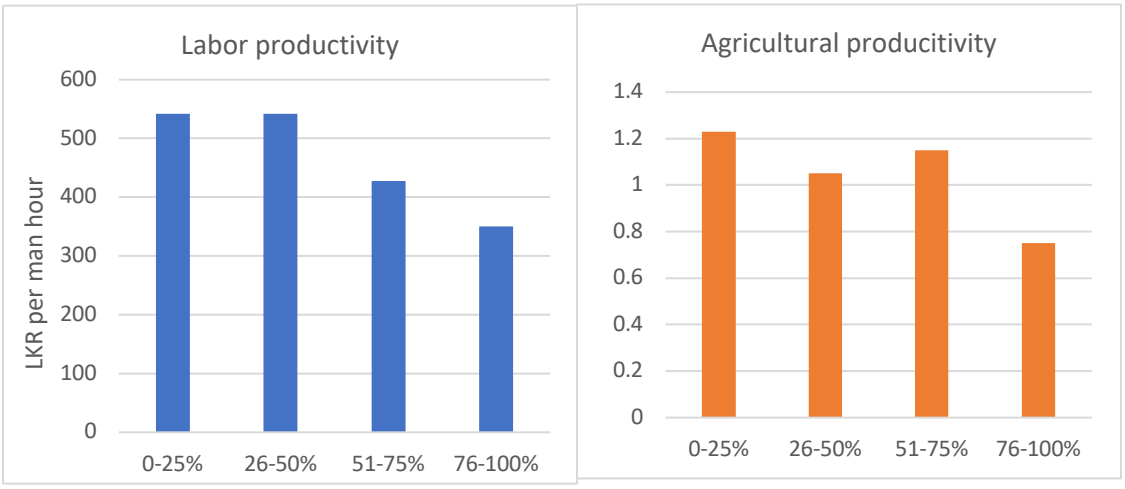
	Labor productivity (Without extreme values) (LKR per man hour)	Agricultural productivity (Without extreme values)
% of less 30 yr workers in tot lb employment		
0-25%	427.44	0.97
26-50%	368.59	0.69
51-75%	393.22	0.94
76-100%	334.31	0.85
% of 30-55 yr workers in tot lb employment		
0-25%	342.67	2.62
26-50%	333.74	0.82
51-75%	416.44	0.81
76-100%	457.85	1.05
% of over 55 yr workers in tot lb employment		
0-25%	448.22	1.01
26-50%	351.37	0.65
51-75%	359.54	0.93
76-100%	355.08	0.79

Source: Authors

Type of worker and productivity

In the case of the relationship between productivity and hired labour, the average labour productivity decline with the higher involvement of family workers at the expense of hired workers. Similarly, in terms of agricultural productivity also, the highest level of average productivity is seen in Figure 6-1 for the lowest involvement of family labour, while the lowest average productivity corresponds to the highest involvement of family labour. This provides some indication that hired workers are more skilled and hence more productive than unskilled family labour, possibly due to the wages of former being linked to their productivity.

Figure 6-1 Productivity by degree of involvement of family (% family labour in total labour employment)



Source: Authors' calculation based on ALS2020

Next, employment in agriculture as primary and secondary employment is considered as a proxy for full time and part time employment in agriculture. When involvement in agriculture is considered based on primary and secondary economic activity, the highest level of average agricultural and labour productivity are associated with the group of households employing the largest share of workers who are involved in agriculture as their primary employment (see Table 6-6). Similarly, relatively higher labour and agricultural productivity are associated with households employing smaller shares of workers who are employed in agriculture as their secondary employment. This provides preliminary evidence of the positive correlation between labour and agriculture productivity with those who are engaged in agriculture as their primary employment and the negative correlation with those engaged in agriculture as their secondary employment. Assuming that workers put more effort and emphasis on primary employment and that they are more experienced and skilled, shows that it is important to employ workers who consider agriculture as their main activity, rather than those who assign a secondary position to agriculture in terms of their economic activities.

Table 6-6 Productivity by degree of primary vs secondary economic activity in agriculture in household

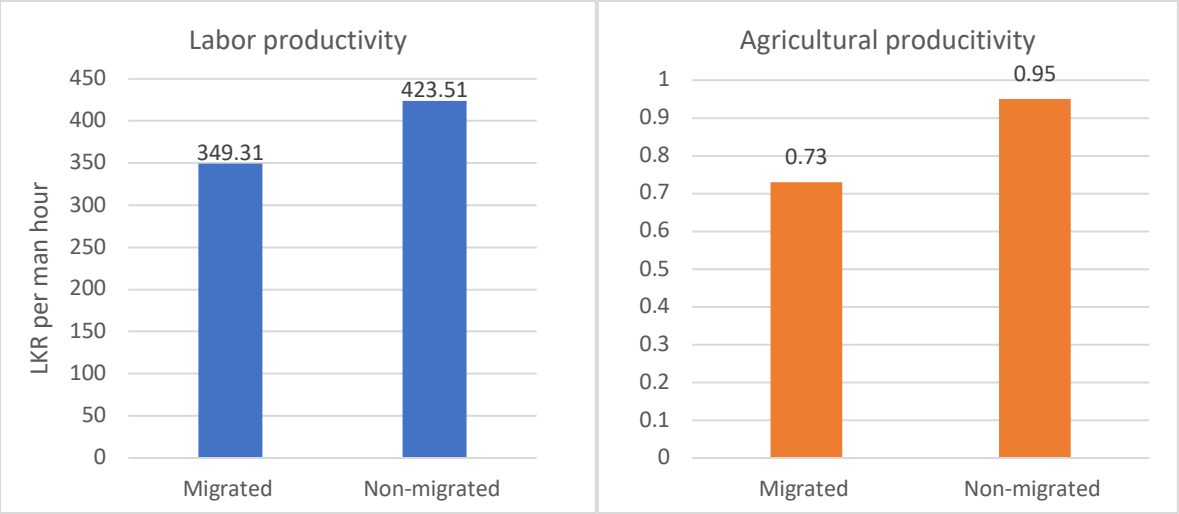
Employment	Labor productivity (LKR per man hour)	Agricultural productivity
% of hh member in agriculture as primary		
0-25%	403.12	0.89
26-50%	441.99	1.00
51-75%	335.75	0.75
76-100%	471.26	1.07
% of hh member in agriculture as secondary employment		
0-25%	420.03	0.95
26-50%	455.53	0.94
51-75%	287.98	0.75
76-100%	356.54	0.81

Source: Authors

Migration and productivity

In the nexus between migration and productivity Figure 6-2 provides preliminary evidence that both labour and agricultural productivity is higher among households without a migrant. This hints that among the two possible channels of migration affecting productivity - remittances being able to contribute positively to productivity versus the absence of labour negatively effecting productivity, the latter appears to out-weigh the former. As such, households without migrants have a higher a labour and agricultural productivity.

Figure 6-2 Productivity by migrant vs non-migrant household



Source: Authors

Productivity by age and migration

Table 6-7 disaggregates migrant and non-migrant households further by the age of workers involved, to examine productivity. In the case of using less than 30 years old workers, among both migrant and non-migrant households the lowest share of workers is associated with highest productivity.

In the case of using 30-55 years workers, migrant and non-migrant households show a different relationship with productivity. Specifically, using the lowest share of 30-55-year-old worker are linked to highest productivity levels for migrant households, while in the non-migrant households, using the highest share of workers in this age groups are associated with the highest productivity.

Similarly, in the case of using over 55 years workers, the migrant and non-migrant households also differ, but now in the opposite way. Specifically, migrant households using more older workers are more productive, while in non-migrant households using a smaller share of older workers is associated with higher productivity. This indicates some possibility that 30-55-year-old workers in non-migrant households are more productive.

This shows that for the migrant households, the optimal mix of workers for higher productivity is a smaller share of 30-55-year-old workers and a larger share of elderly workers. For non-migrant households, this optimal mix is more 30-55-year-old workers and fewer elderly workers. This indicates some possibility that older workers in migrant

households are more productive. This could be because when family members migrate and remittances receipts come in, the younger generation may not be interested in farming, and the older people may have to bear more of the burden and work hard.

Table 6-7 Productivity by age and migration

		Labor productivity ((LKR per man hour - Without extreme values)	Agricultural productivity
	% of less 30 yr workers in tot lb		
Migrant	0-25%	**384.21**	**0.80**
	26-50%	96.29	0.22
	51-75%	-	-
	76-100%	-	-
Non-migrant	0-25%	**428.96**	**0.97**
	26-50%	387.37	0.73
	51-75%	393.22	0.94
	76-100%	334.31	0.85
	% of 30-55 yr workers in tot lb employment		
Migrant	0-25%	**493.43**	**0.85**
	26-50%	234.47	0.59
	51-75%	245.90	0.78
	76-100%	340.68	0.60
Non-migrant	0-25%	331.47	0.73
	26-50%	340.08	0.83
	51-75%	429.95	0.82
	76-100%	**459.47**	**1.05**
	% of 55+ yr workers in tot lb employment		
Migrant	0-25%	279.89	0.52
	26-50%	312.74	0.92
	51-75%	176.19	0.41
	76-100%	**574.36**	**0.99**
Non-migrant	0-25%	**450.75**	**1.02**
	26-50%	355.55	0.62
	51-75%	375.26	0.97
	76-100%	337.61	0.78

Source: Authors

Productivity by age and secondary employment

Table 6-8 disaggregates households by the degree of involvement of secondary workers in agriculture as a proxy for part time workers in agriculture and age groups of all workers employed by the household.

As seen in all three panels there are limited households with more than 75% of the members in agriculture as secondary employment. When households with 0-25% of members in agriculture as secondary employment are considered, the highest agriculture productivity of 459.75 and highest labour productivity of 1.06 are associated with households with 76-100% of workers in the age group of 30-55 years. This shows that productivity is high when a large share of 30-55-year-old workers and small share of part time workers are involved. Together these descriptive findings hint that full time workers- who are fully focused in agriculture and prime aged workers who are more capable than older workers and more knowledgable in agriculture than youth workers are more productive.

In the case of employing workers older than 55 years, the highest agriculture productivity of 447.82 and labour productivity of 1.03 are associated with employing the smallest share of such workers and having less than 25% of family members in agriculture as secondary employment. A similar pattern in also seen in the case of employing workers less than 30 years also.

Table 6-8 Productivity by age and secondary employment

		Labor productivity (LKR per man hour - Without extreme values)	Agricultural productivity
	% of less 30 yr workers in tot lb		
0-25 % of hh member in agriculture as secondary employment	0-25%	**428.32**	**0.97**
	26-50%	338.11	0.68
	51-75%	393.22	0.94
	76-100%	313.90	0.80
>75 % of hh member in	0-25%	356.54	0.81
	26-50%	-	-
	51-75%	-	-

agriculture as	76-100%	-	-
	% of 30-55 yr workers in tot lb		
0-25 % of hh member in agriculture as secondary employment	0-25%	347.23	0.74
	26-50%	331.09	0.77
	51-75%	391.93	0.83
	76-100%	**459.75**	**1.06**
>75 % of hh member in agriculture as secondary	0-25%	-	-
	26-50%	-	-
	51-75%	-	-
	76-100%	356.54	0.81
	% of 55+ yr workers in tot lb employment		
0-25 % of hh member in agriculture as secondary employment	**0-25%**	**447.82**	**1.03**
	26-50%	336.06	0.65
	51-75%	361.26	0.87
	76-100%	361.54	0.80
>75 % of hh member in agriculture as secondary	0-25%	356.54	0.81
	26-50%	-	-
	51-75%	-	-
	76-100%	-	-

Source: Authors

Productivity by age and family workers

The relationship between age of workers and family workers is explored in **Table 7-7**. In all panels for age groups of workers, high productivity levels are associated with having a smaller share of family workers. In the case of employing workers less than 30 years, highest labour productivity of 1,486.94 and agriculture productivity of 2.34 are linked to having a share of 26-50% less than 30 years old workers, and less than 25% family workers.

When employing larger share of family workers are considered the highest labour productivity of 456.47 and agriculture productivity of 0.97 are associated with employing a larger share of young workers. This confirms that among family workers, young workers are more productive.

Table 6-9 Productivity by age and family workers

		Labor productivity (LKR per man hour - Without extreme values)	Agricultural productivity
	% of less 30 yr workers in tot lb		
0-25 % of family labour	0-25%	529.51	1.21
	26-50%	1,486.94	2.34
	51-75%	-	-
	76-100%	787.50	1.73
>75 % of family labour	0-25%	355.94	0.78
	26-50%	294.76	0.57
	51-75%	**456.47**	**0.97**
	76-100%	319.37	0.60
	% of 30-55 yr workers in tot lb		
0-25 % of family labour	0-25%	560.42	1.28
	26-50%	-	-
	51-75%	842.66	1.28
	76-100%	532.62	1.23
>75 % of family labour	0-25%	340.27	0.73
	26-50%	218.04	0.49
	51-75%	351.35	0.69
	76-100%	**385.32**	**0.84**
	% of 55+ yr workers in tot lb		
0-25 % of family labour	0-25%	543.60	1.22
	26-50%	543.60	0.88
	51-75%	-	-
	76-100%	333.33	1.54
>75 % of family labour	0-25%	**378.22**	**1.76**
	26-50%	242.28	1.13
	51-75%	207.17	-
	76-100%	354.20	1.96

Source: Authors

7.2 Estimation

The central focus of this analysis is on agriculture labour and its impact on productivity. The underlying conceptual, analytical and theoretical framework for analysis and the methodology of analysis were presented in Chapters 1 and 4. The estimation focuses on both labour and agricultural productivity, and both types of productivity analyses use three vectors of variables for human, natural and capital resources.

The vector of human resource variables initially controls for household level characteristics. The age and age squared of the oldest person in the household is used to proxy knowledge and experience in agriculture (Tauer, 1984), on the assumption that in these agricultural households the oldest person in the household is knowledgeable about agriculture. The historic and cultural differences in terms of diverse values, goals, motivations, access to land and other resources, among ethnicities and their influence on productivity (Inwood, 2013) is accounted for by the indicator of the ethnicity of the head of the household. The level of education affects the adoption of technology (Appleton & Balihuta, 1996). Thus, the level of schooling of the highest educated person in the household is included on the assumption that even if the actual farmer is not educated the highest educated person in the household would provide relevant information for farming. The household size is included to account for availability of agriculture labour in the household (Ninan, 1984).

Productivity differs by quantity, quality and type of workers in agriculture. The different types of agriculture workers such as family versus hired and part-time versus full-time (OECD, 2001; Fuglie, Gautam, Goyal, & Maloney, 2020). Such differences among workers are controlled for by total man hours used in agriculture, the shares of female and family workers out of total man hours, and the share of full time family workers in agriculture among household members is also included. [13] The age groups of workers are controlled for by the shares of less than 30, 30-55 and over 55 year old workers in total man hours used in agriculture, while the allocation of labour by activity is controlled for by share of man hours used for each of land preparation, plant management, water management and harvesting and post harvesting related activities. Additional controls are also included by activity, age, gender and family labour used in agriculture, and indicator for labour shortage in the area.

The number of hours worked is calculated by multiplying the average number of hours worked per day each individual by the number of days worked, for each agricultural

[13] This is proxied for by those engaged in agriculture as their primary employment.

activity/practice. In the case of agricultural productivity, to calculate the labour cost, since average wage rates are given per day, the number of days worked was multiplied by the wage rate per day (regardless of the hours worked).

The vector of capital resource variables considered include non-agriculture income, which help to obtain inputs and technology for productivity improvement (Peshin, et al., 2018; Ahamed-Lebbe, 2012; Shittu, 2014; Diiro, 2013) and an indicator for migration, of which the associated remittances enable productivity improvements (Paris, T.R.; Pubzen, M.F.R.; Luis, J.; Chai, T.T.N.; Wongsanum, C.; Villanueva, D., 2009; Singh, Singh, & Jha, 2012).[14] The use of high yielding crop varieties, chemical fertilizer, and pesticides lead to higher productivity (Islam, 2018; Fuglie, Gautam, Goyal, & Maloney, 2020; Biggs & Justice, 2015; Verma & Tripathi, 2015; Paudel, Balwadur, Rahat, Justice, & Donald, 2019). To account for these the share of expenses on seeds and chemical fertilizer, an indicator variable for type of fertilizer used in terms of organic versus inorganic and the method of cultivation in term of manual, mechanical, manual & chemical, and machine & chemicals are included by activity (land preparation, plant management and harvesting and post-harvest). Moreover, indicators for use of new crop varieties, new cultivation techniques, new irrigation methods and hybrid seeds are included.

Similarly, to demand for such new inputs and technology some level of exposure to same is required, which is often gained through access to digital-based or electronic extension systems (Fuglie, Gautam, Goyal, & Maloney, 2020). To capture this effect and indicator for use of smart phones is included in the models. The level of agriculture mechanization (Binswanger & Donovan, 1987; The International Bank for Reconstruction and Development / The World Bank , 2010) is controlled for with mechanization usage score (see Mechanization chapter for details). Additionally, control variables are included for availability of enough knowledge to use these machines and sufficient capital.

The higher availability of research centers within a society are highly correlated with the adoption of new technologies (Fuglie, Gautam, Goyal, & Maloney, 2020; Maloney & Caicedo, 2019). To proxy for such support provided by the Department of Agriculture, the variables membership in farmer organization and farmers' perception that the agrarian services centers can provide the know how to adopt modern technology are

[14] Nevertheless, the absence of labour due to migration can also leads to labour shortage, higher food price and labour costs and land abandoning, which negatively affect AP (Pant, 2013; Satyal, 2010; Jaquet, Kohler, & Schwilch, 2019).

included in the models.[15] Moreover, the availability of road connectivity and infrastructure and irrigated water increases productivity by facilitating the exchange of goods and services (Griliches, 1963a, 1963b; Bravo-Ortega & Lederman,2004). Such logistics and connectivity are controlled for by share of cost spent on transportation and an indicator for type of irrigation used by farms. Similarly, the decline and uncertainty in earnings from agriculture reflect a high level of borrowings which is negatively associated with productivity (Path, 2008; Ma, Renwick, & Zhou, 2019). Such implications of indebtedness on productivity is controlled for in models with an indicator variable for indebtedness.

The natural resources vector includes variables to account for uncertainty and resulting impact upon crop production due to natural disasters (Santiapillai & Wijeyamohan, 2010; Dharmaratne & Magedaragamage, 2014; Cumani & Rojas, 2016) such as elephant attacks. The extent of land is controlled for in the model as land fragmentation lead to inefficient allocation of recourses and associated increased costs of production.[16] Similarly, land characteristics such as slope, flat or undulated etc., which makes use of machinery more effective are controlled for in the models. Property rights for land increases the incentives of households and individuals to invest as well as access credit facilities (Deininger, 2003; Tenaw, Islam, & Parviainen). To account for such implications on AP, this analysis includes an indicator variable for land ownership. Literature notes that productivity may be underestimated due to lack of accounting of crops grown in mixture or in sequence (Kelly, Hopkins, Reardon, & Crawford, 1996). This is controlled by indicator variables for type of crops cultivated. Additionally, district level fixed effects are controlled with district dummies.

In estimating the models, the extreme values are excluded and initially an overall model is estimated followed by separate productivity models for paddy, vegetables and other OFCs. The overall model for LP is denoted by overall LP model, while the LP models for paddy, vegetables and other OFCs are denoted by LP paddy, LP vegetables and LP OFC,

[15] Nevertheless, literature shows that the effect of proximity has declined over the years to become nearly zero at present due to spatial frictions of the time, resulting from poor information flow and difficult transport, causing the social rate of return to public research spending decrease (Kantor & Whalley., 2019).

[16] On the contrary, when approached from demand side the demand-side factors land fragmentation may also be due to farmers voluntarily choosing beneficial levels of fragmentation (Sundqvist & Andersson, 2006)

respectively. The AP models for overall, paddy, vegetables and other OFCs are denoted by AP overall, AP paddy, AP vegetables and AP OFC, respectively.

Diagnostic Tests

Diagnostic tests were carried out evaluate possible violations in the regression assumptions and detect problematic outliers. As in the case of the agriculture labour models in Chapter six, the Tukey and Pregibon link test and Ramsey specification test conducted to assess model specification suggested that certain relevant variables considered in the preliminary analysis may be excluded from the regression. Here too, the issue is difficult to resolve due to the vast number of observable and unobservable factors that influence labour and agricultural productivity. The major factors identified through the literature have therefore been considered within the models. To address the issue of irrelevant variables that may reduce the efficiency of estimated coefficients, test statistic values and measures of the overall explanatory power of the models were used. Several independent variables were identified through this process to have a low level of relevance to productivity.

Outliers were identified graphically through scatter diagrams of the dependent and independent variables, while points of high leverage were assessed using the plot of normalized residual squared values and leverage. Highly influential values that indicated sufficient evidence for removal were not included in the analysis. To ensure the efficiency of estimates, the variance of residuals was also examined. Some non-randomness was seen in the plot of residuals against the fitted values indicating the presence of heteroscedasticity. This was confirmed by the Breusch-Pagan test and robust standard errors were used to minimise the adverse impacts on the model.

The inclusion of several explanatory variables that represent closely related concepts, raises the concern of multicollinearity. While low levels of multicollinearity are not problematic, more severe levels can cause estimates to become highly sensitive and present large standard errors. The correlation matrix suggested that highly correlated variables included those containing gender, age and agricultural activity type related information. The large variance inflation factors associated with these variables verified the findings. Finally, the kernel density graphs indicated that the residuals were not normally distributed. As this is not an assumption that is required for point estimation, it has no major impact on the findings.

In keeping with the results of the diagnostic tests, the share of family and female labour, non-agricultural income, use of new irrigation methods and smart phones, barriers to accessing knowledge and capital, the presence of an internal migrant, share of workers

various agricultural activities, and several types of cultivated crops were removed from the initial models. Despite their theoretical relevance, these variables indicated a low contribution to the explanatory power of the regression and were likely to cause multicollinearity as their effect was likely to be captured through other variables within the analysis.

7.3 Results

Table 6-10 depicts determinants of LP and AP. The coefficients on all LP models reflect output per man hour, as LP is calculated as the ratio of the value of agriculture outputs to number of labour input hours used. The coefficients on the AP models reflect the ratio of the value of agriculture outputs to value of agriculture inputs. Given the methodology adopted in the analysis all statistically significant coefficients indicate a correlation with productivity when all else is held equal.

Table 6-10 OLS Regression for Determinants of Labour & Agricultural Productivity - ALS2020

	(1) LP All	(2) LP paddy	(3) LP Ofc	(4) LP veg	(5) AP All	(6) AP paddy	(7) AP Ofc	(8) AP veg
Age (max in hh)	-0.245	-0.472	-1.576	-23.417	0.010	0.024	-0.009	-0.201
Age sq	-0.001	0.005	0.004	0.172	0.000	0.000	0.000	0.001
Sinhala	407.235***	696.057***	-	-	0.726***	1.312***	0.084	-0.133
Tamil	-234.820*	-146.369	23.327	359.408	-0.888***	-0.891***	-	-
Schooling - Grade 1	19.519	418.116	780.192**	-	-0.199	0.385	1.224*	-
Grade 2	195.984	616.334**	560.553**	730.534	0.288	0.877*	0.290	5.256*
Grade 3	186.742	341.377	661.302**	425.970	0.348	0.733	0.313	3.488
Grade 4	65.151	471.770*	417.311	400.096	0.400	0.911*	0.501	2.714
Grade 5	240.331*	613.496**	768.726***	143.210	0.387*	0.884*	0.628	3.922
Grade 6	203.229	619.392**	832.939**	591.705	0.145	0.608	1.169*	4.120
Grade 7	200.856	571.919**	616.405**	645.066*	0.408*	0.890*	0.524	8.921***
Grade 8	124.085	535.388**	709.759***	801.080	0.381	0.843*	0.765	4.582**
Grade 9	198.377	620.179**	718.505***	390.805	0.353	0.945*	0.659	3.511
Grade 10	225.548*	652.723**	567.028***	617.930*	0.314	0.959*	0.606	6.007***
Passed O/L	240.181**	598.456**	617.016***	440.534	0.331	0.927*	0.562	4.412**
Up to A/L	221.982**	696.595***	617.596***	588.758*	0.325*	1.030**	0.595	5.685***
Passed A/L	221.723*	647.553***	633.425***	679.813*	0.339*	1.033**	0.642	5.643***
Household size	-26.910**	-29.730*	-42.495**	34.422	-0.042*	-0.073*	-0.041	0.258
Primary lb % in hh	0.171	0.778	-0.906	1.647	0.000	-0.001	0.002	0.005
Total man hours	-0.028*	-0.061*	-0.023*	-0.194**	0.000	0.000***	0.000**	0.000
30-55 yr lb %	-4.441	-8.526	-5.584	-45.399***	-0.004	-0.024*	0.002	-0.126**
>56 yr lb %	-4.156	-9.855	-1.932	-45.755***	-0.008	-0.030**	-0.001	-0.164**
Land prep lb % 30-55 yrs	-1.397	1.960	-0.599	8.988	-0.002	0.010	-0.002	0.027

	>55+yrs	-1.334	2.787	-2.103	15.351**	0.001	0.014*	0.002	0.069**
Harvest lb %	30-55	1.333	2.092	1.037	16.110***	0.004	0.003	0.001	0.055*
	>55+yrs	1.584	2.906	1.284	13.828**	0.004*	0.005	0.006	0.044
Water m %	30-55	2.482	5.350**	1.038	7.890	0.003	0.009**	-0.003	0.017
	>55yrs	1.989	6.470***	0.121	7.607	0.000	0.008*	-0.008	0.037
Plant m%	30-55 yrs	0.532	-0.882	2.139	11.432***	0.000	0.002	0.000	0.024
	>55+yrs	0.082	-2.227	-0.368	8.011*	0.001	0.003	-0.001	0.008
Hired lb %	in land prep	-0.052	-0.757	-0.146	3.995	0.000	-0.001	0.002	-0.012
	in water mgmt	-1.254	-1.041	-0.738	-0.500	-0.002*	-0.002	-0.007*	-0.006
	in plant mgmt	0.373	-0.757	-1.214	-2.377	0.001	0.000	0.000	-0.008
	in harvest	0.291	0.070	-0.077	2.378	0.001	0.002	0.003	0.005
Male lb %	in land	-0.455	-0.393	-0.825	3.551*	-0.001	0.002	-0.002	0.024*
	in water mgmt	1.563**	0.104	2.998***	1.946	0.004***	0.003	0.007***	-0.009
	in plant mgmt	0.129	1.556	-0.584	-2.681	-0.001	-0.002	0.000	0.004
	in harvest	-0.066	0.123	0.243	-2.045	-0.001	0.000	0.000	-0.013
Labour_shortage		33.097	-6.820	77.362*	54.477	-0.006	-0.034	0.041	-0.329
Cost % Seeds		13.189***	17.097***	8.874**	8.665	0.027***	0.030***	0.019**	-0.043*
	Chemi ferti	7.949***	6.075***	6.717**	3.379	0.003	-0.004	0.007	-0.030
	Transport	11.533***	7.788***	13.480**	14.104	0.013***	0.007**	0.011	0.063
Chemi.fertilizer use		-24.406	-374.709**	15.281	-101.579	0.057	-0.619*	0.077	-2.219
Organic fertilizer use		-46.679	27.042	-38.783	-57.161	-0.096	-0.091	-0.131	-0.250
Water m. meth. Manual		13.251	76.901	-42.189	-196.342*	0.065	0.037	0.130	-0.401
Use	New crops	-94.887**	-42.897	-59.993	-310.920	-0.103	-0.010	-0.063	-1.928*
	Hybrid seeds	-4.921	-12.764	38.991	117.772	0.104	0.068	0.047	0.573
	New cultivation	15.149	-96.647	-44.756	31.523	0.101	0.233	0.039	0.680
Mechanization score		2.803	13.468	-22.501	-2.305	0.001	-0.002	-0.092*	-0.095
Agri ministry		-62.238*	-11.474	-160.103***	-40.019	-0.094	0.062	-0.215	-1.091*
Farmer organization		99.784***	100.209*	107.752**	13.498	0.125**	-0.020	0.250**	0.812
Irrigation	Major	37.134	-87.201	40.780	-310.940	-0.015	-0.082	0.087	-2.975**
	Minor	-62.247	0.851	-77.601	-287.909*	-0.131*	-0.055	-0.207	-1.205
	Rain fed	-48.770	-72.911	-164.548*	-363.015**	-0.216***	-0.207**	-0.391*	-1.755
	Agro well	-9.774	5.850	4.115	-157.827	-0.124	-0.075	-0.050	-1.958**
	Micro	-190.816***	15.806	-211.426**	-335.105*	-0.308*	0.170	-0.308	-1.057
	Other	-104.620*	-100.277	-189.633*	-586.749***	-0.375***	-0.306	-0.523**	-3.214**
Indebtedness		25.518	15.796	26.314	78.456	0.049	0.034	0.046	0.600
Elephant attacks		-89.064	-87.425	151.153	-135.363	-0.145	-0.070	-0.275	0.119
Land	Slope	-80.121**	-47.701	-89.737**	135.585*	-0.130**	-0.044	-0.072	0.442
	Steep slope	-23.521	388.728	183.783	335.625	-0.021	0.468	0.464	2.085
	Undulated	-46.432	-441.258***	-62.205	-98.195	-0.248	-0.306	-0.758*	-2.019
Land ownership		43.818	42.036	16.641	-19.734	0.063	0.061	0.103	1.403***
Land extent (?)		0.034*	0.115***	0.027	0.017	0.000**	0.000***	0.000	0.000
Small land barrier		49.904	13.660	73.844	161.594*	0.099	-0.033	0.236**	0.826*
Crop type	Paddy	63.548	-	-52.798	18.024	0.042	-	0.259	-2.495**
	Fruits	124.681	-272.468**	252.038**	297.240*	-0.123	-0.564**	0.435*	-0.238
	Legumes	-31.706	-31.185	-106.008	45.329	-0.237**	-0.262	-0.391**	-1.602
	Oil crops	-83.104	-	-104.029	151.854	-0.439**	-	-0.398	-2.241*
	Other crops	168.862***	-196.645***	173.366**	1855.611	0.520***	-0.350**	0.498***	4.323

	Roots	-9.031	-132.330	151.144	-103.404	-0.009	-0.080	0.025	-1.764*
District	A'pura	-112.093	-497.064**	200.862	123.341	-1.031***	-1.753***	-0.105	0.039
	Badulla	-105.812	-716.442**	122.375	-251.851	-1.181***	-2.372***	-0.318	-3.329
	Batticaloa	832.713***	864.290***	-	-	0.853***	0.777**	-0.201	3.549
	Jaffna	567.399***	178.189	318.413	-91.608	0.683**	0.516	-	-
	Kilinochchi	424.050***	286.381*	29.850	-	0.528*	0.420	-0.444	-
	Matale	-33.916	-458.709*	186.782	855.905*	-0.911***	-1.898***	-	-1.686
	Moneragala	-122.138	-524.068**	188.722	231.230	-0.949***	-1.937***	-0.098	-1.666
	Mullaitivu	-53.522	-384.674*	234.185	-	-0.951***	-1.684***	-	-
	Polonnaruwa	-243.837	-522.195**	-	-	-1.270***	-1.977***	-0.815*	-
	Vavuniya	331.165**	226.036	-	-	0.417	0.329	-	-
Constant		-252.470	-320.096	-192.523	564.706	0.276	0.280	0.221	7.999**
Observations		823	464	428	234	828	484	427	220
R 2		0.426	0.572	0.373	0.533	0.376	0.47	0.345	0.479

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Cost for family labour imputed based on average male and female wage rate in area.
Significance based on robust standard errors.
Omitted categories: Ethnicity-other; Education – no schooling; Land type- flat; District -Ampara
Source; Authors' calculations

The quantitative models show that compared to households of other ethnicities, a Sinhala farming household has higher labour and agricultural productivities. For instance, when all else equal if the ethnicity of the household members change from other ethnicities to Sinhala, the corresponding increase in LP is 407.2 (see column 1). In the case of paddy (see column 2) the corresponding increase in LP is much higher (LKR 696.1). Similarly, in terms of AP also Sinhala households have a higher productivity and this is much higher when only paddy cultivation is considered in Column 6. In terms of Tamil households, a negative correlation for AP is evident. For instance, switching the ethnicity of the household members from other ethnicities to Tamil lowers overall LP by 234.8 and overall AP by 0.888, while the paddy AP declines by 0.891 (see column 5 and 6). This indicates that the cultural practices of Sinhala farmers, their values, goals, motivations, access to land and other resources are positively correlated with labour and agricultural productivity, while that of Tamil farmers is lowering their LP and AP. Therefore, strategies to improve productivity should be sensitive to ethnicity related aspects.

