Czech University of Life Sciences Prague
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POPULATION AGEING IN RURAL INDIA: IMPLICATIONS FOR AGRICULTURE AND SMALLHOLDER FARMERS

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Prague
July 2018

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

Ph.D. THESIS ASSIGNMENT

Vladimir Milovanovic

Sector Economics and Economics of Enterprise

Thesis title

POPULATION AGEING IN RURAL INDIA: IMPLICATIONS FOR AGRICULTURE AND SMALLHOLDER FARMERS

Objectives of thesis

The research focuses on implications of aging for agriculture and smallholder farmers in Lakhisarai, one of the 38 administrative districts in the state of Bihar. The purpose of the research is to identify and explain the association on between aging and agriculture in greater detail than previously attempted, using rural households as a target group. Whereas Lakhisarai was selected for its exceptional level of poverty, South Asian sub-continent was chosen for having one of the highest levels of population density in the word. The primary thesis objective involves providing answers to questions such as (1) at what age are farmers most/least active, as measured by agricultural involvement index, (2) at what age does their involvement in agriculture begin to decline, and (3) what are the most o en performed day-to-day agricultural activities. This core activity depends on the accurate recall of performed activities over the past year, and relies on a semi-structured questionnaire to gather data on (1) demographics, (2) ownership, (3) income, spending and savings, and (4) agricultural work, and compare across a host of observable dimensions using regression analysis.

The overarching hypothesis is that agricultural involvement, defined as the product of average hours worked during the three documented months and self-reported difficulty of performed agricultural activities during those months, declines with age. Agricultural involvement, as such, is further broken down to its components (self-reported difficulty of performed agricultural activities, also known as agricultural intensity index, and the hours worked), yielding two additional hypotheses.

The secondary objective makes use of accelerator-based devices, also known as step trackers, to record the intensity of day-to-day agricultural activities by tracking farmers' movements as they perform them. In essence, the work intensity index should approximate the effort required for a range of everyday activities performed in rural areas. Intense agricultural activities, which require greater physical exertion, complex range of body movement, and

covering longer distances, for instance, would expectedly result in higher work intensity index, and vice versa. Compiled data, and resulting work intensity index, will then be then correlated with the self-reported difficulty of performed activities.
The third objective involves estimating the cost of aging to households, community, and the government, as the farmer's involvement in agriculture ends or reaches a certain threshold. The assumption is that the longer provisionally non-contributing household members are alive, the higher the overall costs for households, is assessed using the two hypotheses. The assumption is tested as the correlation between longer life and higher costs of living may be challenged by retiree's decision to remain employed or continue to contribute to household income in other ways, including the state pension.
Aside from evaluating the link between aging and agricultural involvement, developing agricultural involvement and agricultural intensity indices, and estimating the cost of aging, a host of regression analyses revolving around household income and expenses will be performed as well. The regressions will assess the impact on household income and expenses that the key independent variables may have, including farmer's age, agricultural involvement, intensity, and hours worked, land ownership, number of all, elderly, young, and dependent household members, average age of elderly household members and children, years of education, age at first agricultural employment, and years of working outside agriculture.

Methodology

The research focuses on smallholder farmers in Lakhisarai, one of the thirty-eight districts within the state of Bihar. The 472-village district in eastern India is made up of seven sub-divisions, with headquarters and major administrative centers situated in Lakhisarai, along with two additional district towns. The survey's target population was defined as the heads of households whose primary occupation is agriculture, while the head of the household status was assigned to any person running the household and looking after qualified dependents. Moreover, the household must also be located at the person's home and the person must pay more than 50 percent of the costs involved in running the household. Both requirements are stated at the beginning of the questionnaire and used as elimination questions.
As the study aims at achieving the results with 95 percent confidence interval and 5 percent margin of error, about 400 surveys were collected, a target is chosen based on the availability of resources, region's geographical specifics, and local transportation options. An additional 200 elderly household member samples were gathered as well and contrasted against the main batch of samples in several regression analyses. The research was carried out with the help of five local student-researchers during a two-week period in November 2017. Incidentally, the fourth quarter also marks the end of the south-west monsoon season in Indian sub-continent and overlaps with winter rice harvest - the country's main rice growing season. Dozens of other crops are harvested at about the same time, including millet, maize, soybean, sugarcane, and others, providing a wealth of opportunities for surveying.
Simple random sampling was used to select 12 villages within Lakhisarai district so that each village has an equal and known chance of being selected. A general overview of chosen villages, including geographical area, number of households, and the total population were provided as well. While the Indian villages vary considerably in size, the average of 552 households per village and resulting sampling frame of 2,948 households (12 villages x 552), should provide sufficient basis for surveying.
In the field, systematic sampling was used to select every fifth house, the method applied as it

allows particular sample size to be targeted. If the household was unavailable for the interview, the surveyor would skip the next four houses and move on to the fifth. No incentives were given due to potential bias, and no repeat visits were made due to me and resource constraints. The approach generated the pool of approximately 611 potential respondents, thus providing base large enough should some households be unavailable or unwilling to participate.

The experimental part of the research involved distributing accelerator-based devices, also known as step trackers (part of fitness tracking family of devices), to 200 randomly selected respondents, and measuring their motion while performing common agricultural activities. Each session was recorded using a step-tracking device, worn by the respondent, and activity chart, filled by the interviewer.

Samples collected using the semi-structured questionnaire and accelerator-based devices were structured, normalized, and formatted in Microsoft Office, and analyzed using simple and stepwise multiple linear regression in SPSS 23 statistical package. Some of the questions to be answered using regression analysis include (1) how does aging impact landless vs. land-rich rural households in terms of household income and expenses, (2) does household size and structure (number of dependents) affect household income and expenses, and (3) how agricultural involvement impacts household income and expenses, among others. Regression analysis thus becomes crucial for understanding collected data and making interferences about the population.

The dissertation is currently organized into five chapters. Following the introduction, research purpose and individual objectives, Chapter 2 offers details on the Indian economy, covering economic aspects of country's colonial past and contemporary trends affecting India's position in the world economy. The chapter ends with projected impact aging population might have on county's economy. Chapter 3 includes the pertinent research literature related to population aging in India, with focus on rural areas. It encompasses topics ranging from the social impact of aging, history of a social security system in India and the current state, changing socioeconomic status of elderly, role of community networks, down to financial dependency of the elderly and necessity to work post-retirement. Major studies on population aging and workforce participation are covered as well.

Chapter 4 outlines research design and methodology, including the study area and data collection methods, the role of semi-structured questionnaire and fitness trackers, the methodology for constructing agricultural involvement and work intensity indices and calculating the cost of aging, as well as applied statistical analysis such as simple and multiple linear regressions, along with accompanying data checks and validations. Chapter 5, being the most important sec on, details results and discussion points in terms of set objective and aims. It starts with simple descriptive statistics and then iterates through each hypothesis, concluding the analysis with an estimated cost of ageing.

The proposed extent of the thesis
130 - 200 pages

Keywords
Population, ageing, smallholder farmers, South Asia, agriculture

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Recommended information sources

Bakshi, S., Pathak P. 2016. Aging and the socioeconomic life of older adults in India: An empirical exposition. SAGE Open, 6(1). DOI: 10.1177/2158244015624130.

Berry W.D., Feldman S. 1985. Multiple regression in practice. Thousand Oaks: SAGE Publications. ISBN: 9780803920545.

Bloom, D.E., Mahal, A.S., Rosenberg, L., Sevilla, J. 2010. Economic security arrangements in the context of population aging in India. International Social Security Review, 63(3-4): 79-97.