The group of indicators for level of education of the highest educated member in the household shows a many statistically significant positive associations with LP and AP. In the case of all crops, switching from no schooling to the completion of the 5th grade in school is associated with a 240.3 increase in LP. This coefficient is the largest in the group of educational variables in this model. For paddy cultivation having a member of the household educated up to A/L is associated with a 696.6 increase in LP, while with OFCs, many levels of education have a positive association with LP. Specifically, switching from

no schooling to education upto 6th grade is associated with the highest increase in OFC LP by 832.9.

In the case of AP, as seen in Column 5 for all crops, only two education levels are statistically significant. The largest increase in productivity is associated with education up to grade 7. As such, if the highest educated person in the household switched from no schooling to passing 7th grade this is correlated with 0.408 increase in AP, and the similar correlation with AP is 1.143. With regards to paddy the AP increases due to many education levels, while the highest increase is due to switching from no schooling to education upto A/L. These findings resonate with the literature, where ay recent study by Shaikh, Hongbing, Khan, & Ahmed (2016), suggests that educated farmers may try to adopt modern methods in most of their farming practices and ensure the use of new technologies in most of the farming practices. Similarly, Appleton & Balihuta (1996) find that skills such as literacy and numeracy enable farmers to follow written instructions related to modern inputs, and thereby enabling their correct application, which leads to productivity improvements.

In the case of OFC AP, education levels up to the 1st and 6th grades are statistically significant. The largest increase in AP is seen among households where the highest education level is one year of schooling as opposed to none, which corresponds to a 1.224 increase in AP. For vegetable AP, passing the 7th grade shows the highest correlation of increasing AP by 8.921. These findings with many positive and significant coefficients on the education level of the highest educated member in the household resonates with findings on the impact of education on improving AP and LP. Moreover, in most models in Table 10, the largest coefficients are concentrated in the 5th, 6th and 7th grades. This indicate that rather than upper end of the school education, education up to middle school level is sufficient to improve productivity in the agriculture sector. Similarly, these findings indicate that strategies to improve LP and AP does not necessarily focus on educating farmers, but level of education of other members in the household is also important. Together all these findings underscore the potential for integrating labour and AP improvement knowhow in to school curriculum.

The household size has a negative correlation in overall and OFC LP models. Specifically, each additional member in the household is associated with a 26.9 lower overall LP in column 1 and a 42.5 lower LP in OFC. A similar negative correlation is seen with household size and AP in the case of overall model in column 5, while in the case of paddy cultivation, each additional member in the household is associated with a 0.073 decrease in AP. These findings are consistent with the hypothesis that excess labour in agricultural communities are associated with lower productivity, and resonates with the

findings by Benjamin & Kimhi (2006), which suggest that, greater household size lead to decrease the agriculture productivity due to the substitution effect of farm labor input.

The models do not show any statistically significant difference in productivity due to changes in the share of full-time agriculture workers in the household (which is proxied for by share of primary agriculture workers). When the labour inputs are disaggregated by age groups, in the case of vegetable LP model, relative to the omitted category of less than 30-year-old workers, increasing the share of 30-55-year-old worker and over 55-year-old workers by 1% is associated with decreasing LP by 45.4 and 45.8 respectively. Similarly, for AP paddy and AP vegetable also the same two groups are associated with lower productivity. These latter models show that greater employment of older workers is associated with lower productivity. These findings are in line with the established literature which identifies that participation in on-farm labor increases with age up to a certain point, after which participation decreases (Tocco, Davidova, & Bailey, 2012). As such, older farmers deviate from agriculture/ show low LP mainly due to adverse effect of their age and their inert resist to new technologies in agriculture production (Guo, Wen, & Zhu, 2015). Hence, from policy perspective, it is important to develop different policies targeting different types of farmer groups based on age. For instance; policy directions can be made towards young farmers targeting improving their skills, providing financial assistance, expand scale of operations and ultimately modernize and industrialize the agriculture production. Therefore, various forms of trainings should be designed and catered to increase efforts to cultivate modern professional farmers and policies should be simultaneously developed to increase agricultural production levels among each group of farmers based on age classes.

The age disaggregation of labour used for different activities show a correlation with productivity. In the case of land prep activities, relative to the omitted group of less than 30, additional percentage labour input of over 55-year-old workers is associated with 15.4 increase in LP in vegetable cultivation. With regards to AP paddy and AP vegetable, higher productivity is associated with employing more 30-55 and over 55-year-old workers, respectively. In the case of harvesting, LP vegetable again indicates a higher productivity with an increased share of older workers. An additional percentage of labour inputs aged 30-55 years and over 55 years in relation to those below 30 years indicate an increase in LP vegetables by 16.1 and 13.8, respectively. Of the two, the larger impact is by the 30–55 year-old group. A higher share of both these age groups also shows some increase in overall AP and AP vegetable cultivation. A similar outcome can be seen in terms of plant management for LP for vegetable cultivation as well, which shows that age of worker in these activities matters mainly in vegetable cultivation. This could be due to the relatively smaller land area cultivated by vegetable growers, which allows

older workers to utilise their experience, increasing productivity without being severely affected by their physical limitations due to ageing.

In the case of water management for paddy, relative to less than 30-year-old workers, higher LPs are associated with 30-55 and over 55-year-old workers. Here increasing the share of workers older than 55 years for water management by 1% correlated to increasing productivity by 6.5, while the corresponding increase for 30-55-year-old workers is 5.6. Nevertheless, in the case of AP, the slightly larger contribution for AP is associated with somewhat younger workers. For instance, increasing the share of 30-55-year-old workers is correlated with increasing AP by 0.009, while the corresponding increase for over 55-year-old workers is 0.008. Overall, these results indicate that age of workers involved in water management matters only in paddy cultivation. Therefore, it's clear that the impact of age groups in labour and agriculture productivity cannot be generalized, and it is worthwhile to identify the age groups which are associated with low AP and LP in each practice and design training programs for each, focusing on promoting new technologies/applications accordingly.

The impact of gender is assessed through the share of male workers in relation to female workers in each agricultural activity. There is some evidence that increasing the share of male workers in land preparation and water management increases labour and agriculture productivity. In land preparation, a 1% increase in the share of men increases labour productivity and agriculture productivity in vegetable cultivation by 3.6 and 0.02, respectively. Overall LP and AP as well as LP and AP associated with OFCs also increase when a there is a higher portion of males increase in water management.

These findings are consistent with literature which highlights there are differences in productivity by type of workers (OECD, 2001; Fuglie, Gautam, Goyal, & Maloney, 2020). Specifically, Deolalikar and Vijverberg (1987) underscore that family labour is less productive than hired labour, while UN Women (2019) highlight a gender gap in productivity in agriculture due to factors such as women's limited ownership of land "can lead to restriction in women's access to irrigation water, as allocations are frequently tied to ownership of land and membership in farmer organizations" (FAO, 2018, p. 59). Similarly, "the system of registration at government Agrarian Service Centres is linked to membership in farmer organizations and land titles. This situation prevents women from receiving subsidies and training from [Department of Agrarian Development] DAD" (FAO, 2018, p. 44). Still, it is important to note that unlike in cited studies, which focused on individual farmers, the current analysis focuses on agricultural households and gender is included as a share of labour inputs, while there is no direct comparison between male and female farmers. As such, the typical issues causing the gender gap in

productivity such as women's low access to inputs, lower returns on the inputs they use and comparatively less secure land rights as well as gender-based distortions in product markets, the unfavourable gendered norms and practices, and unequal power relations etc, may not be at play when modeled in this manner. As such, it is important to retest the same hypotheses about heterogeneities of labour in terms of gender, family vs hired labour and full time versus part time workers, with different data in Sri Lanka, prior to recommending strategies based on this finding.

While findings related to the indicator for labour shortage for the area suggests that the labour productivity of OFCs may be higher in the presence of a labour shortage, it showed no association with the productivity of paddy, vegetables or overall cultivation.

Nevertheless the literature, shows that an absence of labour due to migration leading to labour shortage would negatively affect agriculture productivity. In addition higher food prices, labour costs and land abandoning would have a similar effect (Pant, 2013; Satyal, 2010; Jaquet, Kohler, & Schwilch, 2019).

In terms of the cost components and their relationship with productivity, the higher share of cost spent on seeds, chemical fertilizer and transportation are associated with consistently higher labour productivity for all models except vegetables. In the case of overall model in column 1, the highest increase in LP is associated with spending on seeds, where each additional percentage spent on seeds is linked to a 13.2 increase in AP. Similarly, in the case of paddy model in column 2 also the highest influence on LP is due to increased cost share on seeds. In the case of LP in OFC the cost share of transportation is associated with increasing LP by 13.5. Similarly, the cost share of chemical fertilizers also contributes to higher LP in overall, paddy and OFC models. The highest increase related to chemical fertilizer cost share is associated with overall LP, which is 6.7. These findings indicate that in overall, paddy and OFC models, spending on seeds, chemical fertilizer and transport have a positive association with LP. In paddy a largest bang for the buck is associated with spending on seeds, probably due to high quality seeds at a higher price results in higher productivity. In the case of OFC, the largest bang for buck is associated with transportation, possibly due to the importance of timely transportation of OFCs. These finding are consistent with existing literature which shows that, increased productivity of most domestic agricultural crops at the farm level is due to the usage of improved high yielding seeds and crop varieties together with yield increasing inputs such as chemical fertilizers and pesticides (Somaratne W. G., 1993). Similarly, the importance of transportation for productivity is also highlighted in the 2019 Overarching Agricultural Policy for Sri Lanka (Ministry of Agriculture, 2019) which recognizes the need to strengthen markets and value chains, and find solutions to connectivity and

logistics issues in the sector. The adverse effects of transportation and connectivity issues were strongly highlighted during qualitative data collection for KIIs and FGD where participants identified transportation as a deterrent for growth in the agriculture sector in Sri Lanka. As such, infrastructural facilities such as transportation and markets are key for productivity growth in agriculture.

Even though use of cost share of chemical fertilizer is considered to increase productivity as discussed above, the indicator for its use has a negative coefficient, which means that relative to using a combination of both chemical and organic fertilizer switching to purely chemical fertilizer use is associated with decreasing paddy LP by 374. Similarly, the use of new crop varieties is associated with 94.9 lower overall LP and 1.9 lower AP in vegetables. This shows that the mere use of chemical fertilizer or new crop varieties is insufficient to improve productivity, but substantial investments have to be made in this regard to see an associated productivity improvement. On the other hand, the use of a manual water method indicates a lower labour productivity in vegetable cultivation suggesting that a mechanical method will improve productivity.

In terms of mechanization score, in most model the coefficients are not statistically significant except for AP OFC, which shows that the mechanizations score is negatively associated. This finding is contrary with established literature which shows that, increase in AP of crops in domestic agriculture sector of Sri Lanka have been achieved through mechanization of various aspects of agriculture practices such as, land preparation, weeding, plant management, harvesting and other crop management practices during recent past (Somaratne W. G., 1993). A possible explanation is that this score does not sufficiently reflect the relationship between mechanization and productivity in most situations since it does not consider the effects of specific tools and machines used. In the case of a negative association with AP OFC, that may be due to the low level of mechanization in OFC cultivation (See Table 8-1).

As seen in LP OFC (column3), farmers' perception that the agriculture ministry and its agrarian services centers can provide the know how to adopt modern technology has a negative relationship (-160.1) with productivity. This coefficient could be reflecting either of the two aspects of agriculture ministry and productivity as follows. On the one hand it could be that those who depend on agriculture ministry to provide know how for productivity improvements are those who are waiting for such knowledge to be provided to them and do not seek such knowledge on their own. As such, this negative coefficient may be indicating their lack of drive to seek knowledge. On the other hand, it could also reflect the mis-match in expectation of farmers and what is delivered in terms of information by agriculture ministry and its agrarian services centers. Similarly, as

claimed by one KII stakeholder[17] in private sector, "Even though DoA or Agrarian service centers provide trainings/ island wide extension service to farming community, still there's a matter of effectiveness, how they follow up and go to grass root level". Similarly, another KII respondent[18] mentioned that although DoA and related research institutes involve in many of research projects in agriculture sector, still most of the research outputs are not practical in the field level, and not compatible with the farmer's expectations. As such, as underscored by (Urgessa, 2015) the need of proper extension services alongside with modern technologies is timely need for the enhancement of agriculture and labor productivity since farmers who use extension services are more productive than non-users.

On the contrary, membership in farmer organizations is consistently associated with greater productivity across many models. This shows becoming a member of a farmers' organization would lead to higher productivity by 99.8, 100.2 and 107.8, in the case of overall, paddy and OFC LP models. In the case of overall AP and OFC AP, the productivity gains are 0.125 and 0.250, respectively. These results are moreover consistent with the study of Tolno, Kobayashi, Ichizen, Esham, & Balde, (2015) suggesting the positive effect of membership of farmer organizations towards AP, due to easy access of agricultural input/ equipment, credit facilities, agricultural training and extension services via those farmer organizations. As such, from policy implication perspective; farmer organizations can be identified as a good platform for the provision of agriculture inputs, extension services and credit facilities among farming community; which can immensely enhance the productivity in Sri Lanka's agriculture sector. For instance; one of KII respondent[19] in private sector suggested that farmers can make collective investments through farmer organizations to purchase high-cost machineries such as combined harvesters and tractors etc. Thus, farmer organizations can be used to improve the level of agriculture technology adoption among farmers to achieve better growth in the sector in long run.

In terms of type of irrigation, when overall LP is considered, farmers using micro wells have a 190.8 lower LP, while in the case of OFC a lower LP is associated with rainfed irrigation, by -164.5. In terms of LP in vegetable cultivation, many types of irrigation are associated with negative LP. For instance, the largest negative correlation of 586.7 is

[17] Officer in private sector interviewed on 15/02/2021

[18] Officer in private sector interviewed on 10/02/2021

[19] Officer in private sector interviewed on 12/02/2021

associated with other irrigation. In terms of AP, rainfed, micro and other types of irrigation are associated with negative overall AP, while in the case of paddy cultivation rainfed irrigation is associated with negative AP. In the OFC AP model rainfed and other irrigation are negatively correlated, while in vegetable cultivation, major irrigation, agro wells and other irrigation are associated with negative AP. These results show that in, rainfed agriculture is a hindrance to productivity and thus needs to be focused as a mechanism to improve productivity. As Urgessa (2015) shows rainfed cultivation is risky and negatively impact agriculture productivity enhancement, especially during extreme drought periods. Therefore, promotion of using irrigation system or any other source of water is useful, during drought periods (especially in yala season), so as to increase the agriculture/ farm productivity. Specifically, in the context of Sri Lankan agriculture, there is lack of rainfed water in "yala" season, during which farmers tend to cultivate more OFCs and vegetables, instead paddy, by using major irrigation and other sources of water such as agro wells. As such, due to limited availability of rain-fed water, the extent of land cultivated by the farmers are low in "yala" season, compared to "maha" season, which may have been the basis for the finding of low AP specially in "yala" season. In this context, as highlighted by FAO (2017, p. 17) it is important rebalance "the focus of agricultural policies towards improving efficiency … in the context of limited availability of natural resources, such as land and water.". Furthermore, low productivity associated with micro irrigation, agro-wells and other irrigation may be due to the fact that these irrigation methods are features of smaller scale agricultural cultivation. As such, these operations tend to lack economies of scale and often indicate a lower level of agriculture and labour productivity than larger operations.

Results in Table 9 shows that sloped land is associated with lower overall LP, OFC LP and overall AP models, while undulated land is correlated with lower LP in paddy and lower AP in OFC. Labour productivity of vegetable cultivation however, is positively associated with slopes, which can be expected as the cooler hilly areas are used for vegetable farming. These results indicate that when all else equal, switching from a flat land to a sloped or undulated land is associated with bringing the productivity down in most cases, possibly due to rapid loss of soil fertility and or difficulty in cultivating and using machinery in such unstable sloppy lands (Waragoda, 2000). Therefore, as pointed out by Waragoda (2000); 1. Extension programs have to be designed with the consideration of using modern technologies to avoid aforesaid issues, especially in those types of slopped or undulated lands, 2. implementation of land use planning programs in island wide, 3. develop integrated agriculture development approaches for the enhancement of agricultural productivity in low productivity land classes and 4.

Implementation of community based land use planning programs and watershed development programs, are important.

In the case of land ownership, only AP in vegetable cultivation shows a statistically significant coefficient, reflecting that having ownership of land is associated with 1.4 higher AP. This finding is consistent with findings by Akinola and Adeyemo (2013), which suggests that farmers with defined land ownership rights would have high LP & AP, due to their greater adoption of agriculture productivity enhancing technology than those who rent or engage in sharing cropping. Likewise, literature identifies as land ownership is connected to many facets of benefits in agricultural communities. For instance, (FAO, 2018) underscores that lack of land ownership in Sri Lanka limits farmers from obtaining agricultural assets, services and benefits such as subsidies, credit and irrigation water.

As such, this finding highlights the importance of strategies to ensure land ownership for farmers to support their productivity improvement. With regards to extent of agricultural land, there is a positive correlation with overall LP and AP as well as paddy LP and AP. This finding is consistent with the early studies on the relationship between farm size and productivity. For instance; Akinola & Adeyemo (2013) highlighted the positive effect of land size on agriculture productivity, based on the fact that farmers with large extent of lands will enjoy economies of large-scale production. Further, as noted by Fuglie, Gautam, Goyal, and Maloney, (2020) this positive nexus may be due to smaller farms employing more family labor per hectare leading to lower productivity, as well as more successful farmers consolidating their land and expanding operation to higher productivity. Therefore, government at all levels should provide subsidies and incentives to enhance land distribution and ownership of agricultural land.

In terms of the combined cultivation of crops and their implications on productivity, the results show that the combinations of paddy and fruits, the combination of paddy and other crops lower LP, while the combinations of paddy and fruits, vegetables and paddy, legumes and OFCS, vegetables and, other crops and roots and OFCs are associated with lower AP. On the other hand, fruits and vegetables indicate a higher labour productivity, and fruits and OFCs, as well as OFCs and other crops show higher productivity in both labour agriculture. This finding shows that greater emphasis has to be placed on what combinations of crops can be produced together to maintain high LP and AP. As such, development and adoption of productive efficient, sustainable and profitable cropping systems (eg: diversifying crop rotations/ intercropping/ mix cropping systems) through evaluation of several years of filed experiments by either DoA or relevant research institutes is an important strategy.

Finally, with regards to districts, Anuradhapura, Badulla, Matale, Moneragala, Mullaitivu and Polonnaruwa are associated with negative LP and AP, while Batticaloa, Jaffna, Kilinochchi and Vavuniya are associated with positive LP and AP. This higher LP and AP in mainly Tamil speaking districts is consistent with the KII (with SLCARP) which revealed that farmers in Jaffna are considered hard working and thus more productive than farmers from other regions. This higher productivity associated with these districts may reflect cultural and ethnic factors of farmers that contribute to their productivity. Nevertheless, when the ethnicity Tamil was considered the correlation was negative. As such, this shows that beyond farmers, district level characteristics – type of crops, richness of soil etc. also matter.

In addition to the above labour related variables and a rich set of household level variables, there may be other variables that are not available at the household level that explains productivity, such as institutional level factors, beyond what is captured in the Agriculture ministry related perception variable included in the model. Specifically, while the variable included in the model reflects household level perception if the agriculture ministry and its agrarian services centers can provide the know how to adopt modern technology, there may be gaps between perception and actual service delivery. Moreover, the positive statistical significance on the variable on membership in farmer organizations also indicate that collectivization of farmers contributes to higher productivity. As such, it is important to examine such institutional factors that contribute to productivity of farmers in Sri Lanka, which is beyond the scope of this study.

7.4 Recommendations

Based on the foregone analysis and its results a few key strategies emerge to improve AP and LP in Sri Lanka. They are

- Harness the knowledge and experience of older generations in agricultural households for productivity improvement. Towards this end, it is important to hold knowledge sharing session at community level and formally pass down the experience and knowledge of older farmers to younger farmers. This could be in the form of meetings/workshops and field demonstrations. Provincial agricultural departments can initiate and monitor this as one of their priority programmes.

- Changing attitudes of farmers in terms of more productively utilization of scarce resources to have their maximum benefit, by highlighting the different productivity levels across different regions, crops, communities etc. is required.

- Productivity improvement efforts needs to be sensitive to ethnicity related aspects.

- Level of education in the household contributes to LP and AP improvements. As such, productivity improvement information need not be limited to the level of education of the farmer, but factor in the education level in the household.

- Engage non-farming yet educated family members in farming households to disseminate productivity improvement related information.

- Factor in AP and LP improvement education to the secondary school curriculum.

- Redistribute excess labour in agricultural communities to other sectors to improve AP and LP. Expand part time off- farm activities, and match excess labour with labour shortage areas.

- Type of workers – Family versus hired workers or of full-time vs part time workers do not matter towards productivity. Focusing on all these categories of agriculture workers equally for productivity improvement efforts will be fruitful. However, since there are some differences in productivity based on the share of male workers in relation to female workers, gender considerations should be made.

- Devise age differentiated and agricultural activity wise policies for productivity improvement. For instance, policy directions can be made towards young farmers targeting improving their skills, providing financial assistance, expand scale of operations and ultimately modernize and industrialize the agriculture production. Therefore, various forms of trainings should be designed and catered to increase efforts to cultivate modern professional farmers and policies should be simultaneously developed to increase agricultural production levels among each group of farmers based on age classes. Farmer organizations can play an active role in executing such policies at the ground level.

- Enhance the potential of farmer organization for AP and LP improvement in Sri Lanka. Use farmer organizations as a platform improve the level of agriculture technology adoption and for the provision of agriculture inputs, extension services and credit facilities among farming communities.

- Provide alternative irrigation facilities and promote of using irrigation system or any other source of water, especially in yala season or drought seasons.

- Design extension programs with the consideration of using modern technologies in various types of land.

- Introduce land levelling and reshaping planning programs.

- Develop integrated agriculture development approaches for the enhancement of agricultural productivity in low productivity land.

- Implement community-based land use planning programs and watershed development programs.

- Formulate policies and programmes to enhance land distribution and land ownership.

- Evaluation of several years of filed experiments and data to develop and introduce productive, efficient, sustainable and profitable cropping systems (eg: diversifying crop rotations/ intercropping/ mix cropping systems).

Chapter 8: Mechanization

Mechanization is an important driver of agricultural productivity. Nevertheless, it is often noted that the level of farm mechanization in Sri Lanka is still at a level lower than its potential. For instance, Bawatharani and Karunarachchi (2017, p.236) note that in up country vegetable cultivation, mechanized "operations are not in a satisfactory level because of the use of inappropriate/inadequate implements". In the case of paddy cultivation in Anuradhapura, Gamlath, Gunathilake, and Chamara (2018, p.133) find that "except for tillage and threshing operations, there were considerable differences in mechanization level, mechanization capacity, and power per unit area". In addition to the poor level of mechanization, there is disparity of mechanization within agricultural practices and farmers. Mallikaarachchi and Samaraweera (2018) show that the highest degree of mechanization in paddy cultivation is in land preparation, harvesting and threshing, respectively, while sowing shows no mechanization, while youth and educated farmers tended to use agricultural machinery in all the stages while those more experienced use more traditional methods. As reasons for poor mechanization in OFC production, Kumara, Weerakkody and Epasinghe (2016) identify demand and supply side issues such as unavailability of appropriate machinery, negative attitudes, poor awareness, and unaffordability. As such, it is important to understand ways and means to improve agriculture mechanization in Sri Lanka. This chapter conducts a detailed analysis of farm mechanization in Sri Lanka with regards to the level of mechanization, readiness and barriers for mechanization, involvement of farmer organization or customer hiring centers in the farm mechanization, followed by a statistical analysis of determinants of mechanization. The findings are mapped with regional country success stories to identify a way forward for Sri Lanka to improve agriculture mechanization.

8.1. Level, readiness and barriers for mechanization

Level of farm mechanization is reflected by the usage of machinery and equipment as well as the usage of modern technology for agricultural activities.

Usage of machinery and equipment for agricultural activities

In the Agriculture Labour Survey 2020 (ALS2020), which serves as the primary survey for this study, farm mechanization data is collected from 1020 households on a selected list of machines/equipment used for agricultural activities (see **Table 0-1**). This data reveals that among the selected list, the most popular agricultural machine/equipment is tractor, where 83 percent of the 1020 households used a tractor. Among them, 61 percent used a four wheeled tractor, 40 percent used a two wheeled tractor, and 19 percent used both types. The other equipment were used by a third or less households surveyed, out of which the least used machines were the grain-driller and soil tiller.

Table 0-1:Usage, Ownership and Knowledge of Agricultural Equipment

	% hhs using			% hh owning			% hh with knowhow to use*			% hh like to learn		
Machine / Equipment	**All**	**paddy**	**OFC**	**All**	**paddy**	**OFC**	**All**	**paddy**	**OFC**	**All**	**paddy**	**OFC**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Tractors (Two wheel)	40	42	38	13	15	11	66	68	87	49	48	52
Tractors (Four wheel)	61	85	39	4	6	3	60	62	53	50	46	56
Trailer	30	44	18	4	6	2	56	57	50	48	45	53
Plough/harrow	23	36	12	2	4	1	78	85	46	47	44	53
Grain drill	.3	1	.2	.2	.3	.2	67	67	100	51	51	54
Cultivator	20	31	8	4	5	4	85	86	76	48	47	53
Soil tiller	.9	1	.4	0	0	0	55	50	50	52	51	55
Fertiliser spreader	5	3	8	4	.9	7	72	50	76	58	52	67
Sprayer	33	27	43	25	17	37	85	80	88	45	43	49
Threshers	11	19	3	3	0.5	0.4	69	71	7	51	50	56
Water pumps (for agri.)	26	18	38	19	11	32	85	84	86	49	42	61
Combined harvestor	24	42	7	0.3	0.5	0.4	27	27	14	50	50	54

Notes: * **Among those using % hh with sufficient knowledge to use**
**** Among those without sufficient knowledge % hh like to learn**
Source: Authors

The ALS2020 data indicates that overall, the usage is higher than ownership (see columns 1 and 4 in Table 0-1). Specifically, even though 24 percent of households used the combined harvester, only 0.3 percent owned one, possibly due to the very high cost as perceived by farmers, which deprives many farmers from buying and making hiring more economical. Nevertheless, when costs and benefits are holistically considered owning could be more economical since the owner could hire it out and earn an extra income as well. Similarly, compared to 61 percent usage of four-wheeled tractor, its ownership was only 4 percent of households in the sample. With regards to two-wheeled tractors, the ownership was 13 percent only. With regards to few low valued equipment, the gap between the share of ownership and share of usage was narrower. For instance, 25 percent of the households owned sprayers while its usage was 33 percent. Regarding water pumps, ownership was 19 percent and usage was 26 percent. However, in the case

of water pumps, ownership may be higher than the usage for agriculture purposes due to possible mis-reporting of domestic water pumps under agricultural water pumps.

When usage of equipment and machinery is disaggregated by paddy and OFC farmers relatively higher shares of usage can be seen for the former (compare columns 2 and 3), except for sprayers and water pumps. A similar higher patter is seen for ownership as well, where paddy farmers have higher shares of ownership than OFC farmers except for sprayers and water pumps (compare columns 5 and 6).

Among the selected list of machinery/equipment, cultivator, sprayer and water pump show the highest level of self-reported knowledge for usage among those who are using them, which is 85 percent each (see column 7 in **Table 0-1**). In the case of paddy farmers cultivator, plough harrow and sprayers are the most widely known equipment, while for OFC farmers the corresponding equipment are grain drill, sprayer and two-wheel tractor.

For plough/harrow, fertilizer spreader and thresher, even though the usage level is relatively low, the self-reported knowledge for usage is relatively high (see column 10). In the case of paddy farmers the share with knowledge to use plough/harrow and thresher are high. For tractors, which is the highest used equipment, the level of self-reported knowledge to use is relatively lower (60-66 percent in column 7), indicating that a significant portion of those using tractors do not have the proper knowledge to use same. A larger share of households cultivating OFC are knowledgeable about using two wheeled tractors while in the case of four wheeled tractors the know how is more among paddy farmers. In order to address this knowledge gap in using machinery/equipment, it is important to conduct knowledge dissemination activities for farmers.

However, as shown in column 10 in Table 0-1, nearly 50 percent of the households without sufficient knowledge to use each machine/equipment were reluctant to learn how to use same. When disaggregated by crop type, only smaller shares of paddy farmers are open to learn about how to use these machines relative to OFC farmers. In addition to the overall unfavorable attitude among farmers towards learning agriculture techniques in systematic manner, the above finding shows that paddy farmers are relatively more reluctant than OFC farmers to learn such things. When willingness to learn how to use agriculture techniques is checked for its correlation with age of the oldest person in the household, a weak negative correlation (ranging from -0.16 to -0.23) is seen. This is preliminary evidence suggesting that the households with older farmers are less inclined to learn new agricultural information. Although these findings need further verification, it should be factored in when strategizing agriculture mechanization in Sri Lanka.

The qualitative data reflected mixed opinions by key stakeholders about farmers' attitudes towards adopting modern technology. On the one hand, one stakeholder[20] was of the view that compared to other countries, Sri Lanka's level of mechanization is not bad but we are below the average level. This opinion was further repeated by several stakeholders[21],[22] from private sector institutions mentioning that limited land holding capacity, attitudes, lack of policies and lack of initiatives as the reasons behind the farmer's less adoptability towards mechanization and new technology usage in Sri Lankan agriculture, especially when compared with countries like Israel, Malaysia, India Bangladesh and Nepal.

As evident from the foregone discussion, the paddy sector in Sri Lanka, which adopts a lot of technology and machines in cultivation, is an indication of farmers' willingness and capacity to absorb mechanization and modern technology. Yet their overall lower willingness to learn among paddy farmers also reflect the challenges in terms mechanization. For instance, some stakeholders[23] were of the view, "Sri Lankan farmers are very much in their comfort zone and we find that they are not enterprising enough". Similarly, another stakeholder[24] mentioned that farmers are comfortable with their older methods, and the main reason for their reluctance to adopt new tools or methods is that they give up half way, without investing adequate time required in the learning curve. Moreover, another stakeholder25 from private sector institution mentioned the limited availability of spare parts and lack of after sales services given by some of the private sector companies, discourage farmers to use or given up on their existing farm machineries. For instance, many farmers have "…2-3 broken tractors and tilling equipment" in their gardens. Summing this issue one stakeholder[7] was of the view that Sri Lanka lacks any quality standards developed by either government or DoA for Agri-machinery sector, which causes to accelerate the aforesaid issue. As mentioned by this informant[26], for example, the sprayers used in Sri Lanka does not have any quality

[20] Interview with a researcher on 30/09/2020

[21] Interview with a respondent from private sector on 09/02/2021

[22] Interview with a respondent from private sector on 12/02/2021

23 Interview with a respondent from private sector on 29/09/2020

[24] Interview with a young farmer on 29/09/2020

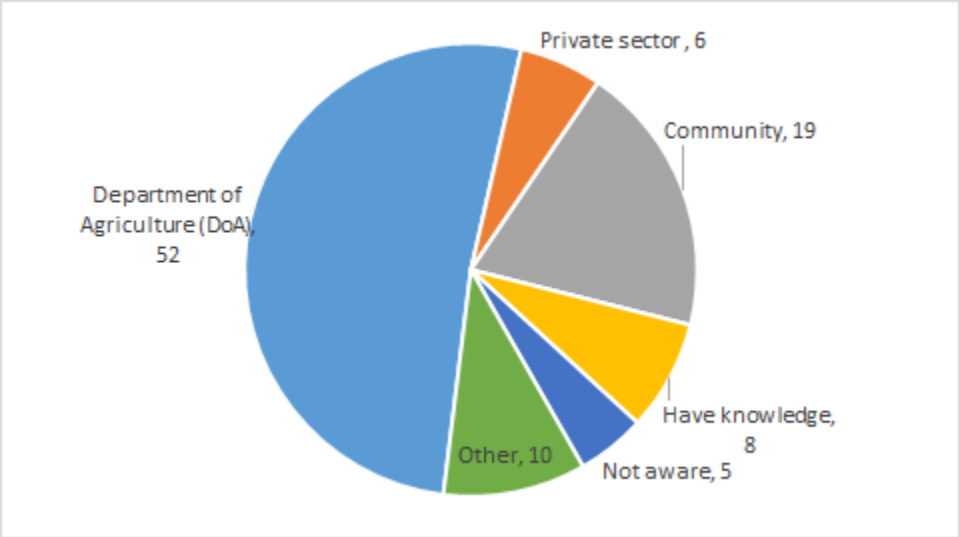
[25] Interview with a respondent from private sector on 09/02/2021

[26] Interview with a respondent from private sector on 16/02/2021

standard. Hence, anyone can use any size nozzle with the sprayer, leading to excessive chemical release leading high cost for farmers as well as the heightening the resistance by pests for chemical. Nevertheless, it is important to underscore that Sri Lanka has institutions (i.e. FMRC), rules and regulations to minimize such issues. As such, it is important to strengthen the existing framework, rules and regulation to ensure introduce and r regularize quality standards, provide guidance for maintenance and ensure the availability of spare parts for Agri-machinery sector, to ensure greater efficiency and productivity of the sector. of importation without their inspections, as indicated by the "uncontrolled dumping of low-quality machines" into the country by Tilakaratna (2003).

The quantitative survey also investigated who is the best stakeholder to provide information about mechanization and modernization to farmers. Among the farmers in the survey who indicated interest to learn, the ideal stakeholders identified can be grouped as DoA, private sector and community members. As seen in Figure 0-1, 52 percent of the farmers identified officials of the DoA, while 19 percent identified members from their community. These community members include various groups such as farmer organizations, youth groups, the elderly or knowledgeable farmers.

Figure 0-1:Stakeholders preferred by farmers to provide mechanization information



Source: Authors based on ALS2020

These quantitative findings were validated as well as challenged in qualitative data. For instance, a stakeholder[27] highlighted that even though farmers complain about some aspects of the services provided by the government sources, farmers still value the

[27] Interview with a respondent from telecom company on 29/09/2020

information provided through the DoA, particularly by those perceived to be key experts in the field. As such, farmers place most trust on information provided by the government sources. Nevertheless, as per qualitative data a key limitation of the services provide by the DoA is with regards to knowledge dissemination to farmers, where research knowledge is not adequately penetrated to the farmers. For instance, as noted by an informant[28], the DoA failed in their efforts to introduce a new Chilly seed variety - MICH 2 to farmers recently. The s re-introduction of same to the farmers through the private sector signifies that DoA's limitations in knowledge dissemination. As suggested by an informant[29] it is the responsibility of DoA to join with private sector and do field/ lab tests and finally introduce those new technologies to farmers via island wide extension services. As such, it is a known factor that Agriculture Extension Service provided by the DoA is has its limitations and the farmers do not trust them. However, still they believe the knowledge and information should come from the government, mainly due to two reasons – (i) cost factor of private sector service provision, and inherent subsidy mentality of farmers prefer to obain such knowledge and information free of charge; and (ii) there is no such organized mechanism to provide knowledge and information outside the government.

Apart from DoA, several KII respondents indicated that Farm Mechanization and Training Centre (FMTC) and Farm Mechanization Research Center (FMRC) as the other two main public sector institutions that are involved in agriculture mechanization process in Sri Lanka. As mentioned by an informant[30]; "Government sector best people are FMTC. So, they have all the facilities, and they can organize training programs for farmers. And specially, I would say that they can identify the farmers as clusters based on regions/ crop specifications/ age/ gender and train them, with the support of private sector as well". Nevertheless, qualitative data shows that, FMRC has not released any kind of new technologies to farming community in recent past (even though they are involving in lot of trials in Agri-machinery sector), while the effectiveness of FMTC trainings needs to be evaluated / go to grass root level"[31]

[28] Interview with a respondent from private sector on 23/02/2021

[29] Interview with a respondent from private sector on 16/02/2021

[30] Interview with a respondent from private sector on 09/02/2021

[31] Interview with a respondent from private sector on 15/02/2021

Usage of modern technology for agricultural activities

Various alternative modern technologies were considered in the survey to gauge the level of usage and knowledge of modern technology for agriculture (see **Table 0-2**). Compared to the use of agricultural machinery and equipment, the use of modern technology was less by farmers in the sample. For example, the highest usage rates were reported for hybrid seeds and new crop varieties, which were 32 percent and 31 percent, respectively. These rates are nearly half of the usage rate of tractors discussed before. This quantitative finding of relatively high popularity of hybrid seeds was backed up by qualitative data, where stakeholders [32] highlighted that throughout the existing network of research centers, the government conducts a substantial investment in research and development in the area of seed technology. However, it was also highlighted that the weaknesses in the information dissemination system of the government and the inadequacy of the number of researchers and facilities are contributing to the limited usage of these new hybrid seeds among farmers[33]. Moreover, stakeholders highlighted the importance of a careful evaluation of the appropriateness of imported hybrid seeds, under stringent research conditions that match the local context[34].

As seen in **Table 0-2**, the level of usage of modern technology in terms of new irrigation techniques, such as drip irrigation and sprinklers, is 11 percent among all farmers in the sample, and 2% among paddy farmers. While 30 percent were aware of these techniques, the interest to learn stood at 75 percent of the sample. The low level of usage seen in survey data is validated by qualitative data, where one KII respondent[35] revealed that farmers who traditionally use rain fed irrigation are comfortable with the uncertainty involved and do not venture into new methods. To address this, the respondent's company has been involved in educating famers that they need not focus only on rain fed irrigation, and providing solar powered drip irrigation kits. Such technology helps farmers to continuously cultivate throughout the year, leading to a more predictable harvest. Also as claimed by another KII respondent [3] stated that still only a very limited number of farmers have adopted modern type of irrigation techniques, especially in

[32] Interview with a researcher on 22/10/2020 and researcher on 24/09/2020

[33] Interview with a respondent from private sector researcher on 24/09/2020

[33] Interview with a respondent from private sector researcher on 24/09/2020

[34] Interview with a respondent from private sector researcher on 30/09/2020

[35] Interview with an owner of modern agriculture company on 29/09/2020

paddy sector, even though it is the major crop cultivation in Sri Lanka. He quantifies that even among commercial scale farmers, only about 5 percent of the farmers have adopted new irrigation techniques like drip and sprinkler irrigation.

The qualitative data [36] also highlighted that the sustainability features of modern irrigation, such as sprinkler systems, drip irrigation, aquaponics and artificial information (AI) based watering systems, result in saving water than when using free flowing water. The stakeholders also underscored the high cost of such modern technologies, lack of technical knowhow and durability problems as the reasons behind average/ low adoption by farmers. [37]

Table 0-2: Modern Technology in Agriculture

	% Households using			% Households heard/known			% Households like to learn		
Technology	All	P	OFC	All	P	OFC	All	P	OFC
Smart phones for agriculture related (weather, price alerts)	22	29	10	34	42	25	74	70	81
Drones for precision weed control/pest control/fertilizer application	10	15	0.4	26	31	22	73	70	79
Sensors to remotely monitor soil condition, water requirements, crop conditions	5	8	0.4	16	21	12	74	71	79
Satellite image techniques	3	4	0.4	14	16	12	72	69	77
New crop varieties	31	33	29	39	45	37	76	70	84
Hybrid seeds	32	26	45	43	44	46	76	72	82
New cultivation methods e.g.: controlled systems – poly tunnels /rain shelters	3	2	6	22	18	28	75	72	81
New irrigation systems – drip/ sprinklers	11	2	23	30	23	38	75	72	81
New transportation / packing / storage systems	16	16	3	21	19	24	78	76	82

Notes : P refers to Paddy
Source: Authors

Among the alternative modern technologies investigated in the survey, the least used were new cultivation methods such as controlled systems which include poly tunnels and rain shelters. These modern cultivation methods were adopted by only 3 percent of the sample. Nevertheless, when OFC cultivating households are focused 6 percent of households are using these methods. Among all households, 22 percent had heard about same and 75 percent were interested in learning about these, while OFC households have

[36] Interview with a young farmer on 29/09/2020

[37] Interview with a respondent from private sector on 12/02/2021

a relatively higher of households that have heard of these and are interested in learning about same Confirming this, during field visits for KIIs, it was seen that few farmers were successfully using such techniques (see **Table 0-2**). Similarly, few KII stakeholders in private sector institutions also mentioned that, although they have taken several initiatives to introduce such technologies to farmers, very few adopt same due to high initial cost and lack of trust among farmers towards these technologies [38]. Further qualitative data revealed that excess rain/sunshine, pest and disease can ruin crops and increase wastage. Hence, these issues can be mitigated by protective farming. However, as qualitative data revealed, farmers are accustomed to address these issues only after the problem arises. These findings show that despite the popularity of modern cultivation methods for agriculture and their capacity to protect crops from erratic weather, Sri Lankan farmers are backward in this aspect. Literature identifies that the drawbacks such as high initial construction cost, destruction of tunnels due to pest problems, wind and rain, and inadequate technical knowledge on operation have contributed to the low uptake of protective systems and controlled environments in Sri Lanka (Kumara, Weerakkody, & Epasinghe, 2015). As such, one private sector stakeholder[39] has been involved in educating farmers to understand the cost of inputs and how to produce efficiently with minimal wastage by adopting modern agriculture technology. This has enabled farmers' transitioning from unsustainable to sustainable practices. Additionally, the same company has been adopting greenhouse production – which is environmentally friendly, by using solar powered grid houses spanning half a million square feet. This has enabled the company to adopt domain precision agriculture, which gets specific products planned for output. The benefit of controlled systems against adverse weather, pests and input scarcity were also highlighted in qualitative data[40]. Nevertheless, as identified in qualitative data, one challenge faced when using such controlled environments is the need for frequent checks which reverts to somewhat of a labour intensive practice, which can be overcome by automation with timers and an alert system for temperature issues.

[38] Interview with a respondent from private sector on 16/02/2021

[39] Interview with an owner of modern agriculture company on 29/09/2020

[40] Interview with a respondent from a telecom company on 29/09/2020

Figure 0-2: Farm in Galnewa, Anuradhapura March 2020

Source: Authors

ALS2020 data reveals that only 22 percent of the farmers used smart phones for agriculture purposes, while only 32 percent have heard of same. In the context of high mobile phone penetration rate of 161.4 lines per 100 people in Sri Lanka in 2019 (CBSL, 2019), and the emergence of several mobile phone-based information dissemination platforms, the usage and awareness of mobile phones for agriculture among the sample of farmers is very low. As per qualitative data, the existing mechanization and modernization related information dissemination by the DoA is largely focused on selling books and other documents, and conducting TV and radio programs. The adoption of modern approaches, such as the YouTube channel called "Krushi TV" and dissemination of information via mobile phones, is limited.

Qualitative data revealed that one main reason for the low usage of phone-based information is because farmers feel that such mobile phone-based services do not provide any new information and the same can be obtained from agriculture instructors of the DoA. On the contrary, qualitative data also highlighted that the farmers complain that officials of the DoA are too young (fresh graduates), who are not from their area, and often not available when most needed. In this context, even though the phone-based information is capable of addressing accessibility issues found in the traditional information dissemination channels of the DoA, these views of farmers underscore their faith in the existing traditional system of the DoA based mechanism, and their 'comfort zone' with the existing methods as well as their reluctance to change.

As highlighted by qualitative data, the huge information asymmetry and the limitations of the current information dissemination mechanisms are aptly displayed by farmers' lack of awareness of the names of pesticides and weedicides they frequently use, and their reliance on the information provided by the sellers. As shown by qualitative data, the primary information requirement of farmers is to obtain crop specific information and advice. For this, currently farmers have to go from place to place depending on the number of different crops they cultivate. Stakeholders revealed that as a result, farmers do not demand for information and try to manage with whatever information that is accessible to them. For example, for insect problems farmers approach sellers of same and accept any product recommended by the latter, without being concerned about its appropriateness for the issue. The second most important data required by the farmers is weather related information and advice. However, the qualitative data underscored the limited nature of weather-related information provided to famers, as currently the DoA sends out one meteorological prediction for the whole season.

As such, these issues of availability and accessibility of most critical information for farmers can easily be addressed by dissemination of information through mobile phones. There are a few initiatives for information dissemination through mobile phones. For instance, the '*Govi Mithuru*' is a mobile phone-based service, launched in 2015, to provide farmers with timely advice tailor made to their crop about land preparation, cultivation, crop protection and harvest. '*Govi Mithuru*' is a partnership between the Ministry of Agriculture of the Government of Sri Lanka and other stakeholders. The '*Govipola*' app is another more recent initiative aimed at enhancing market linkages and price awareness, and matching supply and demand to give farmers easy access to markets (Daily FT, 2019). Similarly *Saru* introduced by Dialog Sri Lanka, is another such initiative (Dialog, n.d.). *Saru* is aimed at developing the knowledge base for local crop recommendations and agro ecological zones, developing necessary materials and knowledge for training farmers on new practices, developing sensor and actuator kits that are fit-for-need and conditions at one-tenth or below the current market price, providing a data and knowledge management system on cloud, and providing advisory content for crop managing and maintaining. *Saru* relies on Internet of Things (IoT), which connects sensors and actuators to be remotely controlled via smart phones. Further, agriculture know-how related to regular operations such as fertilizer application, water management, assessing growth and pest and disease identification are also aimed to be provided to farmers through mobile technology. The system is cloud-connected, and real-time roll-out of rapid updates or interventions is enabled to respond to short-term phenomena in agricultural operations. Another private sector initiated mobile telephone service is "6666 Mobitel Jangama Mila Dharshanaya", which is a call based information

system operating to provide market information. With this facility Mobitel company together with Hector Kobbekaduwa Agrarian Research Training Institute (HARTI) facilitate providing daily wholesale prices of 23 agricultural commodities at eight wholesale markets such as Dambulla, Keppetipola, Colombo. Approximately 15,000 calls are received per month in searching for information. [41]

As found in qualitative data, mobile phone -based information dissemination platforms provide more targeted and customized information to farmers by asking three 3 questions – namely what zone, what are you growing and when? Answers to these questions allow simple and mass customization of information, usually provided by different government sources. The cost of this service is LKR 1 per day, and the farmers access the services only when they have credit in their mobile phones. The information via phones is provided as reminder messages rather than through a hot line, which is rarely used by farmers. For example, the message would remind farmers that they need to manage/open water next week and would ask, have you got the following material ready for this? Similarly, after the 2016 floods and other natural disasters, farmers were provided with time and event sensitive information with area and crop specific advice on what needs to be done to recover. Currently there are over 600,000 users of these services.

Moreover, qualitative data also revealed that, there is a huge potential of promoting smart phones among young farmers for decision making of agriculture related practices such as water management, plant management and pest management etc. Currently farmers overly rely on sellers and dealers of agricultural products for advice on such issues. As such, appropriate introduction of smart phone usage for farming can help farmers obtain accurate information about the products and timing to manage water, soil moisture level, and pest outbreaks. [42] However, it is important to note that farmers are reluctant to pay for such telephone based services. For instance, "Govi Sahana Sarana Agricuture Adversary Service" initiated in 2006 was a hotline that provided 3 minutes of call time free of charge for farmers to obtain agriculture advisory services. During this time approximately 450 calls were received per day and about 100,000 farmers were served per year. Nevertheless, after the facility was expanded to cover all agricultural

[41] Interview with Senior Researcher of HARTI on 06/03/2021

[42] Interview with a respondent from private sector on 12/02/2021

crops, export agricultural crops and coconut under normal telephone charges the its usage dropped to serve approximately 20 farmers per day. [43]

In terms of the use of modern technology for storage, packing and transportation, the quantitative data shows that only 22 percent of farmers in the sample used modern technology, while only 34 percent and 74 percent have heard and would like to learn same, respectively. The low uptake of such new methods results in not being able to transport agricultural produce in a timely manner.

The qualitative data showed that this was in the context of most farmers having limited integration to product value chains and markets, as well as experiencing the serious issue of over production at some times and under production at others. This was aptly confirmed during KIIs and FGDs, where most respondents complained about issues in transportation and lack of access to supply chains. When asking what the key area they need support to improve productivity is, the respondents in the Janakapura KII strongly underscored the issue of timely transportation of their harvest to the markets. The KIIs with other stakeholders further confirmed that post-harvest and storage technology was a key area that needs to be improved to minimize crop wastage and related losses. One suggestion was to use cold storage and related transport facilities to transport agriculture produce with minimal wastage. Here, one stakeholder highlighted the importance of fragmenting the agriculture value chain under the premise that "everyone need not be a farmer", but can be involved in different aspects of agriculture value chain such as storage, packaging and transportation.

The low level of mechanization and adoption of modern technology in the agriculture sector in Sri Lanka is due to a combination of issues. Among a pre-identified list of issues related to mechanization and adoption of modern technology, the greatest issues emerging from ALS202 is the lack of sufficient capital (see **Table 0-3**). In this sample of 1020 households, 76 percent of households agreed that lack of sufficient capital has a ceiling effect on mechanization and adoption of modern technology. When disaggregated by paddy and OFC the issue is more prevalent among the latter. At the same time, on average 58 percent of the households in the survey have personally experienced capital constraints in the mechanization and modernization efforts, while farmers involved in OFC have a higher value of 69 percent. At the same time the land size and steepness are issues faced more by OFC farmers, while lack of sufficient knowledge and trust in new technologies are higher among paddy farmers.

[43] Interview with an official of DoA on 05/03/2021.

Table 0-3: Barriers for mechanization and issues in adopting technology

Barrier/Issue	Perceived as an Issue in Sri Lanka (% of households in sample)			Personally experienced (% of households in sample)		
	All	Paddy	OFC	All	Paddy	OFC
Not having enough capital	76	72	83	58	52	69
Having small land plots or steep land	21	19	23	10	4	15
Not having enough knowledge about how.	23	32	15	15	19	11
Foreign machineries are not suitable	5	8	3	3	5	2
Lack of trust of new technologies	8	12	3	2	2	2

Source: Authors

As seen in Table 0-3, there is mixed evidence about land size and steep land serving as a barrier for mechanization in Sri Lanka. When only 21 percent believed that small land size is an issue applicable at the national level, 95 percent of responding households in this sample indicated that they have experienced difficulty in adopting modern technology or mechanization due to characteristics of their agriculture land. This indicates that even though land size and terrain matter to farmers in this sample, they do not view it as a common issue at the national level. This was further resonated during qualitative data collection, where a KII stakeholder[44] highlighted that for instance, the current farmland extent is not conducive for adopting drone operation for farm operations. Moreover, it was further highlighted that before moving to other technologies like drones, robotics, satellites, and AI etc., it is important to improve the current applications of technology at farmer level.

In terms of reluctance to adopt smart phones for agricultural purposes, some key reasons given were capacity constrsints including age and capital. For instance, among the 179 hosueholds that did not like to learn how to use smart phones for agriculture, 20 percent

[44] Interview with a respondent from private sector on 12/02/2021

indicated that old age was a deterrant, while 17 percent mentioned about capacity constraints that included lack of capital, poor health, lack of time and knowledge constraints. Additionally, another 11 percent were of the view that there was no need to learn. Similarly, in the case of adopting new cultivation methods 10 percent indicated age issues, while for new transportation/packing/storage systems, the age issue was highlighted by 8 percent of the households. And also for other aspects of modern technology considered in the ALS2020, similar reasons were reported for low adoption.

8.2 Role of farmer organizations and hiring centers in farm mechanization in Sri Lanka

As discussed in Chapter 3, farmer organizations started in Sri Lanka during the early 1980's and were formed at Grama Niladari or Village level to organize farmer activities. Traditional farmer organizations focused on providing membership to farmers, distribution of inputs, and irrigation management at local level, and they act as a body for collective voice for farmers (Tharmendra & Sivakumar, 2016). Similarly, farmer organizations help coordinate mobilization of resources, both in terms of financial and labour, procurement and distribution of agricultural inputs on a cooperative basis, efficient water management, adoption of innovative cultivation methods for greater productivity, development of credit and marketing skills and resolution of farmer conflicts (Giragama, Sanker, & Samarakoon, 1999). Farmer organizations also help to improve communication more efficient among farmers and stakeholders. Specifically, farmer organizations are said to assist resolve any disputes or disagreements among farmers.

This importance of farmer organizations was also confirmed in ALS2020. The membership in farmer organization was common among the households in the ALS2020. For instance, 72 percent of households were members of farmer organizations (see Table 0-4). When disaggregated by crop type, membership in farmer organizations was 77 percent among paddy farming households, and 70 percent among OFC cultivating households. Within OFCs, those farming other grains and legumes recorded high shares in membership in farmer organizations, while the lowest membership rate was evident among spice farmers, which was as low as 39 percent. Nevertheless, among the responding households of the ALS2020, a large share of households (84 percent) were of the view that farmer organizations were not contributing to introduce new machinery to farmers. Similarly, from the full sample 93 percent were of the view that farmer organizations did not improve access to new machines. This was further confirmed in

several KIIs held with private sector stakeholders. According to one KII stakeholder[45] most of the farmer organizations discuss collectively about water sharing days and what crops to be cultivated in each season, with very low involvement in gaining new technologies. For instance, farmer organizations in Mahaweli areas are built up based on their irrigation systems, while some special floriculture farmer organizations have regular discussions to find markets. But there are some rare occasions where farmer organizations have made collective investments and bought combined harvesters and tractors etc., while some farmer organization have made such purchases using donations

Moreover, confirming these findings Tharmendra & Sivakumar (2016) highlight that the involvement of farmer organizations in new aspects such as groundwater management is minimal. Hence, these authors highlight that in Jaffna, farmer organizations could play a role in conserving and managing scarce groundwater resources in the district.