Evenson, K., Goto, M.M., Furberg, R.D., 2015. A systematic review of the validity and reliability of consumer-wearable activity trackers. International Journal of Behavioral Nutrition and Physical Activity, DOI: 10.1186/s12966-015-0314-1.

Nasir, Z.M., Ali, S.M. 2000. Labor market participation of the elderly. The Pakistan Development Review, 39: 1075-1086.

Sharma, A. 2016. The changing agricultural demography of India. International Journal of Rural Management, 3(1): 27-41.

Expected date
2017/18 SS - FEM - Doctoral Thesis Defense

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Electronic approval: 1. 12. 2017
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Prague on 22. 06. 2018

ACKGNOWLEDGMENTS

I would like to express my gratitude to my supervisor prof. Ing. Luboš Smutka, Ph.D. for professional guidance, valuable advice, and academic support.

I would also like to extend my thanks to the reviewers whose help and constructive comments produced valuable results.

My appreciation goes to the members of the Department of Economics, Faculty of Economics and Management of the Czech University of Life Sciences Prague for their assistance and direction.

Special thanks go to the Ministry of Education, Youth and Sport of the Czech Republic for financing the entire endeavor and making the whole experience possible.

Most importantly, I would like to thank my family and fiancé for their support and patience.

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LIST OF ABBREVIATIONS

ANOVA - Analysis of Variance

BPM - Beats per Minute

DTF - Distance-to-Frontier

EBA - Enabling the Business of Agriculture

EKG - Electrocardiogram

EPF - Employee Provident Fund

FAO - Food and Agriculture Organization of the United Nations

GATT - General Agreement on Tariffs and Trade

GDP - Gross Domestic Product

IBEF - India Brand Equity Foundation

IGT - Intergenerational Transfers

ILO - International Labor Organizations

IMF - International Monetary Fund

IPCC - Intergovernmental Panel on Climate Change

IPOP - Integrated Programme for Older Persons

LED - Light Emitting Diode

LTCI - Long-Term Care Insurance Scheme

NGO - Non-Governmental Organization

NIOS - National Institute of Open Schooling

NSSO - National Sample Survey Office

OECD - Organization for Economic Co-operation and Development

PAYG - Pay-As-You-Go

PPP - Purchasing Power Parity

SEWA - Self-Employed Women's Association

SPSS - Statistical Package for Social Sciences

UN - United Nations

UNCTAD - United Nations Conference on Trade and Development

UNDP - United Nations Development Programme

UNFPA - United Nations Population Fund

VIF - Variance Inflation Factor

WEF - World Economic Forum

WTO - World Trade Organization

CHAPTER 1: INTRODUCTION

1.1. Background

India faces accelerated population aging accompanied by a set of socio-economic changes, slower economic growth (Brendan and Sek, 2016), and reduced quality of life (Verma et al., 2017; Ghosh et al., 2017). The growth rate of individuals aged 60 and over is three times higher than that of the population (Sathyanarayana et al., 2014), with factors such as declining fertility rate, increasing longevity, and large cohorts advancing to older ages, driving the change (Lee et al., 2014). Presently, some 109 million people in India are over the age of 60, with the figure projected to increase to 300 million by 2050 (United Nations, 2015; Kardile and Peisah, 2017).

Less than 10% of elderly receive a pension of any kind (Uppal and Sarma, 2007), while only 14% can count on financial help from friends or family (Alam et al., 2014). Their position is further compromised by the transition from the traditional familial support system of living arrangements for older persons towards more nuclear family systems, exposing the elderly to inefficiencies of country's social and healthcare systems (Agrawal, 2012). Income, savings, and work participation are thus inseparable components of the wellbeing of India's aging rural population.

The agricultural sector has historically been the backbone of Indian economy, providing employment for 51% of country's workforce (The World Bank, 2010) and accounting for 56% of the landmass (Khanal and Mishra, 2017). More importantly, nearly three-quarters of Indian families depend on rural incomes as it provides continued employment even at older ages (Alam et al., 2014). Although agriculture's share in the economy has progressively declined to about 17% thanks to growing industrial and services sectors (KPMG, 2016), it remains pivotal for 70% of the population living in rural areas.

Understanding the implications of aging for agriculture and smallholder farmers in rural India is driven by the need to understand farmer's involvement in day-to-day agricultural activities as they age, and accurately estimate savings needed for food secure old age as their participation in agriculture diminishes. Ultimately, the hope is that by mapping agricultural involvement across age and gender, as well as activities that comprise that involvement,

alternative employment for the elderly, such as child care, food preparation, and education, could be identified and promoted.

The challenges of population aging, however, are becoming more prominent as the country's rapid industrialization draws younger people out of agriculture (Sharma, 2016). Higher wages associated with secondary and tertiary sectors may seem promising, although the trend of increased use of robots in developed countries, also known as reshoring, erodes traditional labor-cost advantage of developing countries (UNCTAD, 2016). This is especially true of automotive, electrical and electronics industries, and very soon of the apparel industry, too.

The efforts of the aging farmer population to access agricultural technologies necessary to increase their productivity are likely to be hampered by poor infrastructure, low education, and lack of financial credit. Moreover, environmental degradation, water shortages, soil erosion, pests, diseases, and desertification, are serious threats to food supply and are only made worse by the climate change (Eswaran, 1997). This is particularly true for farmers living and working in vulnerable ecosystems that may become more fragile due to climate change (IPCC, 2014). A report by Intergovernmental Panel on Climate Change (IPCC) mentions, among other threats, the danger climate change poses to global yields, citing a decrease of up to 2% per decade in yields of staple crops like maize, wheat, and rice.

The projections look even gloomier once estimated 59-98% increase in the demand for food between 2005 and 2050 is considered (Valin et al., 2013). The population growth, along with rising incomes in developing countries, and resulting dietary changes in the form of eating more protein and meat, are the primary drivers of global food demand (FAO, 2012a). The aging farmer population throughout the world will, therefore, be pressured to increase food production, either by expanding the area of agricultural land or enhancing the productivity of existing land, applying more fertilizers, installing and maintaining better irrigation systems, and adopting precision farming (Elferink and Schierhorn, 2016).

Expanding agricultural land under forecasted climate change, however, will be possible only within countries stretching over the northern latitudes, mainly China, Canada, and Russia (Zabel et al., 2014). As these regions are expected to experience a longer and warmer growing seasons, they are also more likely to grow more food. In countries like India, on the other hand, the ecological and social trade-offs of clearing more land for agriculture will be too

high. The per capita agricultural land in India has already shrunk from around 3,800 m^2 in the 1960s to just below 1,500 m^2 today (FAO, 2015). The situation is identical in neighboring Pakistan and considerably worse in Bangladesh, with less than 600 m^2 of agricultural land available per capita.

Public and private investment in agriculture will, therefore, have to drive the growth in land productivity, a particularly difficult task considering that in most developing countries this type of investment has been declining over the past 30 years (FAO, 2014; FAO, 2012b). Although public investment in agriculture in India in absolute terms has been low, including investment in irrigation and crop diversification programs, country's investment in agriculture as a percentage of agriculture in GDP is on the rise. The government has also been working on promoting private sector participation by allowing 100% foreign direct investment in several segments of the agriculture sector, including fertilizers, agricultural machinery, horticulture, development of seeds, and others (IBEF, 2013b).