Table 0-4: Distribution of membership in farmer organizations

	Total farmer households	**No. of households who are members in farmer organization**	**% of households who are members in farmer organization**
Full sample	1020	735	72
Paddy	573	444	77
OFC	530	369	70
Vegetables	250	163	65
Fruits	64	48	75
Legumes	36	31	86
Other grains	45	41	91
Roots	36	28	78
Spices	31	12	39

Source: Authors

Considering the gap between the usage and ownership of machines used for agriculture and the capital constraints highlighted in quantitative and qualitative data, hiring of agricultural equipment and machines is an important component of agriculture

[45] Interview with a respondent from private sector on 12/02/2021

mechanization, and therefore, hiring centers have an important role to play. The qualitative data supported establishing customer hiring centers in Sri Lanka, due to their capacity to improve mechanization despite the capital constraints of individual farmers to pruchase these equipments. Moreover, such hiring centers would be better placed to service and maintain these machines, and to improve their productivity. As underscored by key stakeholders, the present government is attempting to equip the 567 agrarian service centers (ASC) established throughout the country, with appropriate machines based on the crops cultivated in the respective areas. As such, the hiring of machines is aimed to be carried out through these centers.

Nevertheless, as highlighted by Tilakaratna (2005), there are several restrictions which limit the functioning of hiring centers such as poor purchasing power, seasonal usage of machinery, lack of physical and financial infrastructure, single-purpose machines etc. Similarly, the past experiences of the government-controlled tractor hiring centers and their failure due to poor management and maintenance of the machines need to be carefully re-evaluated in the present context of introducing hiring centers. As such, new interventions with regards to hiring centers need to be supplemented by strong management and maintenance capability, and the purchase of low maintenance machines which align better with the requirements of respective areas. Here, it is important to minimize the space for corruption, and evaluate the appropriateness of machines before purchasing, as most machines produced in Sri Lanka or imported are not suitable for all the crops. Currently, many tax-free incentives are available for anyone who needs to import raw material or agricultural machines.

8.3 Determinants of Mechanization

In the analysis of the determinants of farm mechanization, following the methodology used by Ghosh (2010), a mechanization usage score is developed based on the usage of the twelve equipment/machines stated in **Table 0-5**. Usage of each equipment/machines is assigned the value 1, while the non-use is assigned the value 0. As such, the mechanization usage score could range from 0 to 12. The usage is considered regardless of owned or hired use.

There were 87 households with 0 as the mechanization score, indicating the non-use of any of the 12 aspects of mechanization considered here. Of them 85 cultivated only OFC. The average area cultivated by those with a zero mechanization is 143 perches, while the others have a much higher average of 470 perches. Moreover, the land area cultivated by bottom 50 percent of those with zero mechanization score was 80 perches, while the 75th percentile was 160 perches. This hints that those with smaller land areas tend to be less mechanized. At the same time, none of the households in the sample had used all 12 machines/equipment in their farming activities. The maximum mechanization usage score achieved in the sample was 9, and this maximum score was achieved by only three

households. Meanwhile, only 20 percent of the households had a score of 4 and the average mechanization score was 2.75, indicating that on average, agricultural households use about three machines/equipment (1.8 standard deviations). As seen in Table 0-5, 75 percent of households across most crop groups use about 3-5 machines/ equipment.

Table 0-5: Distribution of the Mechanization usage score

Mechanization usage score	All crops	Paddy	|OFC	Vegetables
Mean	2.75	3.50	2.14	2.12
Std. deviation	1.82	1.78	1.70	1.40
Minimum	0	0	0	0
Maximum	9	9	9	7
25th percentile	1	2	1	1
50th percentile	2	4	2	2
75th percentile	4	5	3	3
Obs	1020	573	530	250

Source: Authors

Similarly, qualitative survey data also revealed that mechanization has been widely applied in paddy sector. Thus, several KII stakeholders in private sector has repeatedly mentioned that, comparatively there is a higher degree of mechanization in paddy sector, especially in land preparation and harvesting. For instance; one KII stakeholder [46] highlighted that in the paddy sector more than 95 percent of land preparation activities and 95-98 percent of harvesting activities are mechanized, while very low level of mechanization – less than 10 percent, is evident in seeding and transplanting related activities. In the case of maize as per this respondent overall mechanization stand at 2-3 percent, while threshing has been mechanized up to some extent, compared to other practices. In the case of other field crops also, the degree of mechanization is still very low – especially in the activities related to seeding and harvesting.

The statistical analysis of determinants of mechanization is based the induced technical change framework developed by Hayami and Ruttan (1970, 1985), and considers mechanical technology substitutes for labour and biological and chemical technology substitute for land (Diao, Silver, & Takeshima, 2016) (see Chapter 1 for more details of the theoretical model). To account for labour and land related aspects in agriculture mechanization, similar to the analysis of productivity, the three main vectors based on

[46] Interview with a respondent from private sector on 16/02/2021

human, capital and natural resources are used as independent variables in the regression analysis, while the mechanization usage score is used as the dependent variable. It should be noted that apart from these resources, the use of machinery in agriculture also requires some level of knowledge and is further influenced by agriculture practices used. These facts are also taken into consideration when selecting independent variables for the regression analysis.

In the vector of human resource variables, age of the oldest person in household is included to account for experience in agriculture, while ethnicity of the head of household is included to account for cultural agricultural practices. The level of education of the maximum educated person in the household is included on the assumption that such an educated person would share his/her knowledge in household decision making, with regards to the use and purchase of machinery. In order to check the gender dimensions of agriculture, mechanization share of females in the household and female share by agriculture practice are included in the models. As hypothesized in the context of productivity, the presence of a migrant in the household enables the household to fund for mechanization. To account for this mechanism, indicator variables for the presence of a migrant in the household are included. Household size is included in the models to control for the availability of labour, which can discourage mechanization. In order to account for previous negative experience in terms of the use of machinery, an indicator for self-reported accidents occurred due to the use of machinery is included in the model.

Adoption of mechanization in agriculture requires capital and knowledge. In terms of capital resources, the household non-agriculture income is included in the models to indicate the affordability of mechanization. Additionally, indicator variables to control for household level self-reported capital constraints for mechanization, and self-reported insufficient knowledge to use machinery are included in the models.

To account for natural resources, the land extent was included, and in addition, indicators for type of land and irrigation are included in the models, which represent issues arising due to small or steep land and inability to use mechanization. Further, mechanization by agriculture practice, type of crop cultivated, method of cultivation are controlled for in the model.

The regression diagnostic tests carried out suggested that the mechanization models met most of the assumptions upon which they were based. Scatter diagrams of independent and dependent variables were used to identify potentially problematic outliers in the data. This indicated one household with an unusually high number of total man hours spent in agriculture. However, the plot of leverage and normalized residual squared values suggested that this did not have a major impact on the regression output.

Furthermore, once removed, there was little change in the results. As such, this observation was retained in the analysis.

In terms of the model specification, the Tukey-Pregibon Linktest and the Ramsey RESET test showed that the models were well specified and included most of the relevant variables. The presence of irrelevant variables was investigated using test statistics and probability values of the estimated coefficients as well as the impact of suspected variables on the overall R^2 and model specification. As the variables representing the share of females in the household, share of female labour, land ownership and machine related accidents were found to make little contribution to the models, these were removed in the final analysis presented below.

As the Breusch-Pagan test and the graph of the residuals against the fitted values indicated that there was a problematic level of heteroscedasticity, robust standard errors have been employed across all models. The correlation coefficients and variance inflation factors did not show a concerning level of multicollinearity other than that within a particular category of variable. The additional condition of normality of residuals was also met. Kernel density graphs showed that the distribution of the residuals sufficiently resembled a normal distribution.

Table 0-6 below depicts the statistically significant coefficients of the models of determinants of mechanization. Column (1) depicts selected coefficients corresponding to the model which takes all households involved in all crops together. Column (2) depicts results for all households involved in paddy cultivation, column (3) for all households involved in OFCs and column (4) for all households involved in vegetable cultivation.

Table 0-6: Selected Determinants of Mechanization – ASL 2020

Mechanization Score		All crops (1)	Paddy (2)	OFC (3)	Vege. (4)
Sinhala		0.056	-0.130	3.208*	
Tamil		-1.820***	-1.702***		0.027
Max schooling in hh	1	-0.075	-3.331***	1.541*	
	2	-0.208	-3.202***	1.080	0.754
	3	-0.157	-3.471***	1.434*	2.032**
	4	-0.032	-3.115***	1.630**	1.553*
	5	-0.885	-3.814***	0.826	1.058
	6	-0.882	-4.064***	1.051	1.229
	7	-0.606	-3.567***	0.230	0.523
	8	-0.139	-3.072***	1.391**	1.795**
	9	-0.222	-3.145***	0.604	1.019
	10	-0.024	-3.016***	1.133*	1.042

11	-0.205	-2.902***	0.815	1.049
12	-0.245	-2.804***	0.776	1.045
13	-0.082	-3.153***	1.093*	1.540**
Internal migrant	0.661**	0.569	0.672**	0.302
Barrier for mech. - capital	0.538***	0.731***	0.311**	0.237
Barrier for mech. - knowledge	0.682***	0.801***	0.551***	0.455
Land slope	0.256*	0.347	0.260**	0.175
Land steep slope	0.015	4.016**	0.216	0.635
Land undulated	0.768*	0.302	0.638	0.363
Land area cultivated	0.000	0.000	0.000***	0.000
Land area OFC cultivated			0.000***	
Crop paddy	0.652***		0.179	0.185
Fruits	0.101	1.681**	-0.192	-0.270
oil crops	0.728**		0.700**	0.594
other crops	-0.202	-0.156	-0.669***	-0.749
spices	-1.029***		-0.956**	
Irrigation - minor	-0.236*	-0.192	-0.269	-0.174
rain fed	-0.196	-0.092	-0.458**	-0.499
agro well	-0.319*	-0.966***	-0.202	-0.066
micro irrig	0.177	-2.516**	0.012	-0.227
other irrig	-0.562**	0.141	-0.671**	-0.718
Seeds % in cost	0.014**	0.010	0.001	-0.003
Chemical /fertilizer % in cost	0.020***	0.014**	0.023***	0.017
Transport/equipment % cost	0.018***	0.009	0.048**	0.072*
Use artificial fertilizer	0.615***	0.260	0.356**	0.469*
Use new crops	0.304*	0.415**	0.402	0.240
Use new irrigation	-0.071	-2.133***	0.009	-0.115
Household size	-0.027	-0.147*	0.069	0.029
Perception: Labour shortage	0.461***	0.713***	0.287**	0.098
Hired % in lndprp hr	0.002	0.000	0.006**	0.007**
Hired % in water m. hrs	-0.005**	-0.002	0.003	0.009
Male % in water m hrs	0.005*	0.004	0.003	0.003
Male % in plant m hrs	-0.004	-0.012*	0.000	0.002
30 55 % in plant m hrs	-0.006	-0.012**	-0.005	0.005
30 55 % in harvest hrs	0.009**	0.016***	-0.002	-0.015*
55+ harvest man hrs	0.007	0.011	-0.005	-0.021**
55+ % in landprp hrs	-0.002	0.001	0.005	0.017*
Elephant attacks	-0.332	-0.358	-0.518**	-0.651*
Mental stress	2.169	1.945	4.896***	
Farmer's organization	-0.061	-0.185	0.074	0.274*
District Anuradhapura	-1.411**	-1.630**	-3.363***	-0.144
Badulla	-1.140*	-3.098***	-2.921***	0.417
Batticaloa	1.327***	1.668***	-1.860***	
Jaffna	2.082***	2.050***		2.241***
Matale	-1.233**	-1.061	-3.385***	

Moneragala	-0.852	-1.693*	-2.526***	0.448
Polonnaruwa	-0.317	-0.497	-1.800**	2.984***
Constant	1.759	6.787***	1.384	-0.654
R^2	0.570	0.527	0.665	0.705
Observations	867	491	454	235

Significance based on robust standard errors.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, $ indicates significant with unrobust SE.
Omitted categories: Ethnicity-other; Education – no schooling; Land type- flat; District –Ampara; Age group: below 29 years. Due to the combined use of irrigation methods and crops, each of these are considered separately with no omitted category.

Ethnicity

When all else equal, the mechanization score of Sinhalese OFC farmers is likely to be 3.208 units higher, relative to those of other ethnic groups. On the contrary, relative to those of other ethnic groups, the mechanization scores of Tamil farmers, in all crops and paddy cultivation, are lower by 1.820 and 1.702 units respectively. This reflects how cultural practices associated with different ethnic groups influence their level of mechanization. Sinhala farmers are more likely to mechanize their agricultural activities, while Tamil farmers are less likely to mechanize. This cultural aspect in agricultural activities evident in quantitative data was also revealed in qualitative data where one KII respondent mentioned that 'Tamil farmers are very hard working compared to Sinhala farmers'. This hard working nature might be a driving force that compels Tamil farmers to rely more on manual techniques and less on machines and equipment which could make their work easier.

Education

The level of school education in the household, depicted by the years of schooling of the maximum educated person in the household, shows a positive association with the mechanization of OFCs and vegetable cultivation. The highest impact of schooling on mechanization among vegetable farmers is seen at the education level up to grade three. When the highest educated person of a household farming vegetables has schooled up to grade 3, the mechanization score is likely to be higher by 2.032 units than such a household with no schooling. Moreover, when the highest educated person of a household farming OFCs has schooled up to grade four, the mechanization score is likely to be 1.630 units higher than such household with no schooling. This may happen via the mechanism where the most educated person shares information and advice on mechanization, which would be adopted by those members in the household who are involved in agriculture. Nevertheless, contrary to the expectation, in the model for paddy, all categories of household education level are associated with lower mechanization, relative to the omitted category of no schooling. This negative effect, which ranged from -3 to -4 units, indicates that in the case of paddy cultivation, the level of education in the household discourages mechanization. While this finding is puzzling,

one possible explanation is that paddy farming is largely carried out by experienced farmers based on their traditional knowledge and experience and such farmers in the households may reject advice from educated household members about mechanization.

Internal Migrants

Households with an internal migrant, who is working in a different area, has a positive correlation with mechanization usage score of all crops and OFCs. This confirms the NELM theories where rural to urban migration provides the necessary capital to encourage mechanization. For instance, having an internal migrant increases the mechanization score of all crops and OFCs by 0.661 and 0.672 units, respectively. This finding is further reinforced by the highly statistically significant positive coefficient of the perception that lack of capital is a barrier for mechanization.

Barriers for mechanization

Here, it is important to understand the nature of the question that collected information for this variable. The respondents were asked if lack of enough capital is a barrier for mechanization. The yes/no answer is based on people's perception, which is likely to be influenced by their experience in mechanization efforts. As such, a positive coefficient reflects the degree of self-selection into mechanization, as only those who tried mechanization may have fully understood the importance of capital. In that spirit, the mechanization usage score of those who have tried to mechanize and realized the importance of capital for mechanization, is 0.538 units higher for all crops, 0.731 units higher for paddy cultivation and 0.311 units higher for OFCs. Similarly, the perception that lack of knowledge to use machines is a barrier for mechanization, shows that those who have tried to mechanize and realized the importance of knowledge for mechanization, have a higher mechanization score. The mechanization usage score of such farmers, is 0.682 units higher for all crops, 0.801 units higher for paddy cultivation and 0.551 units higher for OFCs.

Land

When considering the type of land, contrary to established literature (Kumara, Weerakkody & Epasinghe, 2016), the lands with slopes in all crops and OFCs, steep slopes in paddy cultivation and undulated lands in all crops have become statistically significant. Here, a land with a slope is likely to have a mechanization score nearly 2.5 units higher than that of a flat land, and this value is around 4 units higher for a steep slope, while an undulated land would have a score over 7 units higher than a flat land. Nevertheless, slopes and steep slopes (mid country and upcountry terrains) and undulated lands (low country) are usually considered a barrier to mechanization,

especially because tractor use is severely constrained in these areas. As such, this finding is contrary to existing literature. Some possible underlying reasons for these finds may be that this finding is influenced by the greater use of machines for paddy cultivation. Specifically, as seen in the model for all crops, switching from not cultivating paddy to cultivating paddy results in increasing the mechanization score by 0.651.

The extent of land area matters to mechanization only in the case of OFCs. Here, an increase in overall cultivated land by one perch leads to an increase in the mechanization score by 0.0003979 Nevertheless, on the contrary, when all else equal, when land area used only for OFCs increases by 1 perch, the mechanization score decreases by 0.0003951. Thus, the two opposite effects are almost equal in size. This is possibly driven by the fact that most OFC farmers are also involved in paddy cultivation. Hence, cultivating paddy and OFC together will promote mechanization rather than cultivating OFCs only. This finding further proves the validity of the previously discussed positive coefficient on the crop type indicator for paddy in the model for all crops.

Type of crops

With regards to paddy farmers, switching from not cultivating fruits to cultivating fruits increases mechanization score by 1.681. This shows that cultivating paddy and fruits together leads to higher mechanization. One explanation for this outcome is that the higher income earned from the combination of paddy and fruits allow such farmers to finance for their mechanization. In the case of the model for all crops, cultivating oil crops increases the mechanization score by 0.728 and cultivating spices decreases the mechanization score by 1.029. In the case of the model for OFCs, cultivating oil crops increases the mechanization score by 0.7 while cultivating other crops and spices decreases mechanization usage score by 0.669 and 0.952, respectively. The negative coefficients for the indicator for spices are possibly due to the less ability to mechanize such cultivation practices.

Type of irrigation

In terms of irrigation types, all the statistically significant coefficients reported in **Table 8-6.** show a negative association with mechanization. For instance, in the case of the model for all crops, a farmer switching to minor irrigation, agro wells or other irrigation correlates with a 0.236-0.562 decrease in the mechanization score, while in paddy farming, switching to agro wells and micro irrigation are associated with a decreasing the mechanization score by 0.966 and 2.516, respectively. Agro wells, micro irrigation and other irrigation methods are normally used when an area is not served by a major irrigation scheme. As such, the observed negative association may be due to broader area specific low productivity and low machine usage in the absence of major irrigation. At the same time, when all else equal, in the model for OFCs, switching to rain fed and other

irrigation types lower the mechanization score by 0.458 and 0.671, respectively. As indicated in qualitative data previously, this negative association between rain fed farming and mechanization may be due to them being comfortable with the uncertainty of rain, which acts as a deterrent for their interest to try machines and equipment.

Costs

Specific characteristics of the cost structure in agriculture are related to mechanization. In the model for all crops, the shares of cost of seeds, chemicals/fertilizer, and transport/equipment in total cost, are associated with higher mechanization usage score, where one percentage point increase in each of the above shares lead to a less than 0.02 increase in the mechanization score. In the model for paddy, one percentage point increase in the share of cost of chemicals/fertilizer in total cost increases mechanization score by 0.014, while in the model for OFCs, one percentage point increase in the shares of cost of chemical/fertilizer and cost of transport/equipment, leads to much higher increases in mechanization score which are 0.023 and 0.048 respectively. Similarly, in the model for vegetables, the share of cost of transport/equipment corresponds to an increase in the mechanization score by 0.072. This shows that spending more on non-labour aspects such as seeds, chemical, fertilizer, transport and equipment results in increased mechanization of agriculture processes. At the same time, the use of artificial fertilizer leads to an increase in the mechanization score of all crops by 0.615 and of OFCs by 0.356. The use of new crop varieties in paddy cultivation is related to a 0.469 increase in mechanization, while the use of new irrigation systems such as drip irrigation and sprinklers is associated with lower mechanization. These positive association of cost components such as seeds, chemicals/fertilizer and equipment is consistent with idea that adoption of a 'package of practices' to replace 'traditional' technology (Kerr, 2012; Dethier & Effenberger, 2011) helps promote mechanization.

Availability of Labour

The household size, which is an indication of the availability of labour supply in the household, has a weak negative correlation with mechanization in paddy cultivation. It is shown that the availability of one more member in the household decreases the mechanization usage score by 0.147 units. This takes place as households might try to adopt labour intensive strategies, instead of more efficient mechanized agricultural practices, due to the availability of labour within the household.

The relationship between labour supply and mechanization is further confirmed by the correlation coefficients of the variable representing the farmers' perception of labour shortage in the district they live in. In fact, farmers in areas where they thought that a labour shortage is present, are more mechanized. The strong positive correlation of 0.461

in the model for all crops, 0.713 in the model for paddy, and 0.287 in the model for OFCs shows that the more farmers are concerned about a labour shortage in their area, the higher their level of mechanization.

Similar to adopting mechanization, labour shortage could also be addressed by using hired labour. Although the models investigated the involvement of hired labour man hours by specific agriculture practices, only the share of hired man hours used for land preparation and water management have become statistically significant. One percentage point increase in hired labour man hours in land preparation in OFCs and vegetable cultivation are associated with an increase in the mechanization score by 0.006 and 0.007 respectively. This is probably because hired labour is paid by the task or by day. Thus, using mechanization enables hired workers to work faster and more efficiently. Hence, they are motivated to demand mechanization along with their labour supply. Moreover, KIIs revealed that more mechanization is possible in land preparation stage. In fact, the findings associated with hired labour in land preparation indicate that hired workers are adopting more efficient methods in preparing land. However, in the model for all crops, one percentage point increase in the share of hired labour man hours in water management leads to a decrease in mechanization by 0.005. This finding matches with the previously observed negative relationship between irrigation type and the level of mechanization, possibly caused by the use of less machines/equipment in irrigation and low productivity of the available types of irrigation. Due to the nature of work involved in water management, where most crops need daily water management, and the payment method which is task based, there is possibility for a negative relationship between the share of hired labour man hours in water management and farm mechanization. This highlights the importance of new ways to improve the productivity of irrigation while promoting the productive usage of machines/equipment in water management.

When investigating the involvement of male and female workers by agriculture practices, the involvement of male workers with regard to plant management in paddy cultivation and water management in all crops are statistically significant. Here a one percentage point increase in male man hours is associated with a 0.01 decline in mechanization usage score in plant management of paddy, whereas 0.05 increase is seen in the mechanization usage in water management for all crops. This indicates that in terms of plant management, males are less open to mechanization, possibly due to the fact that male workers in paddy fields tend to rely more on traditional, manual plant management techniques, using less amount of machine/equipment.–This was further confirmed in qualitative data, as compared to males the females' involvement in agriculture is less due to the common perception that females are not capable of using heavy machineries. The qualitative data revealed that, as a result, most of the females are now involved in

floriculture and green house industry, which requires less strenuous work. [47] For water management however, the males seem to be slightly more willing to mechanize, which indicates the importance of considering the impact of gender on each agricultural practice separately.

Age

In examining the age variation by agriculture practices towards mechanization, three age groups, as less than 29 years, 30-55 years and over 55 years, were considered. In paddy cultivation, one percentage increase in the share of 30-55 years old workers' man hours in plant management is associated with a 0.012 lower mechanization. Moreover, one percentage increase in the share of 30-55 year old workers' man hours in harvesting is associated with a 0.009 higher mechanization score in all crops and 0.016 higher mechanization score in paddy. Same age group returning opposite effects on mechanization is mainly due to agriculture practice.

Further, when harvesting and post harvesting activities are considered, while the more involvement of 30-55 years old man hours have a positive effect on mechanization, the more involvement of over 55 years old man hours have negatively affected mechanization, particularly in vegetable cultivation. When examining the same agriculture practice across two age groups, it was indicated that older workers' involvement decreases mechanization. Nevertheless, the older age group of over 55 years is associated with a higher mechanization score by 0.017, in the case of land preparation in vegetable cultivation.

Geographical Area

In terms of district indicators, in the model for all crops, farmers in Anuradhapura and Matale are associated with lower mechanization usage scores, while Batticaloa and Jaffna tend to be more mechanized relative to the omitted district, Ampara, other than in the case of OFCs. For instance, when all else equal, relative to being in Ampara (omitted category), if a farmer switches to Jaffna, his mechanization score increases by 2.082 units. The positive effects in Batticaloa and Jaffna as well as the negative effect in Anuradhapura are also evident in the case of paddy farming. For both Jaffna and Polonnaruwa, a positive coefficient is seen for vegetable cultivation. In Anuradhapura, in all the models except for vegetables, the association with mechanization is negative, and the highest and strongest effect of -3.363 is seen for OFCs. For Badulla, negative coefficients of similar magnitude are seen for paddy and OFCs, while in Matale, the strongest negative effect is for OFCs,

[47] Officer in private sector interviewed on 16/02/2021

which is -3.385. Similarly, Monaragala and Polonnaruwa are associated with negative effects on mechanization in OFCs. Given that the ethnicity Tamil have a negative coefficient, the positive coefficient found in the regions with a higher Tamil population is unlikely due to cultural and ethnic factors in agriculture but more to do with geographic reasons.

Other determinants

Elephant attacks, which is a growing concern among farmers, have a negative effect on the mechanization score. Specifically, in the case of OFC and vegetable farmers, having experienced elephant attacks is related to a 0.518 and 0.651 decline in the mechanization score, respectively. This is possibly due to higher risk associated with farming, which leads to a decrease in the motivation for investment in mechanization. This reveals that addressing elephant attacks would also promote mechanization among farmers.

The indicator for exposure to mental stress reflects a positive association with mechanization, where the effect is 4.896 for OFC farmers. The possible mechanism for this is that the farmers who are more stressed tend adopt mechanization to improve productivity.

Further, it is important to note that the membership in farmer organizations has shown a positive impact on mechanization among vegetable farmers. This is confirmed by the qualitative data which indicates potential of farmers clustering together. For instance. a private sector KII respondents noted that to address the transportation and logistics issues[48] in agriculture, their company adopted a model where farmers are grouped into clusters. It has been identified that the particular clustering has resulted in a neighborhood effect, where farmers end up growing similar crops collectively in larger volumes, thereby making logistics planning more viable, compared with the case where single farmers try to produce something on his/her own. It has also helped farmers realize that when they work as groups, they have better negotiating power, and the inputs, machinery and services could be negotiated better. In fact, a cohesive network of producers who are linked through information and data, create very basic centres of excellence, helping them to elevate their level of awareness and entrepreneurial spirit.

8.4 Learning from regional success stories

[48] Interview with a respondent on 29/09/2020.

Countries that have achieved higher levels of agriculture mechanization offer many lessons for Sri Lanka to be learnt. This section examines such experiences and success stories of regional countries to help shape Sri Lanka's journey towards higher agriculture mechanization. The international experience of countries such as India, Bangladesh, Nepal, Taiwan, Thailand, South Korea, and Japan, show that mechanization has increased agriculture productivity and profitability of the agriculture sector (Naresh & et al. (2012. Rahman & et al. 2011) (Paudel & et al. (2019. Aurangzeb & et al. (2007) Verma & et al. (2015)). (Vortia, Nasrin, Bipasha, & Islam, 2019).

In India, due to agriculture mechanization, "the country has moved forward over the past six decades from one in which it then faced severe food shortages to where today it has become an exporter of many food commodities and a major exporter of other industrial products, including agricultural tractors" (Singh G. , 2015). The 1970 mechanization, increased utilization of fertilizers, improved seeds, and irrigation were the four factors which led India to the Green revolution. In India's mechanization process, the private sector contributed as manufacturers, distributors, and investors, specifically regarding the development and dissemination of the mechanization technologies. Moreover, factors such as increasing sales of machinery (such as tractors), adopting mechanization technology firstly by large scale farmers and later by medium-scale farmers, availability of credit at subsidized rates, high level of effective demand for agricultural machinery and equipment, availability of support services for research and development, and testing standards, human resources development, business, and enterprise-friendly policies have positively contributed to India's success in agricultural mechanization. Similarly, India's mechanization experience has created many new types of jobs related to agriculture, starting from supervisory and managerial level jobs to driving, servicing, and repair and maintenance jobs (Naresh & et al. ,2012). Learning from this Indian experience, Sri Lanka can develop a strategy to attract youth, who are reluctant to engage in typical agriculture activities, to be involved in this new sort auxiliary agriculture activities.

This was further resonated in qualitative data collection, where one KII respondent [49] highlighted that rural areas in India adopt all the new technologies such as drip irrigation. As per the respondent, such new technology adoption is supported by government subsidies, where over 90%-100% subsidiary on drip irrigation, in contrast 30%+ taxes in Sri Lanka on drip irrigation and green house technologies. As such, this stakeholder was

[49] Interview with a respondent from private sector on 10/02/2021

of the view that if the government can reduce such taxes, farmer can afford high quality and appropriate technology at reasonable price.

Experience from Bangladesh shows that mechanized farms could reduce the labour requirements for specific activities such as ploughing and threshing, compared to traditional farms relying mainly on animal power. With the displacement of labour due to mechanization, in Bangladesh, family labour was mostly affected as machines such as power tillers and threshers required skilled labour. In wheat production, highly mechanized farms achieved a higher yield (2.65 t/h) compared to traditional farms (2.57 t/h), and some of this increase in yield can be attributed to mechanization, while other complementary factors are the intensive use of fertilizer and proper management of water. The associated reduction of labour also lead to lower the cost in mechanized farms leading it for higher returns (Rahman & et al. 2011). Bangladeshi experience also shows that mechanization has created employment opportunities in rural areas through diversifying business activities, providing opportunity to involve in manufacturing, repair and maintenance, and other after sale services related with farm machines and equipment. Similarly, Bangladesh's efforts for mechanization identified that highly coordinated research and extension among government organizations, non-governmental organizations (NGO), and private agricultural machinery manufacturers is required to support this process of mechanization, in terms of better understanding of the impact process on the livelihood of the rural poor such as marginal farmers, agricultural labourers, and rural artisans (Islam S. , 2010).

Lessons from the Bangladesh experience emphasize that Sri Lanka should provide agriculture workers with adequate skills to operate and repair new machines, and prepare to offer displaced family workers with alternative livelihoods.

In the recent past, most of the Asian countries' agriculture has mechanized by operating tillage activities, utilizing two wheeled tractors and irrigating from pump sets, most of which are locally made and owned by small farmers. Literature identifies this as a "hidden farmer led revolution" (Biggs & Justice, 2015). On a similar note Sri Lanka should also provide impetus for farmers to lead this mechanization revolution and encourage their ideas and inventions to develop new equipment or to modify imported equipment to suit the local conditions. The experience of adopting mini-tiller for land preparation of smallholder paddy farmers in middle hills of Nepal showed that highly educated wealthier farmers who live closer to input markets and have access to irrigation facilities have a high probability to adopt mini-tiller. The Nepali success story quantifies, if non adopters adopted mini-tiller, they would obtain an increase of output by 1,250 kg/ ha. Moreover, Nepali experience also shows that very small farmers who operate 0.25 ha or

less tend to benefit the most by the adoption of mini-tiller (Paudel & et al. (2019). As such, learning from Nepali experience, Sri Lanka should focus initially on two types of farmers when promoting mini-tillers – those who are more connected to the input markets (in proximity and wealth) and irrigation, and very small farmers, as they are more likely to benefit from such mechanization.

Thailand's agricultural mechanization process started in 1891 with the government initiative to import steam powered tractors and rotary hoes, and since then has reached many heights (Hossen, et al., 2020,). Currently the mechanization of the agriculture sector in Thailand ranges from modern tillage implements, reaping machinery, incalculable kinds of farm equipment to planes and helicopters (for aerial pesticide application at a research level), and different transportation facilities. The Thai experience shows that the ratio between owners of modern technology and renters of same, varies depending on the availability of machines, their capacity, brand and price. Small and less expensive machines are usually owned by farmers, while more expensive equipment are mostly hired through custom rental service. Additionally, in Thailand there is still a significant number of small/marginalized farmers who cannot afford the custom rental services (Hossen, et al., 2020,).

The Thai experience shows that for mechanization, different regions require different mechanization solutions. For instance, the larger and more sophisticated and control-escalated technology such as reapers, transplanters, sowers and electric sprinklers, are used in Thailand's central plains, which is home to more progressive farmers with larger farms. Recent experience in Thailand shows that, farm modernization has been shifting from heavy duty technology towards automation technology such as sowing technology, watering system frameworks, machine operated dispenser, modern reaping technology, dryers utilizing biomass fuel, storehouses, fully automated rice mills etc. A notable feature of mechanization in Thailand is the availability of nationally developed technologies in modifying and adjusting sophisticated/imported machines to suit local conditions (Hossen, et al., 2020,). As such, at present, Thailand is capable of manufacturing a majority of the machines used for agriculture. Currently, Thailand is focusing on precision agriculture in parallel with mechatronic-based machinery research and development. Hence, priority is given to local level fabrication of machinery, while importing only engines and some critical parts. Thailand's emphasis on agriculture-based industrialization has enabled the expansion of manufacturing activity throughout the country. To enhance the local manufacturing and fabrication capacity, Thailand does not tax agricultural machinery and spare parts importation. Nevertheless, literature highlights that technology developed by local small or medium industries lacks standardization in value, durability and performance (Hossen, et al., 2020,).

A notable feature of Thailand's agriculture is the identification of farmers as agribusinesses. Thailand's latest National Agricultural Machinery Plan is the Twelfth National Plan, which covers the period from 2017–2021. This plan aims to lessen production expenses and increase farmer incomes. A notable feature of this plan to establish technological rings, which are aimed at gathering farmers and others stakeholders with regular ventures and shared guidance of the oversight procedure of individual farms, which should turn out to be more proficient and decrease cultivation costs. In Thailand, rapid dissemination of technology developed in the country is carried out by the extension centers working together with universities. Here, the emphasis is placed on both problem-oriented research based on farmers' demands and basic research.

Taiwan started its ten-year mechanization program in 1960 by introducing the power tillers (Lu, 2009). Under the mechanization and automation projects, new machines related to cultivation, transplanting, fertilizer application, harvesting, cleaning, sorting, drying, and packaging in the rice production process were invented and distributed throughout the farmers in the country. Similarly, in 1991, another task force was established to promote and improve the automation in crops, fisheries, livestock production, and related services. As Lu (2009) notes, both projects took a minimum of ten years to show some positive effects and satisfactory results towards mechanization in Taiwan. Additionally, through the integrated project started in 1998, studies were conducted on precision spraying systems for boom sprayers, software integration of a GPS/GIS system for agricultural applications, near-infrared measurements of rice canopy, and yield monitoring systems for rice crop production in Taiwan which helped to the mechanization process in greater extent. On the other hand, Lu (2009) also highlights that even though government policies help to fulfill domestic demand for farm machinery by adopting these policies, the local agricultural machinery industry is at a disadvantage as it faces global competition in the new millennium. (Lu, 2009).

8.5 Way Forward in Mechanization and Modernization

Synthesis of Findings

This chapter analyzed the farm mechanization in Sri Lanka with respect to the level of mechanization, readiness and barriers for mechanization, and the involvement of farmer organizations and customer hiring centers in the farm mechanization process. These aspects of farm mechanization in Sri Lanka were analyzed through descriptive, qualitative and statistical analyses of the determinants of mechanization. The remainder of this section synthesizes qualitative and quantitative findings and develops a detailed

set of recommendations, in order to address the issues in mechanization while reflecting on the success stories in regional countries.

The analyses in this chapter identify a few key themes as constraints to the mechanization of the agriculture sector in Sri Lanka. The first theme is the capital constraint for mechanization. Finding that the usage of machinery is higher than ownership, and that its intensity is greater for high valued machinery, underscore the capital constraint in the agriculture sector in Sri Lanka to invest in mechanization and the role for hiring centers. The study finds many facets of evidence to link the capital constraint with poor mechanization. Qualitative data show that low agriculture income is often associated with challenges to connectivity and integration to agriculture value chains, while the statistical analysis links this to mechanization by showing that higher spending on transport/equipment; chemical fertilizer, and seeds leads to higher mechanization. Similarly, farmers using artificial fertilizer and new crop varieties are likely to have higher yields and thereby higher income. The study finds that the spending on artificial fertilizer and new crop varieties is positively correlated with higher mechanization. Moreover, the positive association between households having an internal migrant located elsewhere and mechanization indicates that agriculture income alone cannot stimulate mechanization in Sri Lanka.

Linked to the capital constraints, the second theme is the capacity constraints to effectively use agricultural machinery and equipment in Sri Lanka. The study finds that knowledge deficits and reluctance to learn on the part of farmers, as well as limitations in the existing mechanisms to improve mechanization, are hindering Sri Lanka's efforts to mechanize the agriculture sector. Among farmers with knowledge deficits, the willingness to learn is low due to their negative attitude towards learning in a systematic manner. At the same time, the government mechanism to address the primary information requirements of farmers and to enhance mechanization capacities is inadequate. Hence, farmers criticize the mechanism adopted by the DoA to enhance their capacity and provide better information. Nonetheless, farmers view the DoA as the ideal source for information on mechanization and modernization, and view that government spending on R&D has a higher influence on the farmers' adoption of new technologies. Similarly, the study finds a role for agriculture communities in efforts for mechanization. Here, farmer organizations in Sri Lanka are contributing to improve mechanization in Sri Lanka to some extent, but its full potential remains unrealized. In terms of the role for the private sector, the study finds that mobile telephone service providers have the potential to address the existing information dissemination issues leading to poor mechanization. However, there are constraints to adopt phones for agricultural purposes, such as age and lack of capital, time and capacity. As such, the study finds that educating and

informing farmers and providing technological assistance can lead to significant developments in agriculture. In addition to educating farmers, improvements in the general level of education in agricultural households, especially in those of OFC and vegetable cultivation, are also associated with greater mechanization. On the contrary, greater education in the households of paddy farmers results in lower mechanization.

The third key theme affecting mechanization is agriculture labour. The qualitative and quantitative findings confirm an overall inverse relationship between the availability of labour and mechanization. Nevertheless, when disaggregated by agricultural practices, type of labor, age group and ethnicity, labour have diverse effects on mechanization. In terms of land preparation, the use of hired workers and those over 55 years of age is associated with higher mechanization. In plant management in paddy cultivation, the use of more males or those in the age group of 35-55 years is associated with lower mechanization. In water management, the use of hired labour is associated with lower mechanization. For harvesting, using more workers in 35-55 age group is associated with higher mechanization, while the use of the older age groups is associated with lower mechanization. Similarly, the study finds that ethnicity of farmers has different correlations with mechanization, where Sinhala farmers involved in OFC have a higher mechanization score, while Tamil farmers in and all crops and paddy show the opposite. Similarly, farmers who are more stressed mentally are associated with higher mechanization.

Finally, conditions for cultivation and crops cultivated also have an influence on mechanization. Qualitative data on perceptions show that size and terrain of land are not a national level deterrent to mechanization, even though a large share of this sample has experienced related issues. The regression component of the study finds that farmers cultivating on steeper or uneven lands are associated with higher mechanization. In terms of irrigation, paddy farmers using agro wells, micro irrigation or new types of irrigation are correlated with low mechanization, while for OFC farmers, use of rain fed and other irrigation are associate with a lower mechanization. Moreover, for OFC farmers, land extent of OFC cultivation and having experienced an elephant attack are correlated with low mechanization score. However, their overall land extent cultivated is positively correlated with mechanization. The study also finds regional diversity in terms of mechanization, where the contextual effects in Batticaloa and Jaffna have a positive association with mechanization in all types of cultivation other than OFCs, and the district effects in Badulla, Matale and Monaragala are negatively associated with mechanization. When type of crop is considered, farmers working on paddy and oil crops, paddy and fruits, oil and other crops are associated with higher mechanization,

while those cultivating spices or other crops are negatively associated with mechanization.

8.6 Recommendations

As such, efforts to improve mechanization in Sri Lanka can focus on addressing issues such as capital constraints, information and capacity constraints, characteristics of agricultural labour, and conditions of agriculture and crop types etc. Nevertheless, the findings from this study show that all farmers in Sri Lanka cannot be mechanized at the same time with a uniform approach. Diversity of farmers in terms of their cultivation conditions, crops, capital constraints, and capacity etc., necessitates differentiated approaches for mechanization to be successful. As such, based on the quantitative and qualitative analyses, this study proposes a four-pillar approach for mechanization in Sri Lanka.

The first pillar is the development of a conducive environment for mechanization in Sri Lanka, by addressing broad based barriers for mechanization, such as overall capital, knowledge and capacity constraints. The second pillar is targeted mechanization efforts to encourage farmers who are struggling to succeed with mechanization. The third pillar is to introduce mechanization to those who are averse to adopt mechanization and modern technology, while the final and fourth pillar is to extrapolate the success and experience from the second and third pillars to all farmers in Sri Lanka.

Pillar 1 - development of a conducive environment for mechanization in Sri Lanka, by addressing broad based barriers for mechanization

Develop hiring centers

The gap between usage and ownership of machinery and equipment can be addressed with customer hiring centers. The machines and equipment that can be considered as potential candidates for hiring centers are tractors, trailers, plough/ harrow, cultivators, and combined harvesters, based on crop types cultivated and the land type in individual areas. Nevertheless, when developing customer centers, it is important to address the issues faced during previous efforts such as poor purchasing power, lack of physical and financial infrastructure, poor management and maintenance of the machines. Some institution level strategies to address these issues include introducing a strong management structure free of curruption, developing technical capacity to evaluate the appropriateness of machines to purchase, and identifying low maintenance high quality

machines that are suitable for hiring. In order to address the financial and maintenance issues arising with seasonal usage and single-purpose machinery needed for agriculture, the hiring centers need to be linked within and among districts. Such linkage can ensure benefits from economies of scale in terms of usage and economise on a number of machines needed to be purchased at the aggregate level in Sri Lanka.

At the same time, previous efforts related to international experience have shown that poor maintenance and limited applicability of foreign machinery negatively affect the sustainability of these centers. As such, simultaneous to purchasing equipment, a group of people from each area should be trained to maintain and customize machinery for use in Sri Lanka. Given the reluctance of the youth to engage in traditional activities in agriculture, their capacity to absorb new technology and their overall background in agriculture, the youth in agricultural families should be identified as potential candidates for these training opportunities. Moreover, these training courses need to be provided in line with National Vocation Qualification (NVQ) levels. At the same time, to facilitate the culture of mechanization and maintenance of mechanization, it is important to provide concessions for the importation of agriculture equipment, machinery and spare parts. Similarly, the services and facilities provided at the FMTC with regards to training farmers about using and maintaining of farm machinery need to be expanded and improved.

Facilitate saving and borrowing for mechanization

In order to address the capital constraint for mechanization, the government should provide incentives for banks to involve in lending for mechanization activities. With regards to the capacity of out-migration from agricultural families to increase mechanization, banks should be encouraged to introduce a savings scheme focusing on 'migrants for mechanization' with attractive rates of interest for internal migrants and their families to save and subsequently invest in mechanization. At the same time, it is important to encourage banks to consider the presence of an internal migrant in the family as a factor for higher credit worthiness and as collateral to facilitate borrowing to improve mechanization.

Similarly, farmer banks at each agrarian service center are involved in promotion and facilitation of savings and credit facilities for farmers. These institutions need to be strengthened to harness their maximum potential towards mechanization and productivity improvement.

Enhance the services of the DoA

Learning from international experience, in order to enhance the services of the DoA, some policy measures suitable for the Sri Lankan context services of the DoA include conducting research and development in parallel to the importation of machinery, developing location and soil condition-specific technology, exempting taxes on spare parts to increase the local fabrication capacity, and working in collaboration with universities and research organizations. Further, Sri Lanka should strive for economic cooperation with other countries and private sector with more emphasis on agro-machinery and processing technology development and production, to facilitate the establishment of joint venture companies.

Similarly, the preference by farmers to learn about machine usage from the DoA indicates the trust placed by farmers on its capacity to provide high quality technical knowledge. Presently, agriculture workers mostly learn by doing, trial and error and from fellow farmers. As a strategy, it might be important to explore the possibility of providing formal training for agriculture workers to use machines/equipment and thereby promote mechanization. To this end, the DoA and farmer organizations can play a major role. Nevertheless, the identified weaknesses such as hiring of inexperienced officers, lack of their understanding of the ground situation in areas, and issues on accessibility to them and their services, require immediate attention for the DoA to deliver a superior service to farmers in Sri Lanka.

Harness the strength of community support

The study finds that farmers prefer to learn from community members. In the context of issues with the DoA officials, the community members and the DoA officials together can serve as resource persons in providing knowledge and training for farmers on mechanization. This would ensure high buy in and trust by farmers, as well as a ready channel for them with easy access to update their knowledge and clarify issues when practically using machines, amidst the accessibility issues to the DoA officials.

Transform farmer organizations for mechanization

The study shows that farmer organizations have minimal impact on agriculture mechanization in Sri Lanka. Nevertheless, their widespread presence and reach shows immense potential to contribute to mechanization. Therefore, farmer organizations need to be transformed to be a focal point in agriculture mechanization in Sri Lanka, which can identify area specific strengths, weaknesses, opportunities and threats for mechanization, bringing them to the attention of the DoA, relevant authorities and policy makers. It can also act as a key stakeholder in the agriculture mechanization efforts in Sri Lanka. Three key areas for the transformation of farmer organizations are, enhancing their negotiating

power in terms of inputs, machinery, transportation, storage and information, integrating to agriculture value chains, and enhancing their capacity to disseminate information and train fellow farmers towards greater mechanization.

Focus on agricultural households instead of individual farmers

Instead of individual farmers, agricultural households should be considered in the strategies to improve mechanization. As such, it is important to harness the potential of all members of the household in mechanization efforts. Instead of focusing farmers per se, information campaigns for of agriculture mechanization should target all family members in agricultural households. School children should be nurtured with a positive attitude toward mechanization and used as mascots to influence parents' attitudes related to technology adoption for agriculture. Adult family members who are not involved in agriculture should be encouraged to serve as a conduit to channel proper information to older and traditional farmers in the family. Female members in the households should be trained and motivated to use machinery they can handle. Migrants in agricultural families can also be considered in this same model to improve mechanization.

Encourage private sector involvement

The government should seek partnerships with the private sector for mechanization in Sri Lanka. Some possible areas for collaboration include dissemination of information, adoption of smart phones for mechanization, provision of training on usage of equipment, provision of opportunities for farmers to integrate with the agriculture value chain, and the identification of new technology, equipment and machinery available in the international market.

Pillar 2 - targeted mechanization to support farmers interested to mechanize.

The overall strategy for mechanization under this pillar involves supporting farmers who are open to mechanization strategies, addressing their barriers and reinforcing their strengths towards mechanization. As such, Pillar 2 focuses on farmers who have identified their barriers and strengths for mechanization through their experience.

Address labour shortage through mechanization

The study finds an inverse relationship between mechanization and labour shortages. Therefore, such farmers and areas facing labour shortages are ideal candidates for the support for mechanization under the second pillar. The mechanization for these farmers and such labour shortage areas needs to focus on equipment and machines that substitute

for labour intensive practices. Here, the findings show that in addition to providing hiring centers, it is also important to provide the adequate knowledge to use this equipment, due to the existing knowledge gap among the users of machinery and equipment. Data reveal that more information and training should be given on the proper usage of tractors and trailers which are highly used despite the low self-reported knowledge on usage.

Hired labour is a remedy for labour shortage. The findings of this study show that hired labour is more likely to adopt mechanization in activities such as land preparation. As such, it is important to initially identify agriculture workers working as hired workers as oppose to family workers in mechanization expansion efforts in Sri Lanka. At the same time, given that such hired workers are unlikely to purchase machines and equipment or become members of farmers organizations, they need to be adequately linked to hiring centers to improve their access and knowledge about machines and equipment

Encourage participation of the youth

This study finds that the youth are less likely to be involved in agriculture. At the same time, findings reflect that the involvement of relatively more young farmers promote agriculture mechanization. As such, it is important to identify specific agriculture practices that can be performed or preferred by young age groups, and adopt campaigns to mechanize those tasks. Here, it is important to make the youth realize that there are various roles to play when the agriculture value chain is fragmented. As such, young farmers can be encouraged to provide knowledge to older farmers. Along these lines, the youth can be encouraged to repair and maintain machines and equipment, develop ideas and inventions, develop new equipment and modify imported equipment for local context.

Adopt ethnicity-specific approaches

Considering the identified differences between Sinhala and Tamil farmers towards mechanization, it is important to adopt a culturally and ethnically sensitive approach to improve mechanization in the agriculture sector in Sri Lanka. In the case of Sinhala farmers, policy intervention should aim to improve their level of mechanization, rather than merely introducing them to mechanization. Strategies to enhance their mechanization level include dissemination of detailed and in-depth information about how to efficiently adopt mechanization, and capital support to upgrade their mechanization.

Support farm modernization

Another area to focus on when encouraging mechanization is farmers' use and investment in new crop varieties, hybrid seeds and artificial fertilizer, as the study finds that such farmers are more mechanized. As such, greater support should be extended to such farmers to adopt other aspects of mechanization and modernization too. The strategies to adopt include introducing machines and equipment that complement the use of these new crop varieties, hybrid seeds, and artificial fertilizers. At the same time, financial and technical support for mechanization can be coupled with similar support for using new crop varieties, hybrid seeds and artificial fertilizer.

Focus on specific crops, conditions and practices

Due to the positive correlation between mechanization and paddy cultivation, particularly in areas with steep slopes, when promoting strategies to improve mechanization, more focus should be given to paddy farmers, especially to those operating on steep slopes, by introducing equipment and machines conducive for paddy farming and farming in steep lands. At the same time, given the high potential for the combination of paddy cultivation with fruits or other crops, for greater mechanization, it is important to introduce them to machinery, equipment and techniques that can be used interchangeably across these crop types.

The district level positive effects in Batticaloa and Jaffna show that strategies focusing these two districts need to focus extra on elevating the already existing mechanization level to higher levels. As such, farmers in these districts can be considered for more sophisticated or more expensive mechanization efforts as they already have the capacity to benefit from such incremental mechanization. Similarly, previous literature shows that very small farmers and those connected to the input markets and irrigation are candidates for early efforts for mechanization. (Paudel, Balwadur, Rahat, Justice & Donald, 2019).

Agriculture mechanization differs by agriculture practices. As such, introducing mechanization strategies should factor in these differences. On the one hand, this study finds that among alternative agricultural practices, harvesting and post harvesting activities can be easily mechanized. As such, related mechanization support should be provided to farmers who have identified challenges in these aspects of their production. On the other hand, the study finds that plant management is hard to be mechanized. As such, targeted strategies should be adopted to introduce plant management related mechanization, initially to farmers who are more receptive to mechanization. At the same time, mechanization of plant management should include support in all areas including financial, technical and capacity support. In addition, small scale irrigation methods are

also associated with a lower mechanization score as their scale of production tends to be small. In such cases, mechanization should be encouraged.

Pillar 3 - introduce mechanization to those who are averse to adopt mechanization and modern technology. Similar to pillar 2, here also, characteristics of farmers, crops, cultivation conditions and agriculture practices should be considered in developing strategies to improve mechanization. Nevertheless, in contrast to promoting agriculture as done in Pillar 2, now the focus is on newly introducing mechanization. As such, strategies should focus on easy options to mechanization.

Introduce modern technology to older workers

In this regard, given the finding that older workers' involvement decreases mechanization, it is important to explore ways to introduce modern technology for older population in a more user-friendly manner, taking into consideration the age and related capacity constraints. Here, younger family members in agricultural households can be employed as channels to introduce such change in older workers.

Focus on ethnicities with less mechanization

Identified differences in the level of mechanization between Sinhala and Tamil farmers indicates the importance of adopting culturally and ethnically sensitive approaches to motivate the latter into mechanization of their agriculture practices.

Introduce mechanization to identified districts

Strategies to introduce and motivate mechanization should hone in on districts such as Matale, Monaragala and Badulla.

Mitigate the risk of elephant attacks

Based on the negative correlation between elephant attacks and mechanization, it is important to adopt strategies to minimize the incidence and risk of elephant attacks. One strategy to address elephant attacks and thereby promote mechanization is introducing insurance to farmers for elephant attacks.

Focus on specific crops, conditions and practices

Among alternative crops, spices cultivation is less likely to be mechanized. As such, strategies in Pillar 3 should focus on spice cultivation when introducing mechanization. Similarly, this study finds that among alternative agricultural practices, harvesting and post harvesting activities can be easily mechanized. As such, when introducing mechanization to farmers who are averse towards mechanization under Pillar 3,

agricultural practices related to harvesting and post harvesting activities should be prioritized.

Introduce new equipment

It is also important to understand what prevents farmers from using equipment such as plough/harrow, fertilizer spreader, thresher and soil tiller, which show low usage despite the relatively high self-reported knowledge on usage. In harnessing the high level of self-reported knowledge, these equipment serve as ideal candidates to be introduced during the implementation of Pillar 3. In the case of equipment like grain drill and soil tiller, promotion of the usage as well as the provision of knowledge on usage are important strategies to adopt.

Pillar 4 - extrapolate the success and experience to all farmers in Sri Lanka.

Strategies in Pillar 4 should focus on evaluating the performance of strategies adopted in the previous three pillars. Based on the success or failure of each strategy, they should be reconfigured for appropriateness before extrapolating to all farmers in Sri Lanka. Moreover, this pillar should also focus on providing alternative livelihoods within agriculture sector for those who lose their employment due to mechanization.

Chapter 9: Strategies to Improve Agriculture Competitiveness in Sri Lanka

9.1 Introduction

The Agriculture sector has been identified as an important strategic sector in the overall policy objective of the Government of Sri Lanka (GoSL) and it plays a significant role in the economy in terms of contributing to GDP, reducing unemployment, alleviating poverty and rural/ regional development. Accordingly, the sector contributes 7% for the country's GDP and employs around 2.072 million people, representing 25.3% of the total workforce across all three sectors in Sri Lanka, in year 2019 (CBSL, 2019). Although the sector contributes substantially to the economy of Sri Lanka, agriculture activities recorded only a marginal growth of 0.6 per cent in year 2019 in value added terms, compared to the growth of 6.5 per cent in year 2018, due to the considerable decline in key agricultural activities as well as slowdown in valueaddition of agriculture related activities, which was reflected in the sub-indices related to the Agriculture segment of Business outlook survey (BOS) conducted by Central Bank of Sri Lanka in 2019. As mentioned in the chapter 01 and subsequent chapters in this report, the major reason behind this is the low agriculture and labor productivity that prevails in Sri Lanka. As such, agriculture records the lowest labour productivity in Sri Lanka in 2017 at LKR 192.87 per hour worked, compared to other two sectors of manufacturing and services (CBSL, 2019). Given the nature of this sector, CBSL (2019, p 60) highlights that "although the agriculture sector has undergone considerable transformation and improvements in response to green revolution practices, productivity levels have been stagnant in recent years".

Given such low performance in agriculture and agricultural labour productivity, it is important to have Government led interventions and supportive mechanisms by various stakeholders including public, private and non-government institutions to upgrade and strengthen this sector to meet the expectations of the country. Accordingly, Chapters 6 to 8 provide a detailed array of recommendations on how (i) to improve youth & female participation in agriculture; (ii) to improve agriculture and agricultural labour productivity; and (iii) to improve mechanization in agriculture, respectively. The objective of this chapter is to amalgamate these identified recommendations into cohesive and implementable priority strategies, that which can be taken up by the identified authorities and implemented. As such, based on the study findings and international experience, this chapter identifies appropriate policy measures and procedures to follow

to implement the proposed policy changes to improve agriculture sector's sustainability, productivity and competitiveness. Additionally, these recommendations also identify possible implementing authorities such as ministries, departments or other organizations, that the government could mobilize to proposed to make suggested strategies a reality. While the implementation strategies and institutions are meant to serve as guiding tools, the exact implementation mechanisms need to be fine-tuned by these identified institutions by integrating same as appropriate into their mandate, activities and budgetary allocations.

9.2 Strategies

Strategy 1: Development of Value Addition and Agri-businesses and Integration with Agriculture Value Chains

The study findings indicate that prevailing greater emphasis on primary production in agriculture is a deterrent in attracting youth and female labour, mechanizing the sector and improving productivity. To address this one strategy is to change the face of agriculture from a more traditional livelihood approach to a more modern sector that also involves value addition across the entire agriculture value chain, where farmers approach agriculture as an agri-business. Such changes can nurture many employment opportunities across the value chain, especially employment opportunities beyond traditional agriculture work. For instance, employment opportunities in transportation and packaging agriculture products would resemble formal employment in the manufacturing sector which aligns more with aspirations of youth. Similarly, providing knowhow and technology adoption for value addition could attract educated workers especially among females to this sector. Moreover, development of ancillary skills and related jobs in agriculture, such as repair and maintenance of agricultural machines and equipment, could attract part time involvement in agriculture related activities and could realign some workers reluctant to engage in traditional agriculture jobs towards improving agriculture mechanization.