Equally important factor, estimated to have a profound impact on the aging farmer population, are the fossil fuels. The current food production system is heavily dependent on oil and gas, used as raw materials in the production of fertilizers and pesticides, as energy at all stages of food production, and in construction and repair of equipment and infrastructure supporting the industry (Green, 1978). Not only is food supply system one of the largest users of fossil fuels, it is also one of the greatest producers of greenhouse gases, which ironically enough, further exposes food production to threats from global warming. With the discovery of oil and gas peaking in the 1960s, and production set to peak as well, dramatic shortages and increases in food prices are expected (Colin, 1997). This will hurt the agricultural sector worldwide, although it is the poorest and oldest households who will be impacted the most.

The Indian aging rural population is facing multiple challenges, from inefficient social safety nets and negligible retirement savings to disengaged youth and lack of knowledge and financial support to increasing automation and reduction in manufacturing jobs, down to uprooting effects of climate change coupled with heavy dependence on fossil fuels. The research deals with the implications of aging on agriculture and smallholder farmers by considering dominant political, economic, environmental, and social limitations of Indian rural areas. It isolates the aging farmer, considers where improvements can be made and then

provides realistic recommendations on how the life of rural poor can be saved, improved, and made meaningful.

The objective and aims are accomplished using a semi-structured questionnaire and motion tracking devices, along with regression and scenario analysis. Detailed insight into key agricultural activities performed by farming population, physical intensity of those activities, and their distribution across age and gender are assessed and commented on. Contributions are also made to the growing body of research supporting the need for and benefits of working later in life, including better health and longer life expectancy (Wu et al., 2016; Litwin, 2007). Ultimately, the study challenges the current rural life structures, career paths, and social norms, and realigns them with the emerging reality of a longer lifespan. To focus on aging as the primary issue of longevity implies missing the full implications of the concept. Longevity does not necessarily suggest being older for longer. Instead, it means living longer, being younger longer, and being older later.

1.2. Purpose and objectives

The research focuses on implications of aging for agriculture and smallholder farmers in Lakhisarai, one of the 38 administrative districts in the state of Bihar. The purpose of the research is to identify and explain the association between aging and agriculture in greater detail than previously attempted, using rural households as a target group. Whereas Lakhisarai was selected for its exceptional level of poverty, South Asian sub-continent was chosen for having one of the highest levels of population density in the word. As the aging of rural population accelerates across countries composing the region, the effect on their economies and especially healthcare sectors, will be considerable. Working preemptively on documenting the effects of rural aging is, therefore, necessary for planning and managing the old age of Indian farmers. Moreover, both practical and theoretical contributions of the performed research are presented, along with a brief interpretation of the results and their limitations, the main points requiring further research, and topic-specific recommendations to policymakers.

1.2.1. Explaining the link between aging, land ownership, and household size, and agricultural involvement, intensity, and hours worked

The primary thesis objective involves providing answers to questions such as (1) at what age are farmers most/least active, as measured by agricultural involvement index, (2) at what age does their involvement in agriculture begin to decline, and (3) what are the most often performed day-to-day agricultural activities. This core activity depends on the accurate recall of performed activities over the past year, and relies on a semi-structured questionnaire to gather data on (1) demographics, (2) ownership, (3) income, spending and savings, and (4) agricultural work, and compare across a host of observable dimensions using regression analysis.

The overarching hypothesis is that agricultural involvement, defined as the product of average hours worked during the three documented months and self-reported difficulty of performed agricultural activities during those months, declines with age (H_{oa}), an obvious statement unless available research is considered, revealing a high level of labor participation even among the oldest population (Alam et al., 2014). Agricultural involvement, as such, is further broken down to its components (self-reported difficulty of performed agricultural activities, also known as agricultural intensity index, and the hours worked), yielding two additional hypotheses: H_{0b} and H_{0c}.

H_{0a}: Agricultural involvement of Lakhisarai farmers, measured by agricultural involvement index, declines with age.
H_{1a}: Agricultural involvement of Lakhisarai farmers, measured by agricultural involvement index, does not decline with age.

H_{0b}: Agricultural involvement of Lakhisarai farmers, measured by reported agricultural intensity index, declines with age.
H_{1b}: Agricultural involvement of Lakhisarai farmers, measured by reported agricultural intensity index, does not decline with age.

H_{0c}: Agricultural involvement of Lakhisarai farmers, measured by hours worked, declines with age.

H_{1c}: Agricultural involvement of Lakhisarai farmers, measured by hours worked, does not decline with age.

Two supporting hypotheses were derived from research questions tied to the primary aim: (1) the first (H_{0d}), leveraging on the close link between land ownership, income, and well-being, and assuming that more land allows farmers to work less and/or retire earlier compared to farmers with less land, and (2) the second (H_{0g}), assuming that a larger family would mean more helping hands and thus allow the farmer to work less and/or retire earlier. Both hypotheses, as was the case with H_{0a}, were also tested using their basic components, namely the agricultural intensity index and the hours worked.

H_{0d}: Higher land ownership advances decline in the agricultural involvement of Lakhisarai farmers, measured by agricultural involvement index.
H_{1d}: Higher land ownership does not advance decline in the agricultural involvement of Lakhisarai farmers, measured by agricultural involvement index.

H_{0e}: Higher land ownership advances decline in the agricultural involvement of Lakhisarai farmers, measured by agricultural intensity index.
H_{1e}: Higher land ownership does not advance decline in the agricultural involvement of Lakhisarai farmers, measured by agricultural intensity index.

H_{0f}: Higher land ownership advances decline in the agricultural involvement of Lakhisarai farmers, measured by hours worked.
H_{1f}: Higher land ownership does not advance decline in the agricultural involvement of Lakhisarai farmers, measured by hours worked.

H_{0g}: Larger household size advances decline in the agricultural involvement of Lakhisarai farmers, measured by agricultural involvement index.
H_{1g}: Larger household size does not advance decline in the agricultural involvement of Lakhisarai farmers, measured by agricultural involvement index.

H_{0h}: Larger household size advances decline in the agricultural involvement of Lakhisarai farmers, measured by agricultural intensity index.

H_{1h}: Larger household size not advance decline in the agricultural involvement of Lakhisarai farmers, measured by agricultural intensity index.

H_{0i}: Larger household size advances decline in the agricultural involvement of Lakhisarai farmers, measured by hours worked.
H_{1i}: Larger household size does not advance decline in the agricultural involvement of Lakhisarai farmers, measured by hours worked.

What is particularly not discernible from available literature is the nature of work, the effort required to perform the activities, and typical daily routine of an average Indian farmer. Moreover, available studies rely on self-reported figures rather than measured values, do not account for differences in land ownership, income, and household size when reporting work participation by age, and use age ranges rather than individual age in most datasets.

1.2.2. Constructing work intensity indices and comparing and explaining the link between aging and recorded agricultural intensity

The secondary objective makes use of accelerator-based devices, also known as step trackers, to record the intensity of day-to-day agricultural activities by tracking farmers' movements as they perform them. The work intensity index should approximate the effort required for a range of everyday activities performed in rural areas. Intense agricultural activities, which require greater physical exertion, complex range of body movement, and covering longer distances, for instance, would expectedly result in higher work intensity indices, and vice versa. Moreover, the intensity of performed activities is expected to decrease with age (i.e. fewer and slower movements), an assumption that is tested using H_{0l} hypothesis. Compiled data, and resulting work intensity indices, will then be correlated with the self-reported difficulty of performed activities (an aggregate intensity index will be calculated, encompassing all three months).

H_{0l}: Agricultural intensity of Lakhisarai farmers, measured by recorded agricultural intensity, declines with age.
H_{1l}: Agricultural intensity of Lakhisarai farmers, measured by recorded agricultural intensity, does not decline with age.