As such developing agriculture value addition and developing agri-businesses can absorb the new workers who may not be interested in primary agriculture production into the agriculture sector and plug them into various areas across the agriculture value chain. The following are specific recommendations to implement above strategy:

Research Findings	Recommendations	Policy Instrument	Description	Responsible Institute	Timeline (Short/Medium/Long)
Chapter 6: Among economically active group, supplementary income may encourage participation in agriculture.	Match individuals with agri-business opportunities.	Value chain development	Youth and females in households that do not have supplementary income sources (such as remittances and non-agriculture income) needs to be identified and encouraged to get involved in Agri-business. Similarly, returnee international migrants with savings who are interested in entrepreneurship could be provided with necessary guidance by the DoA and SLBFE towards investment in agri-businesses or link up with farmers who can be developed into agri-businesspeople.	GN[50], DoA[51], NEDA[52], IDB[53], SED[54], EDB[55], Chamber of Commerce, SAPP[56], SLBF[57]	Short term

[50] Grama Niladhari

[51] Department of Agriculture

[52] National Enterprise Development Authority

[53] Industrial Development Board

[54] Small Enterprises Development

[55] Export Development Board

[56] Smallholder Agribusiness Partnerships Programme

[57] Sri Lanka Bureau of Foreign Employment

Chapter 8: Capital constraints were perceived as a barrier for mechanization.	Facilitate access to credit/loan facilities.	Concessionary Credit Facilities	Provide credit/loan facilities at low interest rates for youth/female who have the investment potential/ interests to involve in agriculture value chains. Here, MoA, DoA, Ministry of Industry and Commerce (MoIC) together with the CBSL could make provisions for banks, micro financial institutions and leasing companies to scale up their lending activities with a special lending window for agriculture purposes and SMEs entering agri-business/ agriculture value chain. Similarly, it is important to enable individuals reported to the Credit Information Bureau of Sri Lanka (CRIB) merely due to being a guarantor of a defaulted loan to obtain credit/loan facilities for agriculture. Here the DoA could work in collaboration with the CRIB.	MoA[58], DoA, MoIC [59] and CRIB[60]	Short term
Chapter 6: Youth and women with higher education and more financial resources may be discouraged	Develop a mechanism to identify potential youth/female for agricultural value chains and provide	Value chain development & skill development	Develop a government mechanism to identify potential youth/female to be involved in upper layers of agriculture value chains and provide them with proper training/extension programs/ in-house workshops (free of charge) to upgrade their technical knowhow, skills and marketing knowledge. Here DoA could collaborate with other institutions and strengthen the existing extension	DoA, IDB, SED, NEDA	Short term

[58] Ministry of Agriculture

[59] Ministry of Industry and Commerce

[60] Credit Information Bureau of Sri Lanka

from agriculture. Such individuals can be identified and given the means to be a part of the upper layers of the agriculture value chain. On the other hand higher agricultural profit encourages participation. .	training & knowledge.		services/ to provide tailor-made extension programmes to cover important services such as preparation of project reports and feasibility reports for credit facilitation, provision of technical information, advisory services, laboratory services, and quality assurance services for the identified individuals those who have potential and interest to engage in agri-businesses or enter in the agriculture value chain.		
	Use a cluster approach.	Value chain development	Cluster them along the entire agriculture value chain from input supply to processing and exportation and link with private sector companies to develop their synergies accordingly. Here the MoA, DoA have to take a lead role and integrate with the institutions such as NEDA, IDB, SED, EDB, Chamber of Commerce, and SAPP.	MoA, DoA, NEDA, IDB, SED, EDB, Chamber of Commerce and SAPP	Short term
	Build up market linkages.	Improvement of market linkages	Build up market linkages through improved information flows, and/or forward (farmers becoming more involved in meeting the needs of consumers) linking of farms to markets and backward linking of consumer supply businesses (supermarkets and processors; out-grower schemes or other supply/value chain networks) to markets. Here DoA should collaboratively work with institutions such as EDB and Chamber of Commerce to open market avenues for those individuals to sell their products in local and international markets.	DoA, EDB and Chamber of Commerce	Medium term

			(Ex: e-commerce arrangements to enable the SMEs to link up with local & international suppliers/ buyers). Similarly, the private sector telecom companies also can play a role in improving information flows, linking farmers to markets and enabling forward and backward linkages in the agriculture value chains by developing virtual platforms.		
Chapter 8: Not having enough knowledge on new technology is seen as a barrier for mechanization	Support for innovations and technology advancements for developing sustainable/competitive agriculture value chain.	Value chain development	It is worthwhile to establish network, platform and link between SMEs and research/technology institutions such as ITI[61], SLINTECH[62], NIPHM[63] to disseminate/ transfer the new technologies to ground/SME level. Accordingly, strengthen the technology transfer programs, outreach of technology demonstration platforms and centers in the industrial park sand through special technology showcase and dissemination exhibitions. Also, DoA, IDB, EDB, SED or regional chambers could link up SMEs with large scale companies to showcase the latest technology adoptions by those large-scale companies.	ITI, SLINTECH, NIPHM, DoA, IDB, EDB, SED	Short term

[61] Industrial Technology Institute

[62] Sri Lanka Institute of Nanotechnology

[63] National Institute of Post Harvest Management

Chapter 6: Higher profits in agriculture encouraged participation.	Showcase successful agribusinesses, and opportunities along the agriculture value chain.	Promotional campaign/ value chain development	Showcase individuals who have succeeded after transforming their activities into agribusinesses and showcase that various opportunities available along the agriculture value chain. Here the DoA could launch a media campaign to showcase various aspects of the sector.	DoA	Short term
Chapters 6, 7 and 8	Integrate agri-business policy interventions & value chain development into key policy areas.	Policy planning	Integrate policy interventions related to agri-business & agriculture value chain development into key policy areas such as enabling environment, technology & innovation, entrepreneurial culture and skills development, access to finance, market facilitation and research and development focused in the National Policy Framework for SME development, (2017). Here the MoA and DoA could take a lead role and provide recommendations to the NPD and MoIC.	MoA, DoA, NPD [64] and MoIC	Medium-long term

Strategy 2: Develop a Diversified Pool of Agriculture Workers with Required Skills

The current emphasis on agriculture labour gives disproportionate prominence to family workers who consider agriculture as their primary livelihood. Nevertheless, there are many other types of agriculture workers such as hired agriculture workers, contract agriculture workers, those engaging in agriculture as a part time or secondary activity, and agricultural entrepreneurs or agri-

[64] Department of National Planning

business persons. Therefore, it is important to focus on all these segments and provide targeted interventions to improve to respective skills required for their scope of work, to improve agriculture and labour productivity and attract new labour to the sector. Similarly, targeted interventions by agricultural activities, geographic areas and age groups of farmers are important. Towards this, the following are some recommendations:

Research Findings	Recommendations	Policy Instrument	Description	Responsible Institute	Timeline (Short/Medium/Long)
Chapter 7: Hired labour shows somewhat higher productivity than family labour in most scenarios.	Focus on training hired/contract workers and develop them into a skilled pool of agriculture workers.	Skill development	Focus on hired workers and contract workers for training on use of equipment and modern technology, information dissemination and develop them into a skilled pool of agriculture workers. Here the Provincial Agriculture Departments, Regional Agrarian Service Centres, and FMTC [65] are identified as institutions to implement this. Moreover, with the support of private telecom companies it is suggested to develop a virtual platform to enable matching of such skilled hired workers with farmers and agri-businesses in need of such workers.	Provincial Agriculture Departments, Regional Agrarian Service Centres, FMTC and private telecom companies.	Short-term
Chapter 7: experience is associated with	"Short-circuit" the experience of older farmers, such	Knowledge transfer	Enabling such a knowledge transfer will allow application of farming techniques early on in the learning curve, to achieve more productive outcomes. As such, initiate a	DOA, farmers organizations	Short-term

[65] Farm Mechanization Training Centre

increased productivity. Younger farmers can benefit from greater knowledge transfer.	that the youth are given access to this same knowledge at an early stage		programme to integrate both young and old farmers -whereby seniors' impart knowledge so that the young can execute these. DOA and farmers organizations to play a lead role in executing such a programme. DOA can change their dissemination approach to a more customized and 'demand driven' approach- ie. Messaging on agriculture technologies etc., should be customized to suit different age groups. To be done by DoA together with private telecom companies, FMTC, Provincial Agriculture Departments, Regional Agrarian Service Centres.	, private telecom companies, FMTC, Provincial Agriculture Departments, Regional Agrarian Service Centres.	
Chapter 8: Mechanization levels differ by district.	Targeting high potential districts for more sophisticated or expensive mechanization efforts	Targeted interventions	Based on district level positive effects on mechanization, the two districts of Batticaloa and Jaffna are found to be already having high levels of mechanization relative to other districts. As such, farmers in these districts can be considered for more sophisticated or more expensive mechanization efforts as they already have the capacity to benefit from such incremental mechanization.	Provincial Agriculture Departments and Regional Agrarian Service Centres.	Short-medium term
Chapter 8: Mechanization levels differ by ethnicity.	Focus on a culturally and ethnically sensitive approach to improve mechanization	Targeted interventions	In the case of Sinhala farmers, policy interventions should aim to improve their level of mechanization, rather than merely introducing them to mechanization. Strategies to enhance their mechanization level include dissemination of detailed and in-depth	Ministry of Agriculture and related authorities such as DOA, Agrarian	Short-term

	in the agriculture sector in Sri Lanka		information about how to efficiently adopt mechanization, and capital support to upgrade their mechanization.	Service Centers and provincial agriculture department.	
Chapter 7: When in the highest education level in the household increases, it raises labour and agricultural productivity.	Adopt a "whole of farmer household/community" approach for productivity development and mechanization and deliver information to all members.	Knowledge and skill development	Different members of agricultural household can be involved in the sector in different capacities. For instance, school children should be educated from an early stage such that gardening/cultivating is incorporated into life skills curricular in schools. Further, the skills of educated family members not involved in agriculture should be leveraged. Relating to the agribusiness approach mentioned earlier, their skill set can be drawn on for the non-agriculture aspects of business operations.	Ministry of Education, Media, MoA, DoA, Ministry of Mass Media	Medium term
Chapter 8: Lower willingness to mechanize among plant management activities.	Promote mechanization of plant management activities	Incentives for promotion	Promoting mechanization of plant management activities is necessary since it is currently an under mechanized activity in agriculture.	Ministry of Agriculture and related authorities such as DOA, Agrarian Service Centers and provincial	Short term

				agriculture department.	

Strategy 3: Improve Land Mobilization and Land Use for Agriculture

The study found that land ownership, extent of land owned/cultivated and land type are key determinants of agricultural productivity and strong factors for drawing youth and females into the agriculture labor force. The current land ownership arrangements in agriculture are broadly two categories – colonized land and owned land. In colonized land the state tenure arrangements deter those colonized from selling but allows transferring to children. As such, at times, children who are not interested in agriculture are inherited with agriculture land without the capacity to sell. On the other hand, both types of land often face the issue of land fragmentation when transferring to second generation, which removes any potential economies of scale that might be present when cultivating on sizable plots of land. Therefore, it is important to improve allocation of land to those who are interested in farming.

Furthermore, techniques to use mobilized land in an optimal manner should be encouraged. Given that mixed cropping increases overall productivity and results in an efficient use of scarce land such that it reaches its maximum potential, it is important to promote mix cropping. In the same vein, adoption of unsustainable methods of cultivation leads to land degradation and related productivity issues. As such, it is important to consider land conservation methods and take measures to mitigate land degradation for productivity improvement. The following are some recommendations:

Research Findings	**Recommendations**	**Policy Instrument**	**Description**	**Responsible Institute**	**Timeline (Short/Medium/Long)**
Chapters 6 and 7: Land ownership	Revisit and adjust the existing land	Laws and regulations	a) Revise restrictions imposed on sale of colonized lands to enable better matching of land supply with those who demand it for	Ministry of Lands, Mahaweli	Short-medium term

increases participation and productivity in agriculture.	laws, regulations and procedures to improve land mobility rather than restrict it.		agricultural purposes. Ministry of Lands. Mahaweli Authority and related institutions to initiate these legal changes. b) Revise necessity for title deeds as a prerequisite to access resources such as subsidized fertilizer and membership in farmers organizations (which opens opportunities for water access, training programmes, etc.) since this requirement disproportionately affects females who are less likely to own title deeds relative to males. Alternative approach to be taken for females where authorities take a more flexible approach and use alternative means of determining eligibility for the above resources, such as family ownership of land and tenure in agriculture sector. Ministry of Lands, DOA, Department of Agrarian Services and Farmers Organizations to cohesively adopt this approach. c) Access to permits for publicly owned land plots such as those under the Mahaweli Development Authority, and the process of	Authority, Ministry of Agriculture, DoA and NRMC[66]	

[66] Natural Resource Management Centre

			eventual transfer of deeds to owner's name, to be streamlined. Ministry of Lands and Mahaweli Development Authority to be responsible for execution. d) Introduce land levelling and reshaping planning programs with the support of NRMC. e) Develop mechanism to link up farmers who are interested in expanding their land area by matching them with land not cultivated. In addition, facilitate the consolidation of small farms into larger fields, via purchases, lease, rental agreements for agricultural equipment. Similarly, a mechanism can be used to allocate land for contract farmers looking for land to work on. Here, MoA and related authorities such as DoA, Provincial Agriculture Departments and Agrarian Service Centres could identify such farmers who are having such needs. Farmers organizations to develop existing membership databases to match land demand and supply in respective areas.		
Chapter 7: Certain combinations of crops cultivated together tend to	Promote viable combined/mixed cropping options	Research and development	a) Conducting field experiments to develop and introduce productive, efficient, sustainable, and profitable cropping systems and combinations (Eg; diversifying cropping rotations/	MoA, DoA and Ministry of Finance	Short-medium term

be more productive.			intercropping/ mix cropping systems) Field experiments could be conducted with the involvement of research institutes such as FCRDI [67] , HORDI [68] and disseminate the findings to farmers via island wide extension services through DoA, Provincial agriculture departments and regional Agrarian service centres. Donor funding can be pursued from agencies such as IFAD[69] and SLCARP[70]. b) Provide technical support and guidance towards their sustainability, through DOA extension services. c) Provide adequate budgetary allocations towards research & development in the agriculture sector, to be advocated for my agricultural sector as a whole, from the GoSL. MoA and DoA guide Ministry of Finance to include specific recommendations for future budget proposals.		

[67] Field Crop Research & Development Institute

[68] Horticultural Crop Research & Development Institute

[69] International Fund for Agriculture Development

[70] Sri Lanka Council for Agriculture Research Policy

Chapter 7 and 8: Land ownership, extent and type of land have an impact on productivity and mechanization.	Take steps to mitigate land degradation	Capacity development and information dissemination	a) Article 48 d of the Agrarian Development Act, No. 46 of 2000 (Parliament of Sri Lanka, 2000) underscores the role of farmer organizations in soil conservation and efficient water usage. Support capacity development in Farmers' Organizations to involve in these measures. b) Disseminate information on land conservation through Farmer organizations and DOA extension services.	DoA, and farmer organizations	Short term

Strategy 4: Developing Irrigation Infrastructure and Practices

Due to the water scarcity of most of the districts in dry and intermediate zones specially during "yala" season, irrigation is one of a critical determinant of agriculture productivity in Sri Lanka. Therefore, farmer's attention is on conserving and replenishing water resources to be utilized in the dry periods for their agriculture practices. Hence, the government also should have a way forward and streamline the irrigation policies within the agriculture policy agendas. Therefore, policy directions should be made upon promoting integrated water resource management among farming community.

Research Findings	**Recommendations**	**Policy Instrument**	**Description**	**Responsible Institute**	**Timeline (Short/Medium/Long)**

Chapter 7 and 8: Rainfed irrigation leads to lower productivity and mechanization.	Provide incentives to farmers to develop irrigation systems.	Incentives	Farmers can be provided incentives/ funds to develop agro wells/ other form of irrigation techniques such as micro irrigation systems (ex; Drip/ sprinkler irrigation), beyond depending on major irrigation scheme, to ensure efficient usage of water in agriculture. Here the DoA can channel funding from International donors towards such projects.	DoA and Ministry of Finance	Short term
	Provide tax exemptions on technology imports related to irrigation.	Tax exemption	Provide tax exemption on importation of such latest irrigation techniques related equipment. Here the Irrigation Department and FMRC can provide recommendations to MoA and DoA guide Ministry of Finance to include specific recommendations for future budget proposals.	Irrigation Department and FMRC, MoA, DoA and Ministry of Finance	Short term
	Ensure after sales services.	Regulatory compliance	Ensure after sales services are provided by the private sector operators who import or distribute such technology. DoA to monitor.	Private sector and DoA	Short-long term
	Provide knowledge and training on maintaining and repairing modern irrigation solutions.	Knowledge transfer, skill developme nt	Here the private sector importers of such technology and FMTC could guide the DoA's Provincial Agriculture Departments, Regional Agrarian Service Centres, to provide necessary training. Identification of appropriate candidates for such training can be done through the Farmers' Organizations.	Private sector importers, FMTC, Provincial Agriculture Departments and Regional Agrarian Service Centres	Short term

Chapter 7: Certain combinations of crops cultivated together tend to be more productive.	Introducing crop mix.	Research and developme nt, information disseminati on	Introducing crop mix by diversifying to include low water consuming crops, land levelling and changing the irrigation techniques, which can increase the water use efficiency. Here HORDI, FCRDI, DoA could conduct research and field experiments and disseminate the findings/ recommendations to farmers via extension officers and agriculture instructors in the field, while the DoA's Regional Agrarian Service Centres could provide necessary training and capacity building for farmers.	HORDI, FCRDI, DoA, Regional Agrarian Service Centres	Short- term
Chapter 7 and 8: Rainfed irrigation leads to lower productivity and mechanization.	Increase public investment in new irrigation systems and making existing operations sustainable.	Investments and budget allocations	Increase public investment in developing new irrigation systems (in the areas where the water resources are lacking) and making existing operations sustainable. Government should allocate adequate budget for the development and maintenance of existing irrigation systems. Irrigation Department, Mahaweli Authority, MoA and DoA guide Ministry of Finance to include specific recommendations for future budget proposals.	Irrigation Department, Mahaweli Authority, MoA, DoA, Ministry of Finance	Short-medium term
	Develop maintenance standards and guidelines to encourage	Regulatory compliance	Maintenance standards and guidelines should be developed to encourage sustainable water resource/irrigation management among farmers. Here DoA Mahaweli Authority and	DoA Mahaweli Authority, NRMC, Farmers'	Short-long term

	sustainable water resource/ irrigation management.		NRMC could develop such standards and guidelines, inform farmers through Farmers' Organizations and monitor same.	Organizations	
	Create institutional arrangements on water policy and enact comprehensive water resource legislation.	Institutional restructuring	Create institutional arrangements that encourage better implementation of existing water policy and enact comprehensive water resource legislation to integrate existing piecemeal legislation. Appoint a high-level decision-making and coordinating body such as the Water Resources Board.	Natural Resource Management Centre and Irrigation Department	Short term
Chapter 7 and 8: Farmer organization membership is associated with higher productivity and mechanization.	Utilize farmer organizations for efficient water usage.	Improved governance structures	Utilize farmer organizations as per their mandate for efficient water usage (Article 48 d of the Agrarian Development Act, No. 46 of 2000) to promote water conservation and sustainable methods in agriculture.	Provincial Agriculture Departments, farmer organizations and Regional Agrarian Service Centres	Short-long term

Strategy 5: Harnessing Full Potential of Farmers' Organizations

Farmers organizations can play an important role in improving the level of agriculture technology adoption, mechanization, productivity and achieving sustainable growth in the sector. The study findings reveal a correlation between membership in farmer organization and productivity improvement in Sri Lanka. Hence, farmer organizations have the potential to serve as an ideal platform for dissemination of valuable information and providing a critical collective power to farmers. Focusing on these potentials

and capacities, the following are some areas to focus in transforming farmer organizations beyond their current limited operational scope of fertilizer distribution and irrigation meetings, to involve in a broader scope:

Research Findings	Recommendations	Policy Instrument	Description	Responsible Institute	Timeline (Short/Medium/Long)
Chapter 7 and 8: Farmer organization membership is associated with higher productivity and mechanization.	Utilize farm organizations for disseminating information and training.	Information dissemination	Utilize farm organizations' potential for disseminating information and training with regards to adoption of modern technology and greater mechanization. Given that the mandate of farmer organizations as per the Agrarian Development Act, No. 46 of 2000 involves a role in implementing programmes to educate member (Article 48 f), the MoA and DoA could take lead role to ensure that farmer organizations are used as a critical node in these activities.	Farmer organizations, MoA and DoA	Short term
	Involve farm organizations for marketing output, integrate smallholder farmers towards market-oriented production	Production process restructuring	Involve farm organizations for marketing of output, integrating smallholder farmers towards market-oriented production and transforming famers into agri-businesses. Similarly, and enhance their negotiating power in terms of inputs, machinery, transportation, storage and information. Here the MoA and DoA through their grassroot level extension services could provide training and other technical support to farmer organizations to	Farmer organizations ,MoA and DoA	Short term

	and transforming into agri-businesses.		improve their negotiation power and help them integrate with agriculture value chains.		
	Collect updated information to facilitate evidence-based policy changes at the grassroot level.	Research and developme nt	As per the Agrarian Development Act, No. 46 of 2000 the mandate of farmer organizations involves a data collection role (article 48 b and c). Here the DoA together with donor funding (Ex: IFAD / SLCARP) can provide technical capacity building and encourage farmer organizations to collect updated information to facilitate evidence-based policy changes at the grassroot level.	Farmer organizations , DoA, IFAD/ SLCARP	Short term
	Link Farmers' Organizations to value chains.	Value chain developme nt	In order to harness the full potential of farmer organizations, government needs to link them with different nodes of the agriculture value chains from input supply to processing and exportation to leverage their strengths/synergies and to develop sustainable agriculture value chain in long term. In this regard, the DoA and related authorities including Provincial Agriculture Departments and Regional Agrarian Service Departments have greater responsibility, to access the farmer organizations, monitor and link them with different nodes of agri. supply chain for the betterment of farmers.	Farmer organizations , DoA, Provincial Agriculture Departments and Regional Agrarian Service Departments	Short term

Strategy 6: Leveraging Hiring Centers

As identified in this study, limited ownership and use of machineries and equipment are major challenges for agriculture mechanization in Sri Lanka. Hence most of the smallholder farmers are averse to adopting mechanization and modern technology due to the high cost of investment of such machineries, which most of them are unable to incur. Nevertheless, there are private hiring centers in operation. Thus, from policy perspective Government should focus on developing a conducive environment for farmers to adopt mechanization through various approaches such as:

Research Findings	**Recommendations**	**Policy Instrument**	**Description**	**Responsible Institute**	**Timeline (Short/Medium/Long)**
Chapter 8: Equipment usage is higher than ownership and capital constraints deter mechanization.	Expand hiring centers across all agricultural areas.	Improve governance structures	Expand hiring centers across all agricultural areas in a more systematic manner, ideally as Public Private Partnerships (PPP). Here the MoA and DoA would have to highlight the significance of such investments to the BOI[71], to attract foreign investment from agricultural equipment manufacturers to invest in these joint ventures.	MoA, DoA, BOI	Short term
	Introduce exemptions/ relaxations on taxes on	Tax exemptions	Introduce exemptions/ relaxations on taxes on Agriculture machinery imports. The MoA and DoA together with Ministry of Finance would	MoA, DoA, Ministry of Finance	Short term

[71] Board of Investment of Sri Lanka

	Agriculture machinery imports.		have to make such recommendations for future budget proposals.		
	Monitor and regularize importation procedures of farm machineries.	Regulatory compliance	Monitor and regularize importation procedures of farm machineries by the private sector to ensure introducing high quality, low cost, technologically advanced machineries to farmers with adequately available spare parts and island wide after sales services which is a greater concern of farmers as identified in this study. Here the FMRC could provide guidance to Department of Customs to regulate imports accordingly.	FMRC, Department of Customs	Short-long term
	Introduce subsidy scheme to refund/ bare-up the fuel cost.	Subsidy	Introduce subsidy scheme to refund/ bare-up the fuel cost resulted from usage of some selected machineries which are having higher degree of fuel consumption. The MoA and DoA together with Ministry of Finance would have to make such recommendations for future budget proposals.	MoA, DoA, Ministry of Finance	Short term
	Provide guidance for entrepreneurs to channel their investments to	Advice and guidance	Micro financial institutes and rural & regional banks to provide guidance for entrepreneurs to channel their investments to set up hiring centers. Here the DoA could work with CBSL to encourage financial institutions.	DoA, CBSL, Regional Chambers of Commerce	Short-medium term

	set up hiring centers.				
Chapter 8: Learn from regional experiences.	Develop a skilled pool of workers to maintain and repair machineries at the grassroot level.	Skill development	Develop a skilled pool of workers to maintain and repair the agriculture machineries at the grassroot level. Here the DoA's Provincial Agriculture Departments, Regional Agrarian Service Centres, FMTC, with the technical support from private sector machinery importers, regional technical colleges and TEVT [72] can introduce training courses with employment placement in Hiring Centers upon completion of training.	DoA's Provincial Agriculture Departments, Regional Agrarian Service Centres, FMTC, private sector machinery importers, regional technical colleges, TEVT, and Hiring Centers	Short term
Chapter 8: Different levels of mechanization associated with age groups.	Design differentiated and demand driven extension	Targeted extension programmes	Design differentiated and demand driven extension programs targeting different farmer age groups on how to benefit from hired equipment and machinery. This responsibility	Provincial Agriculture Departments, Regional	Short-medium term

[72] Technical Education & Vocational Training Centres

	programs targeting different age groups.		could be taken by the DoA's mechanism for Extension services through the Provincial Agriculture Departments, Regional Agrarian Service Centres.	Agrarian Service Centres.	