The practical implications of such findings are numerous, ranging from (1) more accurate classification of typical agricultural activities and better workload distribution across age groups and gender within households and wider communities, (2) wage differentiation for agricultural laborers based on actual work intensity rather than hours or days worked, (3) refined performance and compensation management for agricultural laborers, (4) balanced work division in agricultural cooperatives, and (5) improved recommendations on calories intake, among others. The results could thus open a new way of studying farm work and provide an objective way of measuring agricultural performance.

1.2.3. Estimating the cost of aging and explaining the link between aging and household expenses

The third objective involves estimating the cost of aging to households, community, and the government, after the farmer's involvement in agriculture ends or reaches a certain threshold. The assumption that the longer provisionally non-contributing household members are alive, or the higher the number of elderly household members, the higher the overall costs for household, is assessed using the two hypotheses (H_{0j}, H_{0k}, respectively). The assumption is tested as the correlation between longer life and higher costs of living may be challenged by retiree's decision to remain employed or continue to contribute to household income in other ways, including the state pension.

H_{0j}: The higher the average age of elderly rural household members (60 and above) in Lakhisarai district, the higher the average household member expenses.
H_{1j}: The higher the average age of elderly rural household members (60 and above) in Lakhisarai district, the lower the average household member expenses.

H_{0k}: The higher the number of elderly rural household members (60 and above) within Lakhisarai district households, the higher the average household member expenses.
H_{1k}: The higher the number of elderly rural household members (60 and above) within Lakhisarai district households, the lower the average household member expenses.

Being able to estimate the living expenses of households with a different number of non-contributing family members is, therefore, the key to developing retirement and savings plan

for rural dwellers, particularly if agriculture is the primary source of income. Savings projections may then be extended to households, wider communities, and individual states.

1.2.4. Supplementary household income and expenses regression output

Aside from evaluating the link between aging and agricultural involvement, developing agricultural involvement and agricultural intensity indices, and estimating the cost of aging, a host of regression analyses revolving around household income and expenses will be performed as well. The regressions will assess the impact on household income and expenses that the key independent variables may have, including farmer's age, agricultural involvement, intensity, and hours worked, land ownership, number of all, elderly, young, and dependent household members, average age of elderly household members and children, years of education, and the number of years of working outside agriculture.

The objective and individual aims will be carried out using a semi-structured questionnaire administered across 400 randomly selected households within Lakhisarai district, supplemented with a separate section used to collect data on 200 elderly household members. Moreover, around 200 additional participants of all ages will partake in the experimental phase of research using motion tracking devices. The target number of surveys are based on the preferred margin of error and confidence intervals (95% confidence interval and 5% margin of error), available resources, time, and geographical and transportation specifics of the region. The research output is presumed to offer new insight into dynamics of everyday life of Indian rural households, the impact of aging on smallholder farmers, potential applications and limits of motion tracking devices in agriculture, and importance of planning for old age.

1.3. The significance of the study

Population aging can be viewed as a complex and multifaceted phenomenon, one of the crowning achievements of the last century, but also a significant challenge to modern societies. Aging impacts all aspects of human life, from economic growth and international relations to the sustainability of individual families, and the daily lives of all citizens. Building long-living societies, therefore, calls for proactive financial planning and making the topic a national and global priority.

The study paints a compelling picture of the impact aging has on one of the most populous and, at the same time, most densely populated countries, India. It provides a description of population aging trends within rural areas, including elderly employment, elderly financial dependence, and the role of government. More importantly, it fills some of the more pressing gaps in available research by venturing into the unexplored area of individual agricultural activities, using a combination of semi-structured questionnaire and fitness trackers to gather data on a host of agricultural tasks performed by Indian smallholder farmers.

1.4. Organization of dissertation

The dissertation is organized into six chapters. Following the introduction, research purpose and individual objectives, Chapter 2 presents details on the Indian economy, covering economic aspects of country's colonial past and contemporary trends affecting India's position in the world economy. The chapter ends with projected impact aging population might have on country's economy. Chapter 3 includes research literature related to population aging in India, with focus on rural areas. It encompasses topics ranging from the social impact of aging, history of a social security system in India and the current state, changing socioeconomic status of elderly, the role of community networks, down to financial dependency of the elderly and necessity to work post-retirement. Major studies on population aging and workforce participation are covered as well.

Chapter 4 outlines research design and methodology, including the study area and data collection methods, the role of semi-structured questionnaire and fitness trackers, the methodology for constructing agricultural involvement and work intensity indices and calculating the cost of aging, as well as applied statistical analysis such as simple and multiple linear regressions, along with accompanying data checks and validations. Chapter 5, being the most important section, details results and discussion points in terms of set objective and aims. It starts with simple descriptive statistics and then iterates through each hypothesis, concluding the analysis with an estimated cost of aging hypothesis testing and the synthesis of study findings. Finally, Chapter 6 briefly summarizes research results, outlines theoretical and practical contributions, and puts forward conclusions and recommendations for future research.

CHAPTER 2: INDIAN ECONOMY - HISTORY AND CONTEMPORARY TRENDS

2.1. Historical developments

The history of India's economy is that of exploitation by the British Empire, beginning with the Battle of Plassey in 1757, which consolidated Empire's presence in Bengal and much of India over the next hundred years. As the Industrial Revolution marked the transition to new manufacturing processes in 1760 Britain (Inikori, 2002), and later throughout continental Europe, sustaining its growth prompted an increase in demand for raw materials from India. The initial objective of establishing trading relations was, therefore, soon replaced with the intention of monopolizing the Indian market for finished British goods. The declining power of the Mughal Empire during the 18th century allowed the British to establish their dominance over the Indian sub-continent by interfering in the political affairs of the Indian rulers (NIOS, 2013). Gaining control over the country, however, proved a difficult task as many regional powers resisted the British imperialist efforts.

During the British rule, the share of India in the world economy shrunk from 24.4% in 1700 to just above 4% in 1950, with comparable decline recorded in country's industrial output (Angus, 2003). The centuries-long world dominance allowed the British East India Company to pressure the Indian government into opening its market for British goods and abolishing the country's tariffs and duties. Although the dominance of the British East India Company was subdued between 1793 and 1813 owing to anti-monopoly campaigns staged by the British manufactures, India nevertheless remained an economic colony of industrial England. The Empire retained its protectionist measures and continued taxing its Indian imports. British textiles imports from India, for example, were restricted, yet the country continued importing Indian raw cotton without any tariffs. This allowed "the empire on which the sun never sets" to manufacture the textiles at home and then export them back to Indian consumers, this time, without any restrictions. Within a few years, India went from being an exporter of clothes to exporter of raw cotton, and an importer of British clothes (NIOS, 2013).

The radical change in trade policy soon led to industry's collapse, promptly followed by the demise of metalwork, glass and paper industries. Resulting unemployment forced many to migrate back to rural areas in search of work, further intensifying the pressure on the rural economy. Indian nationalist leaders later dubbed this process as de-industrialization (Jeffrey

and Williamson, 2005). United Kingdom's monopoly over the Indian sub-continent and excessive sourcing of raw goods from the country are therefore often blamed for the poor state of India's economy after its independence in 1947 (Cypher, 2014; Broadberry and Gupta, 2005). Another major economic consequence of the British rule was the substitution of subsistence crops with cash crops, such as tea, coffee, indigo, opium, cotton, jute, sugarcane, and oilseed (NIOS, 2013). This, in turn, precipitated dozens of famines, the most devastating of which was the Bengal Famine of 1943, killing between 3 and 4 million people.

India's post-independence economy was characterized by a mix of colonial legacy and Soviet planned economy (Datt and Sundharam, 2009). Economic policy was predominantly protectionist, with focus on import substitution, government intervention, and central planning. Most key industries were nationalized during the 1950s, while rapid development of heavy industry became the top priority. Private initiative was suppressed as businesses were forced to apply for a license under the Industries Act of 1951 before launching, expanding, or changing their products (Stanley, 2006). At the same time, the Green Revolution led to increased crop productivity and improved linkage between agriculture and industry.

Unlike the previous two decades, the 1970s were a decade of capacity expansion, lower corporate taxes, and industry-wide encouragement of small-scale enterprises. After the collapse of the Soviet Union and decades of failed economic planning, increasing budgetary deficit, and what was known as the "Hindu rate of growth," the 1980s and 1990s brought about change in thinking (Tripathi, 2006). Floating exchange rate was introduced, government spending was tamed, and foreign investments encouraged. While the growth was higher compared to previous decades, it was also more fragile.

The Gulf War and ensuing oil crises and a budgetary trade deficit at the beginning of 1990, forced the Indian government to make a deal with the International Monetary Fund in order to refinance its loans, promising to de-regulate its economy in return (Ahuja, 2006). India folded despite being one of the founding members of GATT and its successor, WTO. Economic reforms were initiated accordingly in 1991, leading to a reduced system of licenses and regulations required to set up and run businesses in India, lower tariffs and interest rates, and improved marked competition as many government-run monopolies were dismantled (Ibid.). The liberalization movement, however, had little effect on trade unions and farmers, as

reforming labor laws and reducing agricultural subsidies remained controversial topics (The Economist, 1997).

Although the overall post-Independence economic progress led to an increase in life expectancy, higher literacy rates, and greater food security, the benefits remain unevenly distributed between the urban and rural areas (Ahuja, 2006). Moreover, aside from purely geographical disparities, widespread economic and social inequalities, along with the low status of human development, are particularly concerning in India. Food insecurity on a mass scale, inability to meet basic needs such as housing, sanitation and appropriate healthcare, universal education, and access to employment, make the inclusive growth a mirage.

2.2. Contemporary trends

The Global Competitiveness Report (2016-17), which ranks countries according to Global Competitiveness Index, highlights India's advance to 39th position, an improvement of 16 spots from the previous year (WEF, 2016a). The boost, attributable to better infrastructure and strong economic growth (Deep Singh, 2016), however, was not characteristic of all South Asian nations. Neighboring Bangladesh ranked 106th, while Pakistan occupied a distant 122nd position. Similarly, according to the World Bank's Doing Business 2018 index, which ranks economies on their ease of doing business from 1 to 190, India managed to move up the ranking from 130th spot in 2017 to 100th in 2018, positioning itself for the first time among the top 100 economies (The World Bank, 2018a).

Continuous high growth rates and improved credit rating are predicted to make India the third largest superpower by 2035, after the US and China (Dominic, 2003). More recently, after a temporary slowdown during the world economic crisis of 2008, the country went back on track with a 2017 year-over-year GDP growth of 7.2% (Figure 1), driven mainly by the start-up boom and manufacturing expansion (Government of India, 2018b). India's 2017 nominal GDP is estimated at $2.4 trillion (6th largest economy) or $9.5 trillion, expressed in purchasing power parity (PPP) dollars (3rd largest economy) (IMF, 2018a). Nominal GDP per capita for the same year is projected at $1,852 ($7,173 in PPP dollars), placing India on a distant 141st position (123rd position, expressed in PPP dollars).

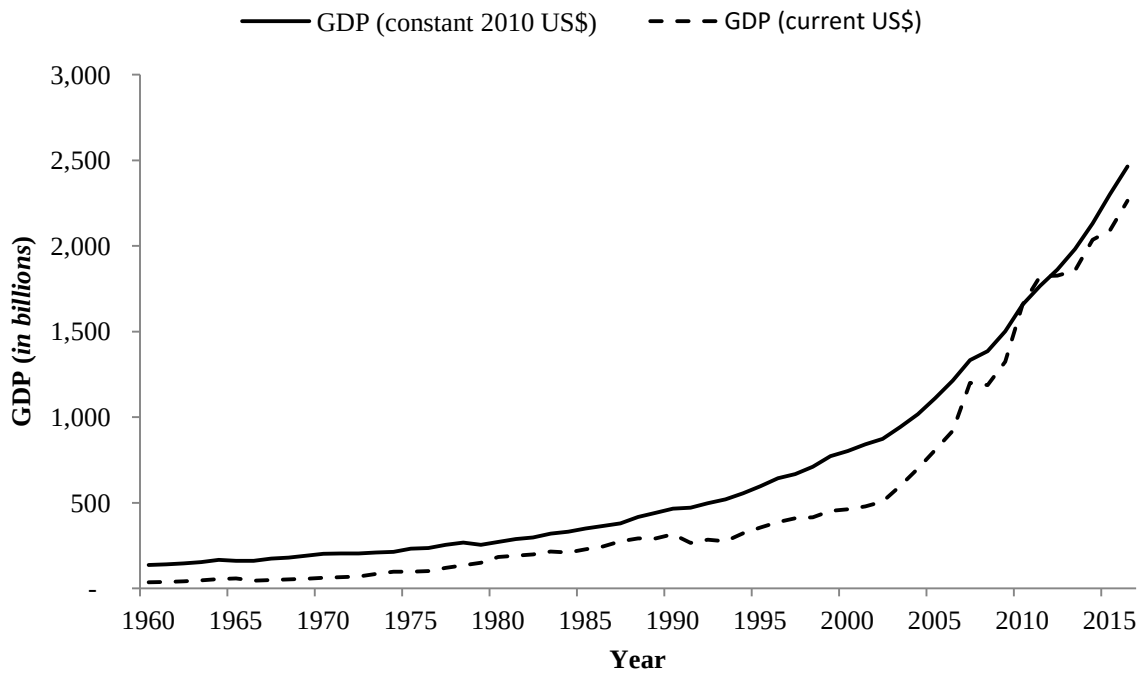

Figure 1. GDP trend between 1960 and 2016 (The World Bank, 2018b)

The country's public debt currently stands at 67.7% of GDP (IMF, 2018b), with the government revenues and expenses for 2017 estimated at $540 and $710 billion, respectively (IMF, 2018c). The inward foreign direct investment stock (total accumulated value of foreign-owned assets) in 2016 amounted to $318.5 billion, while the outward FDI stock was $144.1 billion (United Nations, 2016). The labor force of 520 million, on the other hand, is the second largest after China's (ILO, 2017), with agriculture employing 47% of the total, services sector 31%, and industry 22% (Government of India, 2014b) (Figure 2). The government-reported unemployment rate stood at 3.6% at the end of 2017, while the average yearly net salary was $1,284 (Government of India, 2017). At the same time, about 21% of the population was below the international poverty line (lived on less than $1.9 a day), while 58% lived on less than $3.1 a day (expressed at 2011 PPP dollars) (The World Bank, 2016).