Strategy 7: Resolve Limitations in Extension Services Provided by DOA

Agriculture education, research and extension services are widely regarded in Sri Lanka to play an important role in improving agricultural systems and its provision has been seen for many years as a principle responsibility of the GoSL. However, there are many limitations in this mechanism. Among them, the large gap in human resources in the public-sector organizations responsible for research and advisory services delivery, poorly motivated cadre resulting from outdated career advancement schemes, poor remuneration compared to those in parallel organizations, poor facilities, increased allocation of researchers' time on administrative duties, mismatch between supply and demand for extension services, and unreasonable allocation of large geographical areas per extension officers, are prominent (Ministry of Agriculture, Rural Economic Affairs, Irrigation, and Fisheries, And, 2019). The following are specific recommendations to overcome these challenges:

Research Findings	**Recommendations**	**Policy Instrument**	**Description**	**Responsible Institute**	**Timeline (Short/Medium/Long)**
Chapter 7 and 8: High potential for a greater role by DoA and extension services as it is seen as a	Overhaul the extension server delivery model to a demand driven one.	Service delivery model restructuring	Overhaul the extension service delivery model from supply driven model to a demand driven one. Towards this the DoA needs to develop a mechanism, possibly through the mandate of Farmers' Organizations for data collection, to periodically identify farmers' needs in terms of	DoA and Farmers' Organizations.	Short term

reliable source of information and support.			extension services and upskill extension officers accordingly, and provide a demand driven service.		
	Mobilize fragmented and diversified structure of the agriculture sector service delivery mechanism.	Agriculture sector service delivery mechanism restructuring	Mobilize the fragmented and diversified structure of the agriculture sector service delivery mechanism spanning across varied intuitional structure, such as Mahaweli Officers, Extension Officers, *Krupanisa*, to provide a more integrated delivery of extension services that reaches a wider geographic than currently covered by the extension officers alone. Here the Ministry of Agriculture would need to take a leading role and mobilize institutions such as the DoA, Provincial Agriculture Departments, Regional Agrarian Service Centres, Mahaweli Authority, and Irrigation Department into a coherent service delivery structure.	MoA, DoA, Provincial Agriculture Departments, Regional Agrarian Service Centres, Mahaweli Authority, and Irrigation Department	Short term
	Enhance extension services by improving capacity constraints.	Knowledge transfer, skill development	Enhance extension services by improving capacity constraints by improving the number of trained staff and equipping them with information on the latest agriculture technologies to be disseminated among the farming community.	DoA	Short term

	Post extension officers in their own areas.	Improved governance structures	Post extension officers in their own areas to improve commitment, accountability, and approachability.	DoA	
	Introduce a performance based rewarding system for officers.	Incentives	Introduce a performance based rewarding system for officers involved in agriculture sector. To be done by DoA in consultation with MoF.	DoA and MoF	Short-medium term
	Remove the disconnect between national level research and provincial level service delivery.	Improved coordination	Remove the disconnect between agriculture research conducted at the national level and extension service delivery conducted at the provincial level, by bringing both functions under either national level functions or provincial level functions.	DoA and MoA	Short-long term

Strategy 8: Mitigating Uncertainties to Increase Agriculture Profitability

The study found that high uncertainty and low profitability are discouraging agriculture employment and mechanization. Strategies to mitigate these risks and increase profitability are as follows:

Research Findings	Recommendations	Policy Instrument	Description	Responsible Institute	Timeline (Short/Medium/Long)
Chapters 6, 7 and 8: Lack of access to reliable irrigation methods, vulnerability to natural disasters adversely affect agricultural sector.	Provision of rural infrastructure that minimizes losses and costs.	Rural infrastructure provision	Provision of rural infrastructure that minimizes the postharvest losses and transport costs, and shorten the lead time, while increasing overall rural mobility (i.e. Storage facilities in and road access facilities in village level etc). Here, the DoA and MoF have to allocate funds for rural infrastructure development in this area, while the monitoring could be carried out by Divisional Secretariats and Grama Niladari in the region.	DoA, MoF, Divisional Secretariats and Grama Niladari	Short term
	Educate the farmers with modern technique.	Knowledge transfer, skill development	Educate the farmers with modern techniques to minimize the post-harvest losses via in house workshops and training programs through FMRC, FMTC, Farmers' Organizations, DoA and NIPHM.	FMRC, FMTC, Farmers' Organizations, DoA and NIPHM	Short term
	Establish facilities and introduce modern technology for storage.	Technology transfer	Establish facilities and introduce modern technology for storage of agriculture products during postharvest stage in village levels. Here, the DoA with the support of private sector should establish such storage facilities as PPPs and introduce such modern technology.	DoA, private sector	Short term

	Introduce guarantee price scheme.	Guarantee price	Introduce insurance scheme for farmers affected by natural hazards such as elephant attacks and rescind the existing crop insurance schemes for farmers. Limitations in existing insurance schemes have created mistrust among farmers. Therefore, a novel insurance scheme which captures the needs of farmers while also offering a viable business opportunity for insurance providers should be introduced. In a related IPS study, affordability of premiums, verification of crop losses, and claim settlement are identified as implementing challenges for specific insurance schemes to cover risks caused by wild elephants. Moreover, such a product should be implemented first at a pilot level involving a limited group of villagers to identify practical issues associated with it, before scaling up to a wider group of beneficiaries. Such an insurance scheme will have a greater impact if offered as a part of an integrated solution strategically combined with other mitigation measures such as electric fences. This could be executed by the Ministry of Agriculture and related authorities, Agriculture, Agrarian Insurance Board and private insurance companies.	Ministry of Agriculture and related authorities, Agriculture and AAIB[73] and private insurance companies	Short-long term

[73] Agrarian Insurance Board

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Appendix 1: Profile of Agriculture Workers using HIES2016 data

As per HIES2016 data agriculture workers are defined as those engaging in agriculture sector in the areas of (1) crop agriculture and (2) mixed farming (both crop and animal production) as per the Sri Lanka Standardized Industrial Classification (SLSIC) industry codes.[74] Due to scope of the study being limited to paddy and other food crops (OFCs), those involved in the plantation (tea, rubber and coconut) sector have been omitted from this group. Similarly, animal production is also not considered (although it is classified as an agricultural activity) unless the individual is engaged in animal production simultaneous to crop agriculture (mixed farming). When defined in this manner, the HIES2016 sample consists of a total of 4805 individuals involved in agriculture, which at the national level represents 1,135,910 individuals (See Appendix 1 Table 1). In this sample 2,264 individuals receive only agriculture income. Another 698 receive both agriculture & non- agriculture incomes. All households having at least one agriculture worker (regardless of above income source classification) is defined as an agricultural household. The HIES2016 sample consists of 3623 households, which represents 849,033 households at the national level.

Appendix 1 Table 1: Sample Composition for Agriculture Labour Profile

	Sample	Population
Total households	21,756	5,436,653
Total individuals	88,282	21,964,489
Agricultural workers	4,805	1,135, 910
receive only agriculture income	2,264	535,064
receive both agriculture & non-agriculture incomes	698	165,990
Agricultural households	3,623	849,033

Source: Authors based on HIES2016.

Profile of workers earning income only from agricultural activities– HIES2016

[74] All codes <1400 (except 1261, 1271 & 1291) and codes 1500, 1611-1619 and 1631-1649. SLSIC is the localized version of ISIC Revision 4.

Appendix 1 Table 2: Age by gender

	Male	Female	Total	
Av. Age (yrs)	53	49	52	
Share (%)	79	21	100	
	% in age group		% of total in age group	Av. Age (yrs)
Below 19 (%)	100	0	0.1	18
19-29 (%)	84	16	4	25
30-55 (%)	72	28	53	45
Over 55 (%)	86	14	43	63
Total	79	21	100	52

Source: Authors based on HIES2016.

Appendix 1 Table 3: Marital status and relationship of head of household

Marital status	%		Relationship	%
Never married	6		Head	76
Married	85		Spouse	11
Widowed/divorced /separated	9		Children	9
			Other	3

Source: Authors based on HIES2016.

Appendix 1 Table 4: Ethnicity and religion

Ethnicity	%		Religion	%
Sinhala	87		Buddhist	86
Tamil	11		Hindu	9
Muslim	2		Islam	2
Other	0		Christian	2
Total	100		Total	100

Source: Authors based on HIES2016.

Appendix 1 Table 5: Education

Age group	Sex (% in educ group)		% of total in educ group		Age group (% in educ group)		
	Male	Female			19-29	30-55	Over 55
No schooling	67	33	3		0	42	58
Grade 1-5	83	17	26		0	42	58
Grade 6-10	79	21	52		5	58	37
O/L	76	24	7		6	52	42
Grade 12	71	29	5		9	68	24
A/L	72	28	6		11	55	34
Tertiary	78	22	1		10	0	90

Source: Authors based on HIES2016.

Appendix 1 Table 6: Annual Income deciles

Decile				
	Range	Mean (LKR)	Number	%
Average		255,510		
1	1,000 – 24,000	13,430	244	11
2	24,500 – 47,047	35,283	209	9
3	47,200 – 75,000	60,503	238	11
4	75,600 – 108,000	91,704	215	10
5	109,200 – 146,160	127,315	226	10
6	146,700 - 195,000	168,553	232	10
7	196,000 – 255,000	224,062	222	10
8	255,500 - 345,000	295,687	226	10
9	346,100 - 540,000	421,082	228	10
10	542,500 – 8,400,000	1,134,895	224	10
Total			2,264	100

Note: In HIES2016, the deciles are unweighted and for the sample.

Source: Authors based on HIES2016.

Appendix 1 Table 7: Agriculture Crop Products

Agriculture Products	%
Paddy	53
Legumes	1
Oil Crops	1
Vegetables	19
Roots	2
Fruits	4
Spices	7

Other Crops	-
Other Grains	-
Beverage Crops	0
Other Cereals	4
Other Non-perennial Crops	2
Other Perennial Crops	3
Crop Related Support – Seed & Plant Propagation	2
Total	100

Source: Authors based on HIES2016.

Appendix 1 Table 8: Agricultural Activity breakdown

Activity	Total	Gender			Age group (in yrs)		
		Male	Female	>19	19-29	30-55	55 +
HIES Secondary Data 2016							
Crop Agriculture Only	98	79	21		4	52	43
Mixed Farming (crop farming & animal husbandry)	2	72	28		3	62	35

Source: Authors based on HIES2016

Appendix 1 Table 9: Gender and age by district

	Sex (% in district)		Age group (% in agri product group)			
	Male	Female	Below 19	19-29	30-55	Over 55
Colombo	82	18	0	7	28	65
Gampaha	89	11	0	3	25	72
Kalutara	85	15	0	7	38	55
Kandy	77	23	0	3	47	50
Matale	82	18	0	2	53	46
Nuwareliya	76	24	1	6	48	46
Galle	52	48	0	2	39	59
Matara	77	23	0	2	32	66
Hambantota	79	21	0	4	55	40
Jaffna	87	13	0	7	54	39
Mannar	100	0	0	0	55	45
Vavuniya	74	26	0	2	63	35
Mullaittivu	87	13	0	8	56	37
Killinochchi	100	0	0	0	36	64
Batticaloa	88	12	0	7	66	27
Ampara	92	8	0	3	56	40
Trincomalee	80	20	0	9	55	36
Kurunagala	73	27	0	2	47	51
Puttalam	67	33	0	4	61	35
Anuradhapura	77	23	0	4	63	34
Polannaruwa	87	13	0	3	55	41
Baddulla	75	25	0	6	58	36
Monaragala	79	21	1	9	59	31
Ratnapura	85	15	0	3	52	46
Kegalle	84	16	0	0	27	73
Total	79	21	0	4	53	43

Source: Authors based on HIES2016.

Appendix 1 Table 10: Crop involvement of individuals by district

District	Paddy	Other Cereals	Legumes	Oil	Vegetable	Roots	Other NPFC	Fruits	Spice	Other PC	Other Support	Total
Colombo	39	0	0	6	13	13	12	0	0	18	0	100
Gampaha	21	2	0	2	13	7	9	19	2	22	2	100
Kalutara	42	0	0	0	34	7	0	0	18	0	0	100
Kandy	53	0	0	0	15	0	0	2	21	0	7	98
Matale	54	0	0	0	14	11	2	2	16	1	0	100
Nuwareliya	13	0	0	0	81	2	2	0	1	0	0	100
Galle	15	2	0	2	10	0	3	0	68	0	0	100
Matara	52	0	0	0	2	0	2	5	32	2	4	100
Hambantota	56	0	2	0	18	1	0	11	9	0	1	100
Jaffna	27	0	0	0	34	19	4	7	2	8	0	100
Mannar	81	0	0	0	16	0	0	3	0	0	0	100
Vavuniya	57	0	2	11	18	4	0	6	0	3	0	100
Mullaittivu	84	1	0	4	9	0	0	3	0	0	0	100
Killinochchi	83	0	0	0	17	0	0	0	0	0	0	100
Batticaloa	76	0	0	0	17	0	0	0	3	0	5	100
Ampara	91	1	6	0	1	0	0	1	0	0	0	100
Trincomalee	80	0	0	5	14	0	0	0	0	0	0	100
Kurunagala	67	1	0	1	8	2	1	2	0	17	2	100
Puttalam	54	0	2	0	37	0	5	0	0	2	0	100
Anuradhapura	69	9	2	2	4	1	2	3	0	0	9	100
Polannaruwa	92	0	0	1	3	0	4	0	1	0	0	100
Baddulla	44	4	0	0	38	3	2	1	9	0	1	100
Monaragala	33	32	0	2	7	1	7	7	9	0	2	100
Ratnapura	33	0	0	1	25	3	5	15	14	0	4	100
Kegalle	62	3	0	0	13	3	0	6	7	3	4	100

*NPC= Non Perennia crops; PC= Perennial crops

Source: Authors based on HIES2016.

Profile of workers earning agricultural and other income

The second analysis aims to investigate the profile of individuals involved in agriculture as the minor or part-time activity. In terms of secondary HIES data, the analysis is based on the sample of 698 representing 165,990 individuals who work part-time; that is, those earning other types of income in addition to agriculture income.

Appendix 1 Table 11: Age and gender of those involved in agriculture as minor activity

	HIES Secondary Data 2016			
	Male	Female	Total	
Av. Age (yrs)	48	49	48	
Share (%)	83	17	-	
	% in age group		% of total in age group	Ave age in yrs
Below 19 (%)	0	0	0	0
19-29 (%)	91	9	6	26
30-55 (%)	84	16	65	44
Over 55 (%)	80	20	29	63
Total			100	

Source: Authors based on HIES2016.

Appendix 1 Table 12: Ethnicity and religion of those involved in agriculture as minor activity

Ethnicity	HIES Secondary Data 2016	Religion	HIES Secondary Data 2016
Sinhala	86	Buddhist	85
Tamil	10	Hindu	9
Muslim	3	Islam	3
Total	100	Total	100

Notes: may not add to 100 due to rounding.

Source: Authors based on HIES2016.

Appendix 1 Table 13: Schooling level of those involved in agriculture as minor activity (in %)

Level of schooling	HIES Secondary Data 2016					
	Total	Gender		Age group (in yrs)		
		Male	Female	19-29	30-55	55 +
No schooling	4	81	19	0	46	54
Grade 1-5	28	84	16	2	60	37
Grade 6-10	54	83	17	8	68	24
O/L	6	94	6	5	68	27
Grade 12	3	87	13	8	71	21
A/L	6	73	27	8	72	20

Source: Authors based on HIES2016.

Appendix 1 Table 14: Agriculture products and activities

Crops	HIES Secondary Data 2016					
	Total	Gender		Age group (in yrs)		
		Male	Female	19-29	30-55	55 +
Paddy	58	89	11	6	67	27
Vegetables	15	76	24	8	62	31
Fruits	2	60	40	0	69	31
Legumes	1	74	26	7	65	27
Other Crops	3	82	18	4	63	33
Other Grains	3	47	53	0	88	12
Roots	1	69	31	15	49	36
Spice & other	10	87	13	7	50	43
Crop support – Seed & plant propagation	6	72	28	0	78	22
Total	100					

Source: Authors based on HIES2016

Workers in agriculture industry but earning only non-agriculture income (non-agriculture output income, employment income, & other income)

Appendix 1 Table 15: Characteristics of household members

Age group	Sex (% in age group)		% of total in age group
	Male	Female	
Below 19	93	7	1
19-29	82	18	15
30-55	59	41	59
Over 55	66	34	24
			100
	%		%
Ethnic		Religion	
Sinhala	60	Buddhist	59
Tamil	29	Hindu	25
Muslim	11	Islam	11
Other	0	Christian	5
Total	100	Total	100
Education			
No schooling			7
Grade 1-5			33
Grade 6-10			51
O/L			5
Grade 12			2
A/L			2
Tertiary - Diploma Degree Phd			0
Total			100
Occupation			
Other food crop growing and trading			7
Paddy farming and trading			17
Crop farming labor - pluckers, helpers, & other agri labor			44
Cinnamon crushers			9
Other			24
Total			100

Source: Authors based on HIES2016.

Appendix 2: List of Key Informant Interview and Focus Group Discussion Participants

Appendix 2 Table 1: List of Key Informant Interview Participants

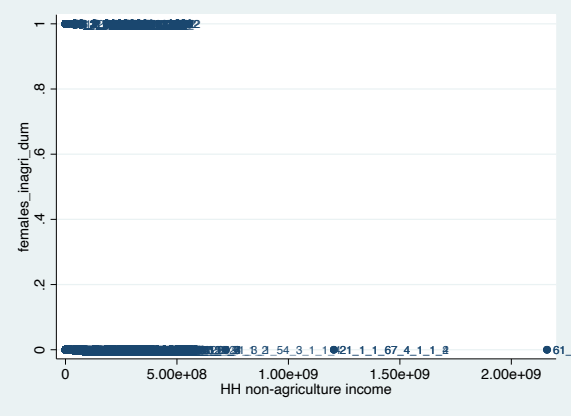
#	Institution	Sector	Interview Date
1	Faculty of Agriculture, University of Peradeniya.	Academia	30.09.2020
2	Seed and Planting Material Development Centre	Government	30.09.2020
3	Extension and Training centre	Government	30.09.2020
4	Socio Economic and Planning Centre	Government	22.10.2020
5	National Agriculture Information and Communication Centre	Government	30.09.2020
6	Faculty of Agriculture, University of Peradeniya.	Academia	30.09.2020
7	Dialog - Sustainability	Private sector	29.09.2020
8	District Agriculture Director	Government	13.03.2020
9	Rantharu Farmer Organization	Non-government	12.03.2020
10	Agrarian Service Center, Ipologama	Government	13.03.2020
11	Ex-Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI)	Academia	29.09.2020
12	SLCARP	Academia	24.09.2020
13	Saaraketha	Private sector	29.09.2020
14	Young farmer - Informal business	Private sector	29.09.2020
15	Modern Agri Pvt Ltd	Private sector	09.02.2021
16	Modern Agri Pvt Ltd	Private sector	10.02.2021
17	Unipower Pvt Ltd	Private sector	12.02.2021
18	AiGrow Pvt Ltd	Private sector	13.02.2021
19	Dimo Agri Pvt Ltd	Private sector	15.02.2021
20	Hayleys Agriculture Holdings Ltd	Private sector	16.02.2021
21	CIC Agribusiness	Private sector	18.02.2021
22	Bours Agri	Private sector	23.02.2021
23	HARTI	Academia	06.03.2021
24	Department of Agriculture	Government	05.03.2021

Appendix 2 Table 2: List of Focus Group Discussion Participants

Number of Participants	Location	Interview Date
23	Galnewa, Anuradhapura	13/02/2020
17	Welioya, Mullaitivu	15/02/2020
7	Madukanda, Vavuniya	15/02/2020
8	Nallur, Jaffna	14/02/2020

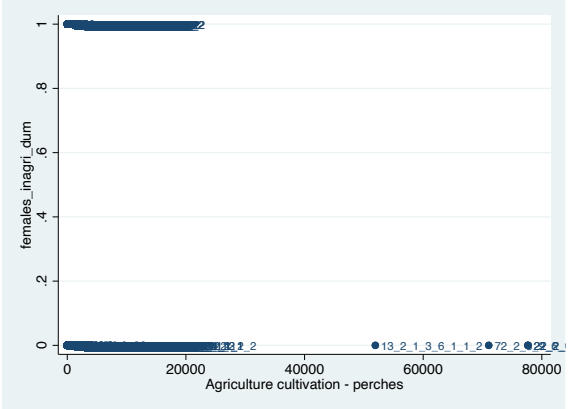
Appendix 3: Regression Diagnostics for Chapter 6 - Youth and Female Labour in Agriculture

Appendix 3 Figure 1: Scatter plot of females in agriculture and household non-agricultural income (Rupees)



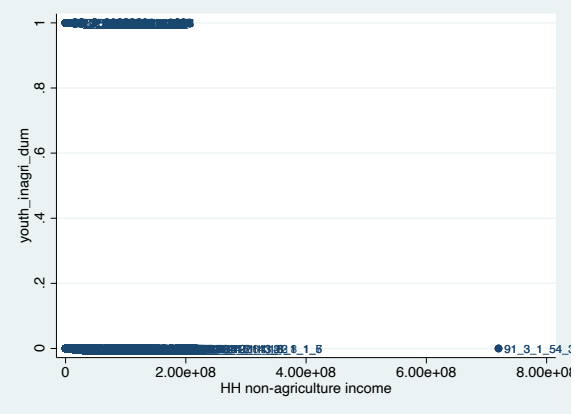
Source: Authors based on HIES

Appendix 3 Figure 2: Scatter plot of females in agriculture and extent of land cultivated (perches)



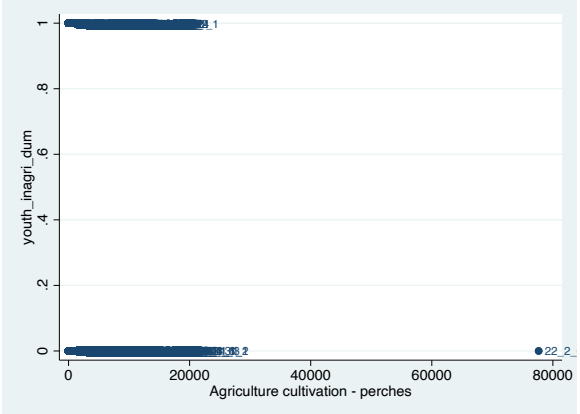
Source: Authors based on HIES

Appendix 3 Figure 3: Scatter plot of youth in agriculture and household non-agricultural income (Rupees)



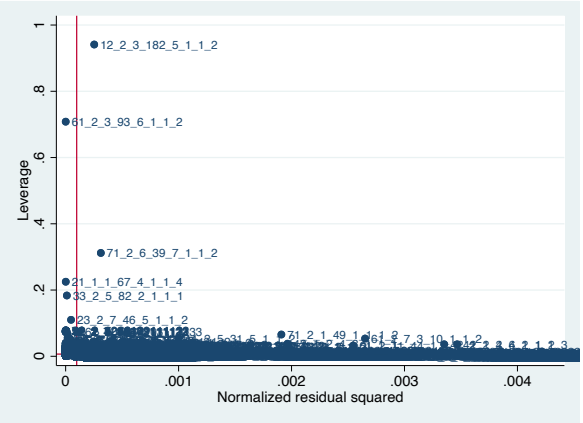
Source: Authors based on HIES

Appendix 3 Figure 4: Scatter plot of youth in agriculture and extent of land cultivated (perches)



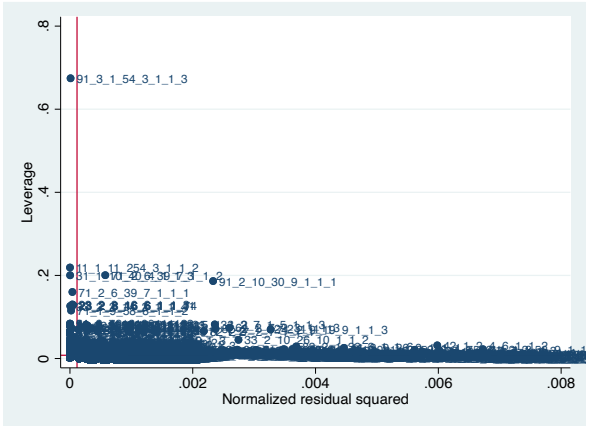
Source: Authors based on HIES

Appendix 3 Figure 5: Plot of leverage and normalized residuals squared of females



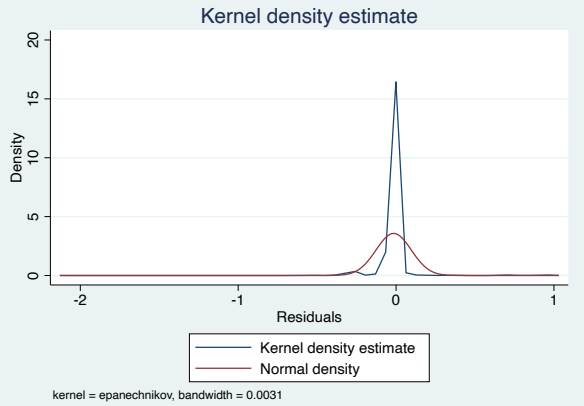
Source: Authors based on HIES

Appendix 3 Figure 6: Plot of leverage and normalized residuals squared of youth



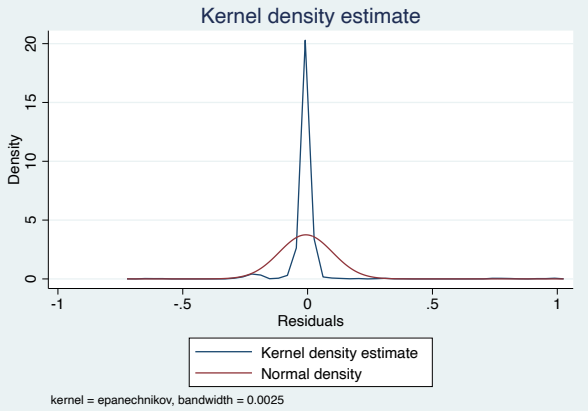
Source: Authors based on HIES

Appendix 3 Figure 7: Kernel density estimate of residuals of the Pooled OLS model for female



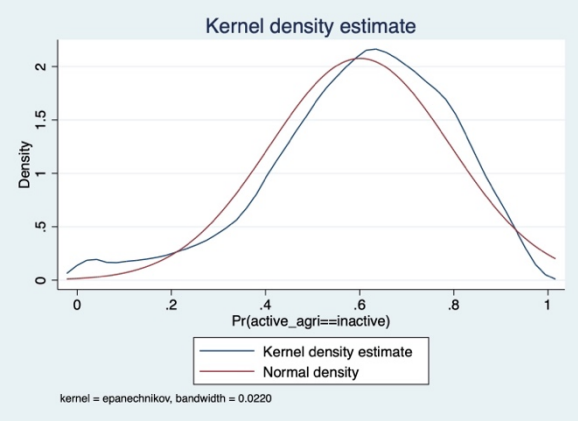
Source: Authors based on HIES

Appendix Figure 8: Kernel density estimate of residuals of the youth of Pooled OLS model for youth



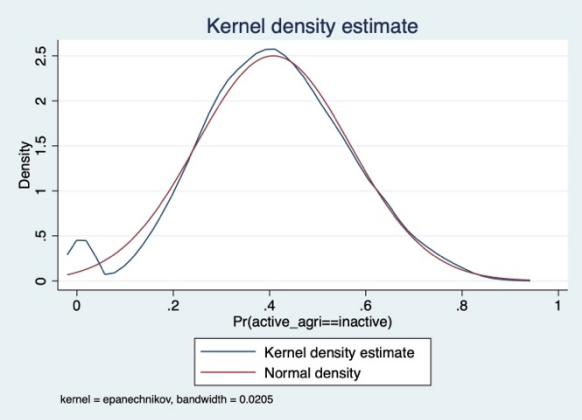
Source: Authors based on HIES

Appendix 3 Figure 9: Kernel density estimate of deviance residuals of the MNP model for females



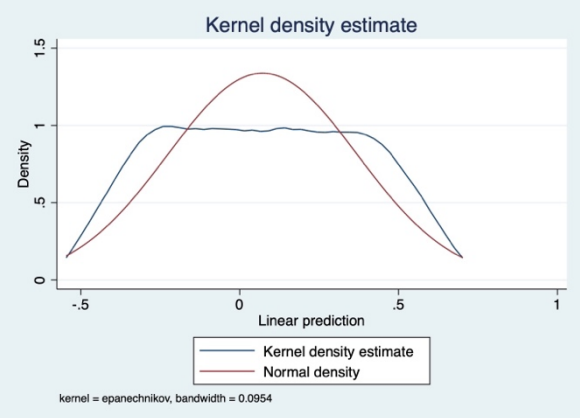
Source: Authors based on HIES

Appendix 3 Figure 10: Kernel density estimate of deviance residuals of the MNP model for youth



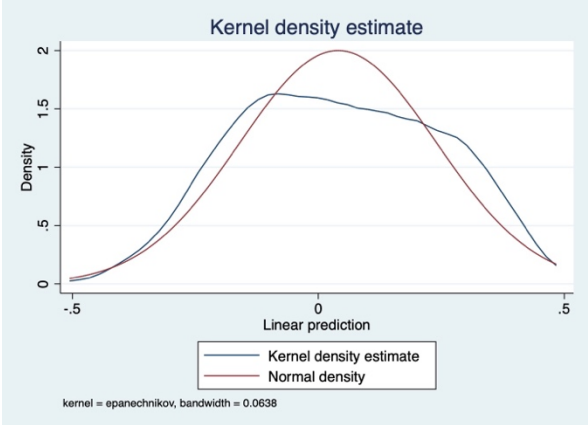
Source: Authors based on HIES

Appendix 3 Figure 11: Kernel density estimate of residuals of the pseudo panel model for youth



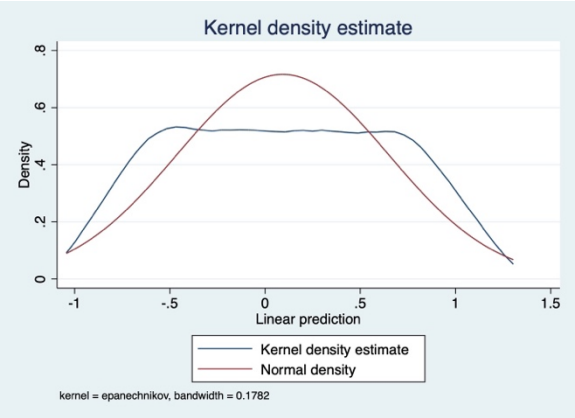
Source: Authors based on HIES

Appendix 3 Figure 12: Kernel density estimate of residuals of the pseudo panel model for young males



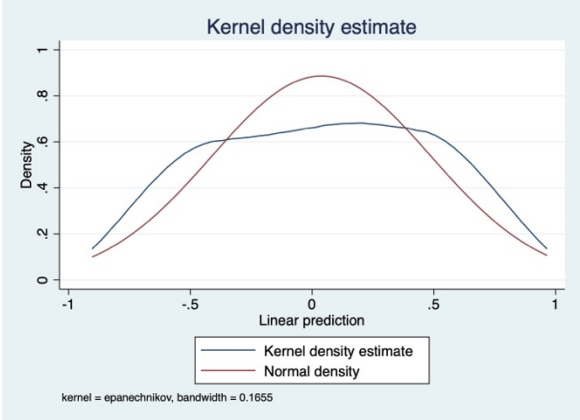
Source: Authors based on HIES

Appendix 3 Figure 13: Kernel density estimate of residuals of the pseudo panel model for young females