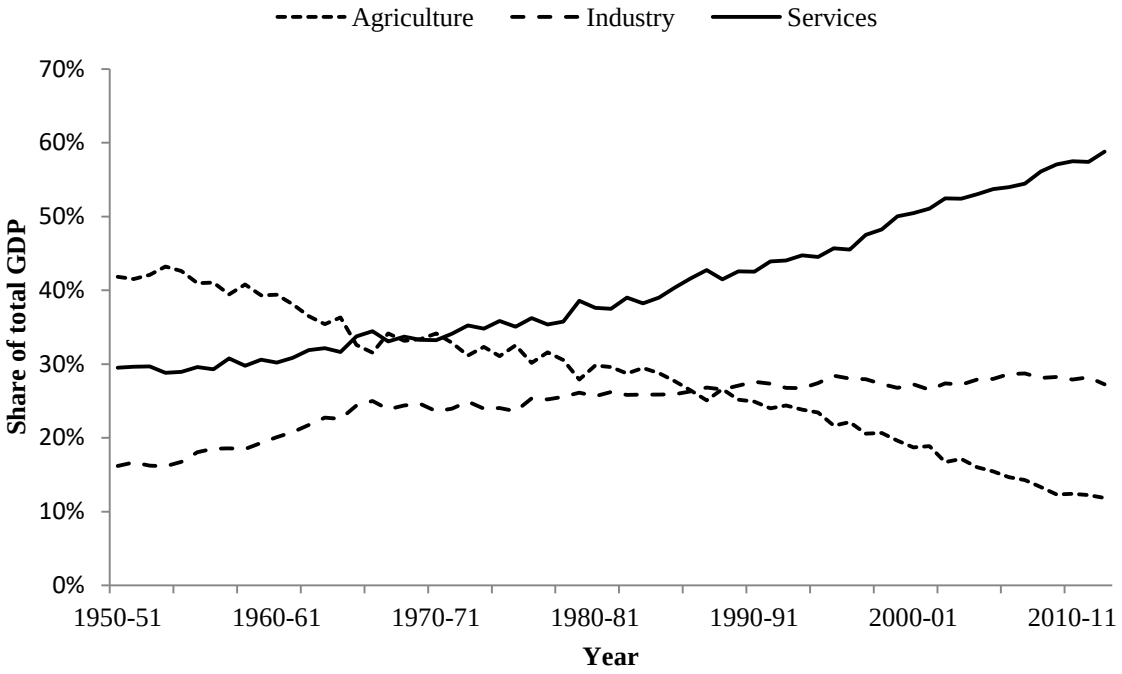

Figure 2. Sector contribution to GDP between 1950 and 2013 (Government of India, 2014a)

Sector-wise, India is a global agricultural powerhouse, being the largest producer of milk, pulses and spices, and having the world's largest area under wheat, rice and cotton. Moreover, it is the second largest producer of rice, wheat, cotton, sugarcane, fish, sheep and goat meat, fruit, vegetables, and tea. The country has 195 million hectares of land under cultivation, 63% of which is rainfed, while 65 million hectares are under forests (The World Bank, 2012). Although the sector's share in GDP has been declining for decades, it remains the single largest source of employment for Indian population.

Today, however, the yields of most crops are only half of those of Vietnam and Indonesia. This is partially due to heavy government regulations, agricultural subsidies that distort market signals, and inefficiencies in the food supply chain, and partly owing to unpredictable weather, small average farm size, and lack of awareness in the use of modern agricultural practices and technologies. Moreover, the inadequacy of infrastructure and efficient railway network dating back to 19th century are to blame for up to a third of India's agricultural production being wasted due to spoilage (The Wall Street Journal, 2013).

The government has introduced several schemes over the past few decades to modernize agriculture and increase manufacturing by expanding agribusiness and food processing.

Agricultural subsidies for poor farmers, including fertilizer subsidies, free electricity, and price floor schemes, have been part of the Indian landscape since the county's Independence. Although changes to agricultural sector remain under intense political opposition as interest groups often obstruct government attempts to lower the costs of agricultural programmers, improvements in the regulatory department have received due recognition.

Enabling the Business of Agriculture (EBA) 2017 report, which quantifies legal barriers for businesses operating in agriculture within 62 economies and across 8 topic areas, assigned distance-to-frontier (DTF) score of 52.5 for Indian agricultural markets, 41.2 for transport, and 17.6 for water, showing areas where better regulatory practices can be adopted. At the same time, the country has a DTF score of 66.6 for seed, 66.7 for ICT, and 69.6 for fertilizer, indicating it is very near the frontier in these topics (Figure 3). The report also ranks the topic's DTF from highest to lowest and assigns a ranking from 1 to 62, with countries being scored based on both the quality and efficiency of their regulatory systems (The World Bank, 2017). Accordingly, India achieved the highest ranking for finance and the lowest for water-related regulatory practices.

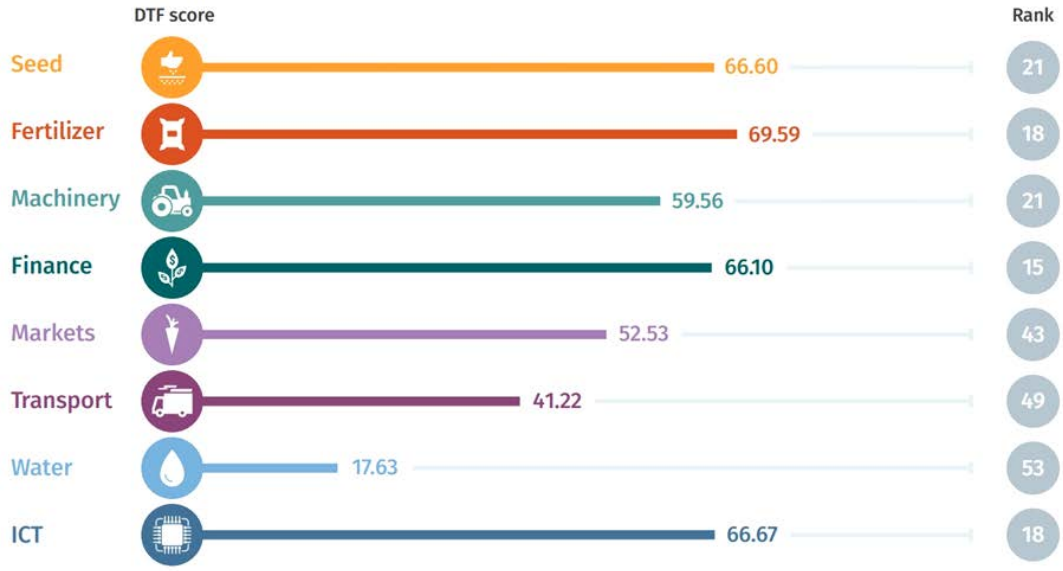

Figure 3. Enabling the Business of Agriculture 2017 DTF (distance-to-frontier) scores and ranking of Indian agribusiness environment (The World Bank, 2017)

Industry, on the other hand, accounts for 29% of the country's GDP and employs 22% of the total workforce (Government of India, 2014b). Major contributing sectors include petroleum

products and chemicals, pharmaceuticals, the auto industry and engineering, textiles, mining, iron and steel, and defense. India is also home to the world's largest refinery complex, with petroleum products alone accounting for 34% of the country's exports. Although the textiles industry is considerably smaller, contributing 4% to the country's GDP and 17% to exports, together with cotton farms it employs close to 45 million people (IBEF, 2013a). Engineering, which includes transport equipment, machine tools, capital goods, automobiles, and railways, is the largest sub-sector within the industrial sector, providing employment for over four million people (Ibid.).