Source: Authors based on HIES

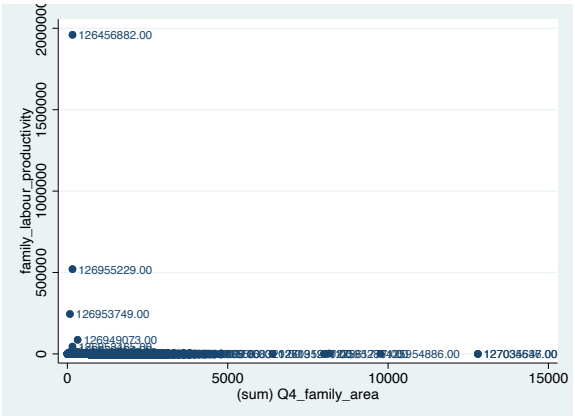
Appendix 3 Figure 14: Kernel density estimate of residuals of the pseudo panel model for females



Source: Authors based on HIES

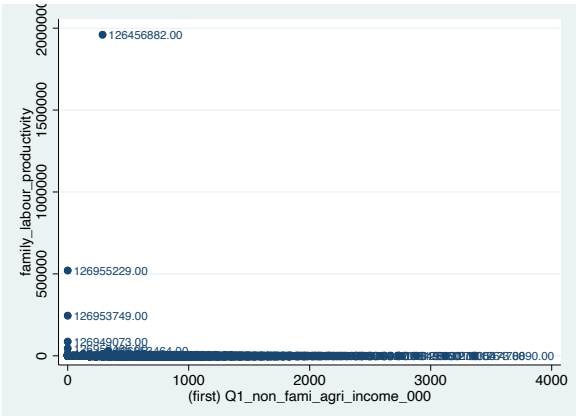
Appendix 4: Regression Diagnostics for Chapter 7 - Labour and Agricultural Productivity

Appendix 4 Figure 14: Scatter plot of family labour productivity and extent of agricultural land cultivated (Perches)



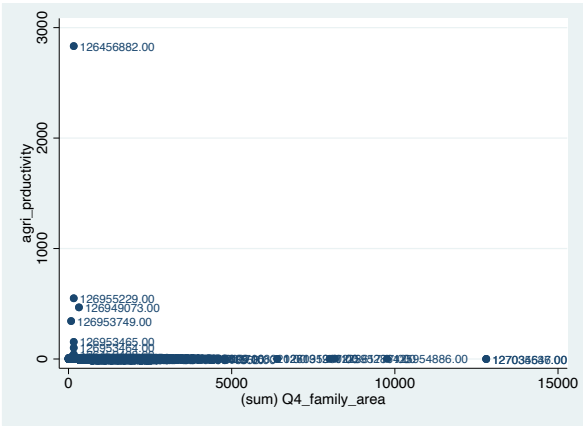
Source: Authors based on ALS 2020

Appendix 3 Figure 15: Scatter plot of family labour productivity and non-labour incomes (Rupees)



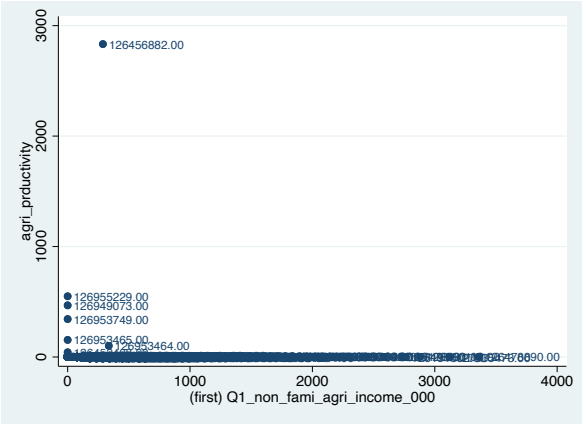
Source: Authors based on ALS 2020

Appendix 4 Figure 16: Scatter plot of family agriculture productivity and extent of agricultural land cultivated (Perches)



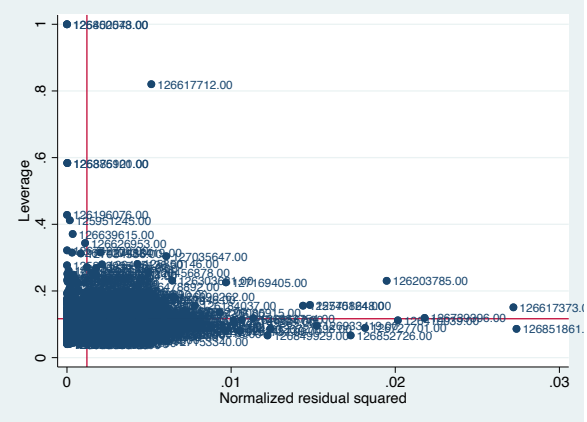
Source: Authors based on ALS 2020

Appendix 4 Figure 17: Scatter plot of family agriculture productivity and non-labour incomes (Rupees)



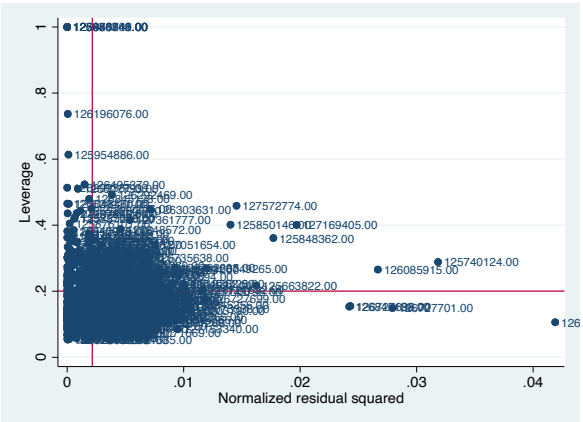
Source: Authors based on ALS 2020

Appendix 4 Figure 18: Plot of leverage and normalized residuals squared for labour productivity (All crops)



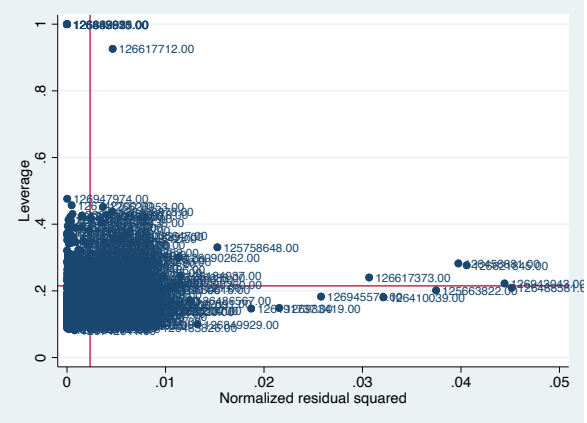
Source: Authors based on ALS 2020

Appendix 4 Figure 19: Plot of leverage and normalized residuals squared of labour productivity (paddy)



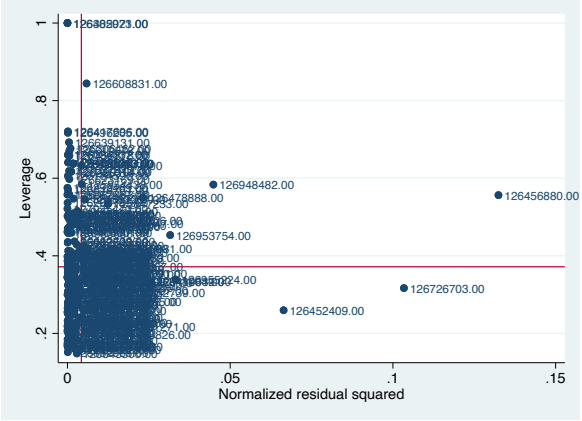
Source: Authors based on HIES

Appendix 4 Figure 20: Plot of leverage and normalized residuals squared of labour productivity (OFC)



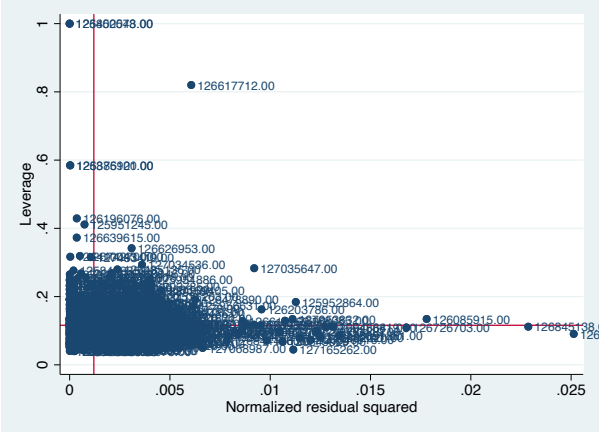
Source: Authors based on ALS 2020

Appendix 4 Figure 21: Plot of leverage and normalized residuals squared of labour productivity (vegetables)



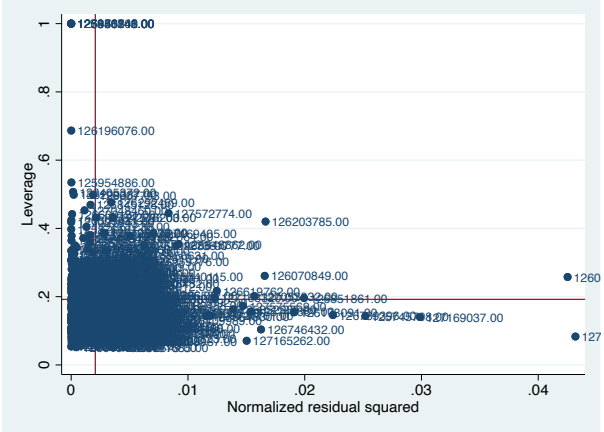
Source: Authors based on ALS 2020

Appendix 4 Figure 22: Plot of leverage and normalized residuals squared of agriculture productivity (All crops)



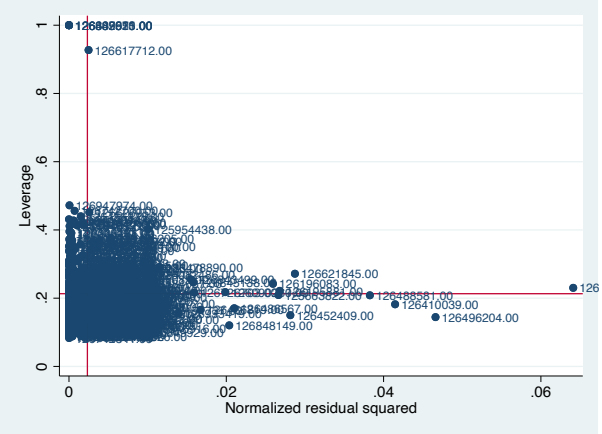
Source: Authors based on ALS 2020

Appendix 4 Figure 23: Plot of leverage and normalized residuals squared of agriculture productivity (paddy)



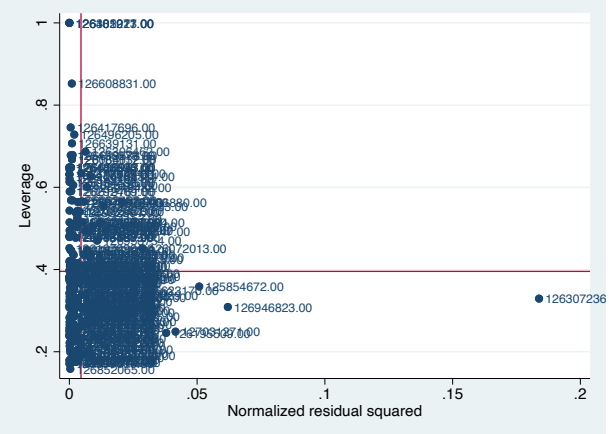
Source: Authors based on ALS 2020

Appendix 4 Figure 24: Plot of leverage and normalized residuals squared of agriculture productivity (OFC)



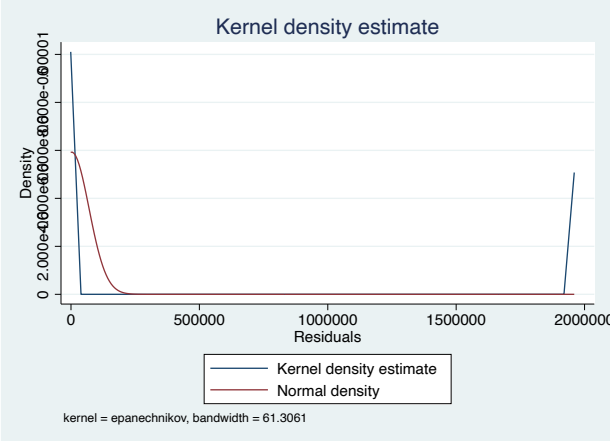
Source: Authors based on ALS 2020

Appendix 4 Figure 25: Plot of leverage and normalized residuals squared of agriculture productivity (vegetables)



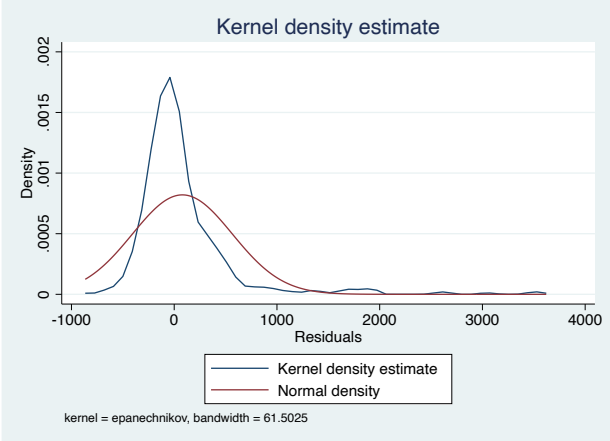
Source: Authors based on ALS 2020

Appendix 4 Figure 26: Kernel density estimate of residuals of labour productivity (All crops)



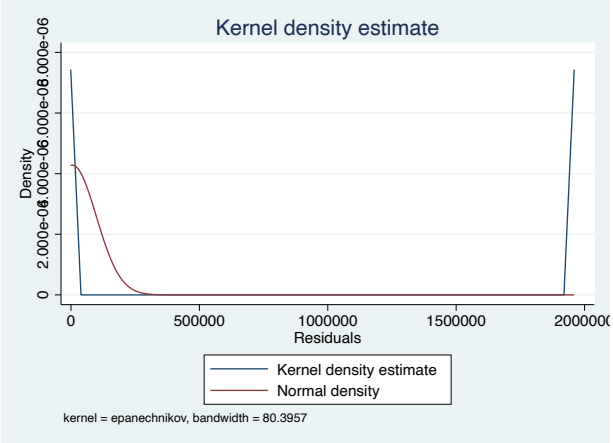
Source: Authors based on ALS 2020

Appendix 4 Figure 27: Kernel density estimate of residuals of labour productivity (paddy)



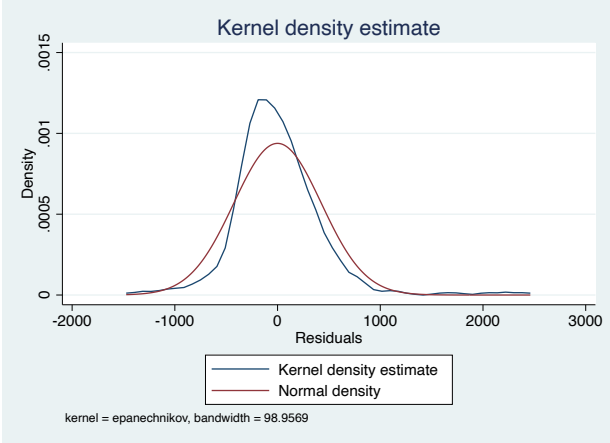
Source: Authors based on ALS 2020

Appendix 4 Figure 28: Kernel density estimate of residuals of labour productivity (OFC)



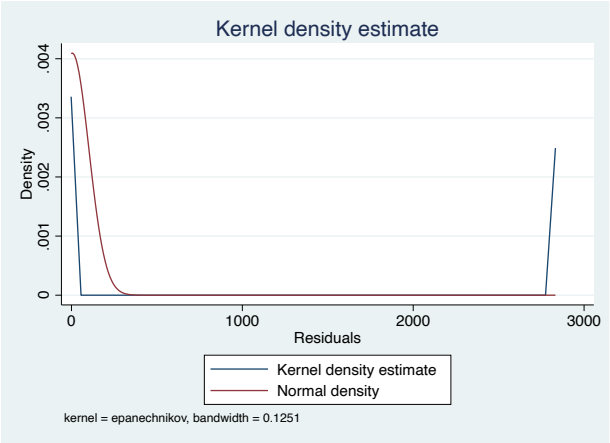
Source: Authors based on ALS 2020

Appendix 4 Figure 29: Kernel density estimate of residuals of labour productivity (vegetables)



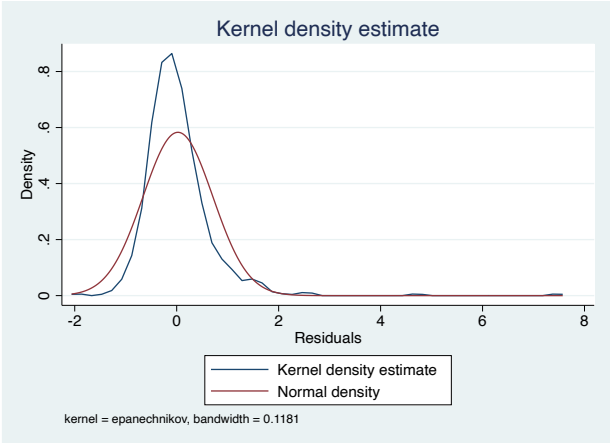
Source: Authors based on ALS 2020

Appendix 4 Figure 30: Kernel density estimate of residuals of agriculture productivity (All crops)



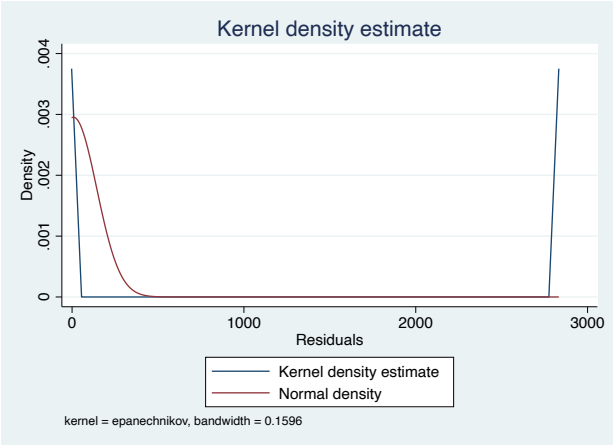
Source: Authors based on ALS 2020

Appendix 4 Figure 31: Kernel density estimate of residuals of agriculture productivity (paddy)



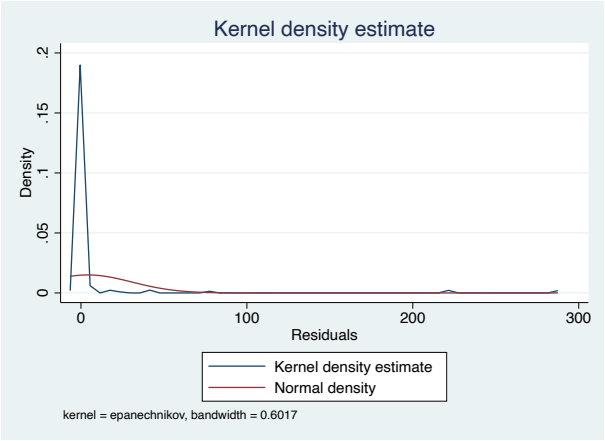
Source: Authors based on ALS 2020

Appendix 4 Figure 32: Kernel density estimate of residuals of agriculture productivity (OFC)



Source: Authors based on ALS 2020

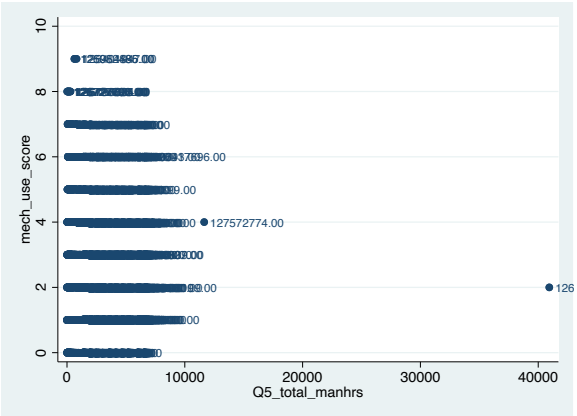
Appendix 4 Figure 33: Kernel density estimate of residuals of agriculture productivity (vegetables)



Source: Authors based on ALS 2020

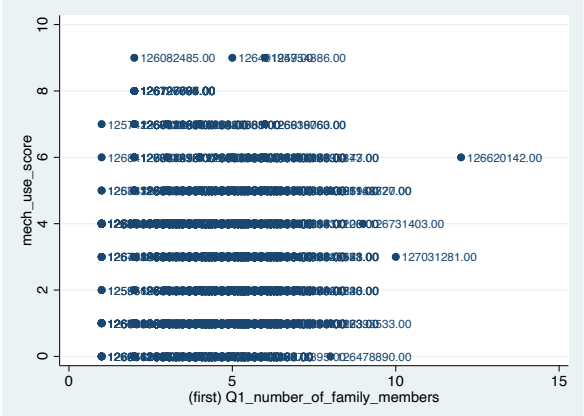
Appendix 5: Regression Diagnostics for Chapter 8 – Agriculture Mechanization

Appendix 5 Figure 34: Scatter plot of mechanization score and total household man hours in agriculture



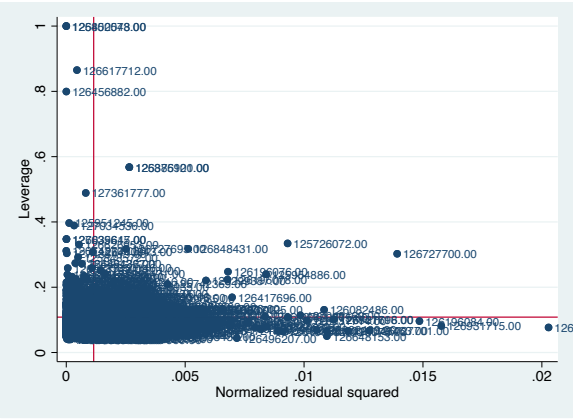
Source: Authors based on ALS 2020

Appendix 5 Figure 35: Scatter plot of mechanization score and number of family members



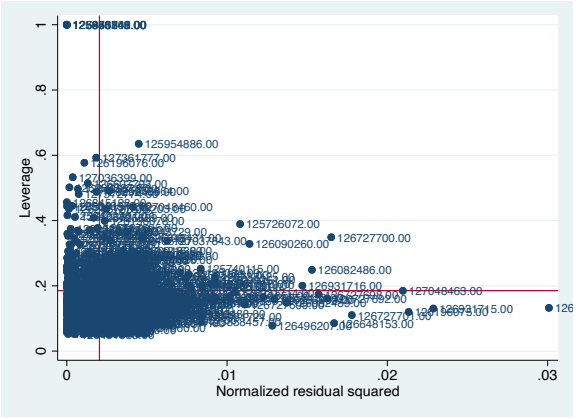
Source: Authors based on ALS 2020

Appendix 5 Figure 36: Plot of leverage and normalized residuals squared for mechanization (All crops)



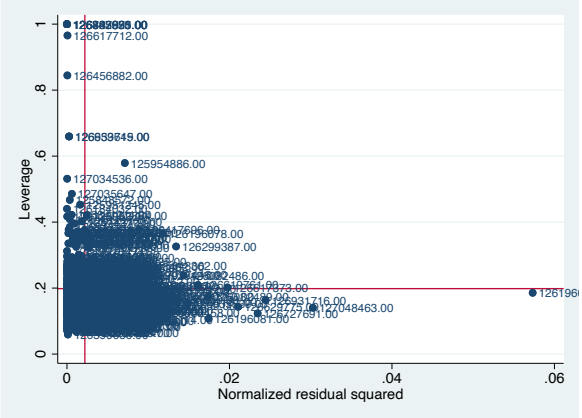
Source: Authors based on ALS 2020

Appendix 5 Figure 37: Plot of leverage and normalized residuals squared for mechanization (paddy)



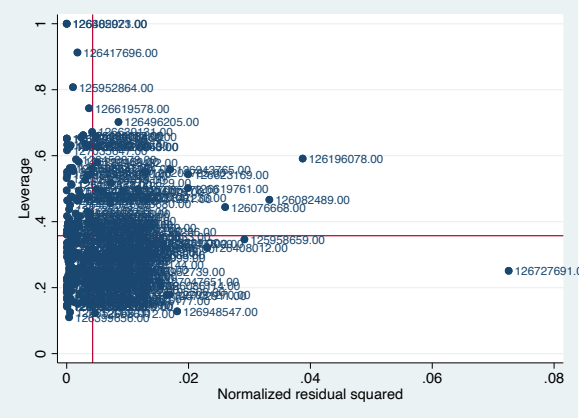
Source: Authors based on ALS 2020

Appendix 5 Figure 38: Plot of leverage and normalized residuals squared for mechanization (OFC)



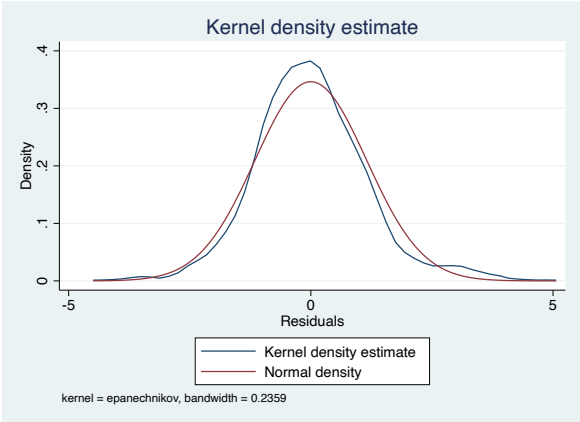
Source: Authors based on ALS 2020

Appendix 5 Figure 39: Plot of leverage and normalized residuals squared for mechanization (vegetables)



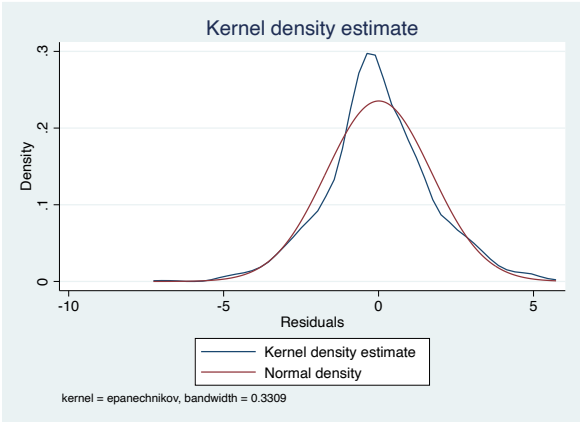
Source: Authors based on ALS 2020

Appendix 5 Figure 40: Kernel density estimation of residuals of mechanization (All crops)



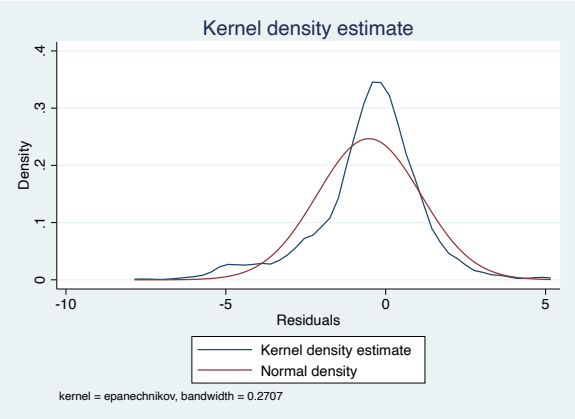
Source: Authors based on ALS 2020

Appendix 5 Figure 41: Kernel density estimation of residuals of mechanization (paddy)



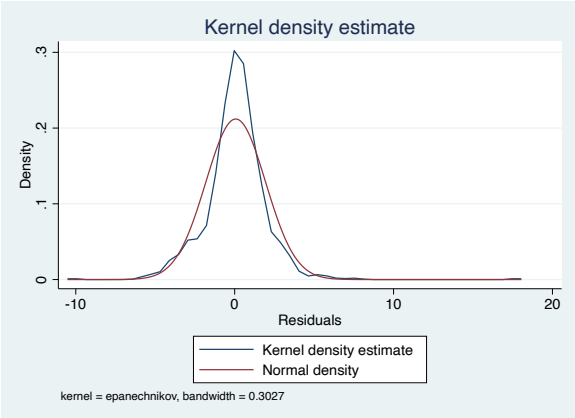
Source: Authors based on ALS 2020

Appendix 5 Figure 42: Kernel density estimation of residuals of mechanization (OFC)



Source: Authors based on ALS 2020

Appendix 5 Figure 43: Kernel density estimation of residuals of mechanization (vegetables)



Source: Authors based on ALS 2020