The services sector, however, is by far the largest sector, accounting for 53.7% of country's GDP, up from 15% in 1950 (IBEF, 2018). The sector provides employment to 31% of the workforce and accounts for 60.7% of foreign direct investment inflow. The country has one of the fastest growing services sectors in the world, with the government encouraging commercial services exports, despite multiple, uncoordinated governing bodies adversely affecting its growth. Although the sector has the highest labor productivity (compared to agriculture and industry), its competitiveness is contained in only a handful of services and focused only on a limited number of markets.

All three sectors are important contributors to international trade, although to varying degrees. The country's main trading partners include China, the United States, the United Arab Emirates, Saudi Arabia, and the European Union (Government of India, 2018a). In 2016, India exported $275.8 billion worth of goods and services while importing $384.3 billion, with growing oil imports blamed for country's current account deficit (WTO, 2016; Ramakrishnan, 2010). Manufactured goods accounted for 68.4% of exports, followed by the fuels and mining products (15.7%), and agricultural commodities (13.2%) (Ibid.). Around 47.8% of imported goods, on the other hand, were manufactured products, followed by fuels and mining products (33.1%), and agricultural commodities (7.1%).

The top exports included refined petroleum ($25.4 billion), polished diamonds ($24 billion), jewellery ($12.6 billion), and medications ($11.6 billion), while the top imports constituted crude petroleum ($60.7 billion), gold ($22.9 billion), diamonds ($19 billion), coal briquettes ($12.7 billion) and telephones ($10.6 billion) (UN, 2018). The country has historically been covering its trade deficit via company borrowings in the foreign capital markets and through remittances by the non-resident Indians, as some 16 million Diaspora members remitted close

to $70 billion in 2016 (Pew Research Center, 2018). This year, however, also marked the first time since 1991 that India managed to fund its deficit through foreign direct investment inflows instead, suggesting a rising confidence among long-term investors (Nayak, 2017).

2.3. The impact of aging on the economy

Population aging impact on the economic growth has evolved into a major concern for governments worldwide. As the fertility and mortality rates began to decline during the 1970s, the growing working-age population and resultant imbalance in population structure created a favorable environment for demographic dividend and accompanying increase in labor productivity. The inequitable age structure, however, developed into a concern, as consumption and saving patterns, public expenditure, and human capital became key mechanisms through which aging affected economic growth (Mason, 2005).

Population aging is most readily associated with increased public spending on social security and medical services, coupled with declining tax revenue and the budget deficit (Eiras and Niepelt, 2012; Lisenkova et al., 2012; Tosun, 2003). Davies and Robert (2006) also include the impact on foreign direct investment, as foreign companies often hesitate to invest in countries with aging societies due to the country's lower potential to generate wealth. Mincer (1974) supports this claim by highlighting that the productive capacity of societies composed of the older labor force is bound to be significantly different (lower) from the one with a younger labor force. Elgin and Tumen (2010) offer another perspective by saying that aging has a significant impact on the economic growth of developing countries but not on their developed counterparts. The authors cite the extensive use of machinery rather than human labor force in developed countries as an explanation why a decline in the human labor force is likely to have no impact on their productivity and economic growth.

Tyers and Shi (2007) agree with the causality, forecasting that developing countries such as Indonesia, India, and China will indeed experience a decline in their GDPs because of the fall in labor force participation due to aging. The extent to which this prediction materializes, however, will be contingent upon the health and mobility of an aging population. If people are alive for longer, but with poor mobility, elderly work participation will be lower. If, on the other hand, people live longer and are physically active, the adverse effects will be less pronounced. Sanderson and Scherbov (2008) thus encapsulate the need to track changes in

age-specific health profiles by saying that “using prospective age instead of chronological age is a way to implement a population-based concept of old age that considers improvements in health and life expectancy.”

In contrast, Lee et al. (2011) contend that unlike in most Western nations, an aging population has a positive effect on the economic performance in Asian countries. The authors argue that aging typically necessitates increased government spending, which is likely to translate into higher economic growth. The concept seems plausible, as an average person aged 75 years and above consumes 19% more than an average individual aged 25-39 years (Guest and McDonald, 2003). Alders and Broer (2004) and Hock and Weil (2012) support the claim by asserting that a decrease in labor supply caused by the aging population would raise wages and increase the opportunity cost of having children, leading to a shift from having children to goods consumption. Moreover, this would help the government save on education for young people who generally pay little or no taxes, despite the net cost of retired people being greater than the net cost of young people. They conclude that the aging population should have no effect on consumption and household savings patterns.

Figure 4 backs this notion with an overview of fiscal support ratios for several Asian countries, showing the pressures on fiscal substantiality coming from public transfers. As the number of taxpayers rises relative to the number of beneficiaries, the fiscal support ratio increases as well, and vice versa (2010 is the base year). The fiscal impact of population aging is projected to have the greatest effect in Japan, where the year of the most favorable age structure was 1976. Japan will, therefore, have to increase taxes, decrease benefits, or deal with a mounting budget deficit in the future.

In the case of India, population aging in combination with current tax and benefit policies would make almost no difference over the next thirty years. The Philippines are even projected to experience an increase in their fiscal support ratios, as the net transfers to the elderly are modest or in some cases negative. Miller (2011) thus states that in case of India, projected changes in the age structure will, in fact, relax public sector budget constraints, unless, of course, generous transfer systems are implemented, which ultimately prove to be unsustainable.

Table 1. Fiscal support ratios between 1950 and 2050 in major Asian countries (Miller, 2011)

Country	1950	2010	2020	2030	2050	Year of most favorable age structure
China	89	100	97	89	82	2012
India	98	100	102	103	102	2028
Indonesia	79	100	106	110	108	2033
Japan	91	100	92	87	74	1976
Philippines	87	100	106	111	116	2050
Korea	76	100	97	89	80	2008
Thailand	66	100	104	104	104	2039

Majority of studies hold an opposing view that aging has a negative impact on economic growth, with both labor supply and productivity forecasted to decline (Ilmakunnas and Ilmakunnas, 2010). What Lee et al. (2011), Miller (2011), Guest and McDonald (2003), Alders and Broer (2004), and Hock and Weil (2012) fail to account for or underestimate is a decrease in labor income tax, which is likely to negatively impact government revenue and lead to lower government spending and slower economic growth (Tosun, 2003). In countries with inherent budgetary imbalance, this may require of those in work to contribute more through taxes, thus creating a disincentive to work and disincentive for companies to invest. Similarly, higher savings for pensions may reduce capital available for more productive investments, leading again to a decline in productivity and sluggish economic growth.

At the same time, on the consumption side, as the population ages, the demand for some of the goods and services may be impacted as they become less valuable to older households. Walder and Doring (2012) point out declining demand for education and a growing demand for medical care as examples of the shift in preferences. This means that traditional consumer goods and services such as family housing, cars, and travel arrangements, among others, are likely to be replaced by and condensed in a much smaller number of growing industries, namely health and elderly care.

Blake and Mayhew (2006) offer a solution by claiming that the adverse effects of an aging population on economic growth could be mitigated by a steady stream of immigration. Such an approach, however, is neither encouraged nor realistic, as other studies have found that different levels of migration do not lead to different rates of population aging (Murphy, 2016).

Murphy summarizes by saying that “changing population age structure in the long term is more complicated than simply opening our borders to more migrants in the hope of increasing the proportion of working-age people.”

More practical options should thus be pursued, including higher elderly employability, life-long learning, and re-training programs, and focus on improved productivity of the elderly workforce. In the case of India, policy choices in the areas of governance, macroeconomic management, trade, and human capital formation are also necessary to realize the full potential of the country’s demographic dividend. This is particularly true if higher female labor force participation is to be accomplished. Lastly, demographic and social differences within India need to be considered (Duraisamy and Mahal, 2005), as different economic growth rates among individual states could intensify inequality and political frictions within the country. Figure 4 shows an example of such differences, where the state of Sikkim has an equal number of working and not-working residents, while Bihar is burdened with two dependents for every working person.

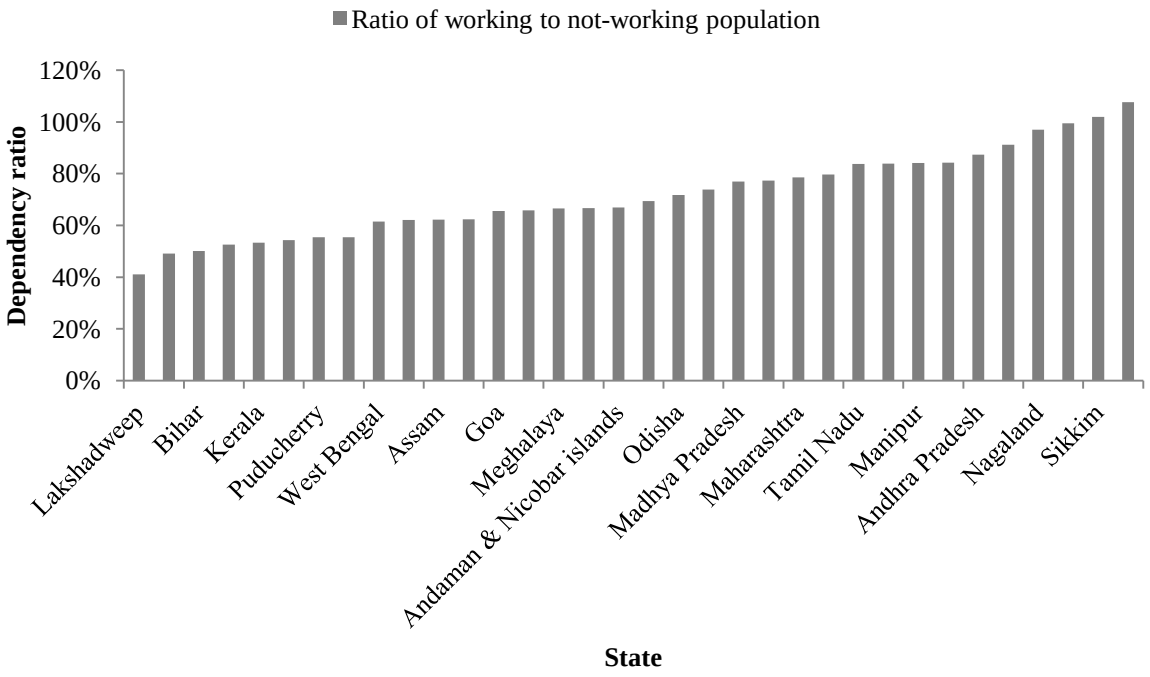

Figure 4. The ratio of working to the not-working population by state (Government of India, 2015b)

CHAPTER 3: POPULATION AGEING IN RURAL INDIA

3.2. Declining birth and death rates

Population aging is an increasing median age in the population of a region due to declining fertility rates and/or rising life expectancy (UNDP, 2005). Declining fertility is a greater contributor (Rosenzweig, 1997), as reflected in a decline in the proportion of the population composed of children, and a rise in the proportion of the population that is elderly. Figure 5 shows an example of this trend using crude birth and death rates for India per 1,000 people, for period 1960-2015.

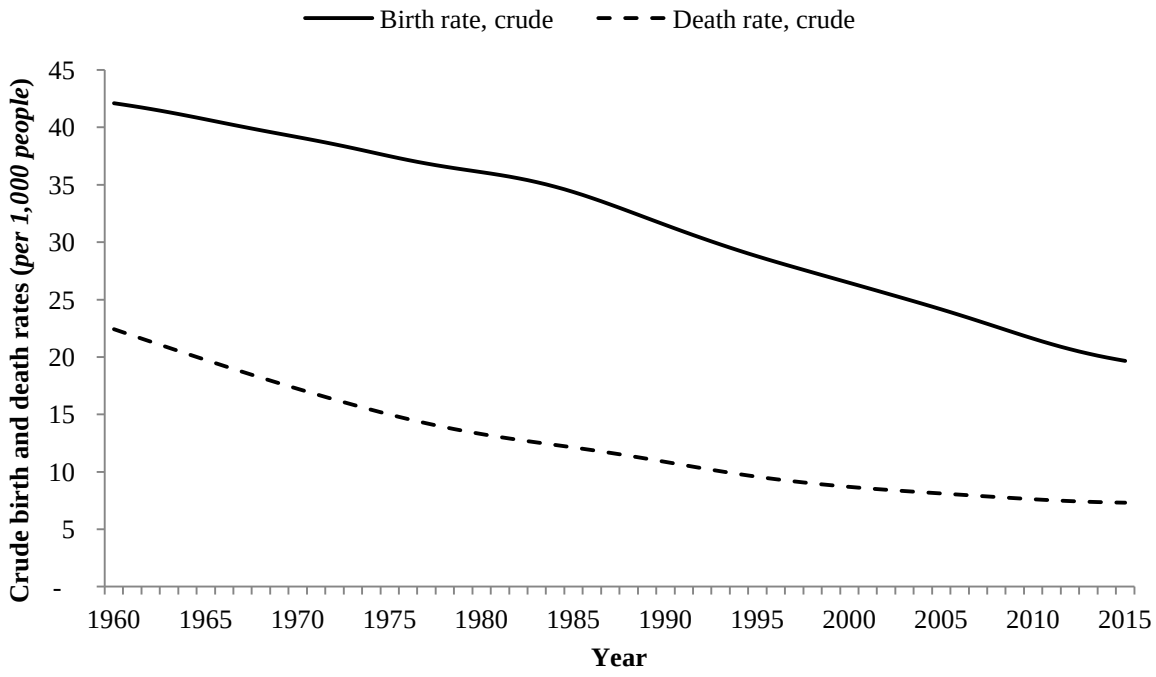

Figure 5. Indian crude birth and death rates between 1960 and 2015 (The World Bank, 2018b)

The number of people aged 60 years and over throughout the world has tripled since 1950, with the absolute number expected to reach 2.1 billion by 2050 (UN, 2015). Countries, however, vary significantly in terms of the degree and pace of aging, and the UN expects populations that began aging later to have less time to adapt to its implications (UN, 2001). Moreover, as many developing countries are experiencing faster fertility transitions, they will experience an even faster population aging in the future than the currently developed

countries. Active aging model is thus intently pursued by many nations, as it acknowledges the contributions made by the older members of society and promotes their active involvement in all areas of life. It allows people to realize their potential through employment, including volunteering, community work, and helping to raise children, while having a direct impact on their health and physical and mental well-being.

The decline in fertility rates and rising life expectancy are relatively recent phenomena in India. Up until the early 1950s, the sequence of high birth rates followed by high death rates helped keep the elderly population at a low level. The cycle was interrupted in the early 1960s with a sharp decline in population death rate and an increase in life expectancy at the age of 60, from the estimated 41.2 years in 1960 to 68.3 in 2015. The decline in birth rates followed and gradually accelerated during the 1970s (Chanana and Talwar, 1987), reaching 2.2 children per women as of 2017, with most of the Indian states already well below the replacement level of 2.1 (Chandra, 2016, Government of India, 2015b). Consequently, the elderly population grew faster than the general population, a trend which is expected to continue (Figure 6).

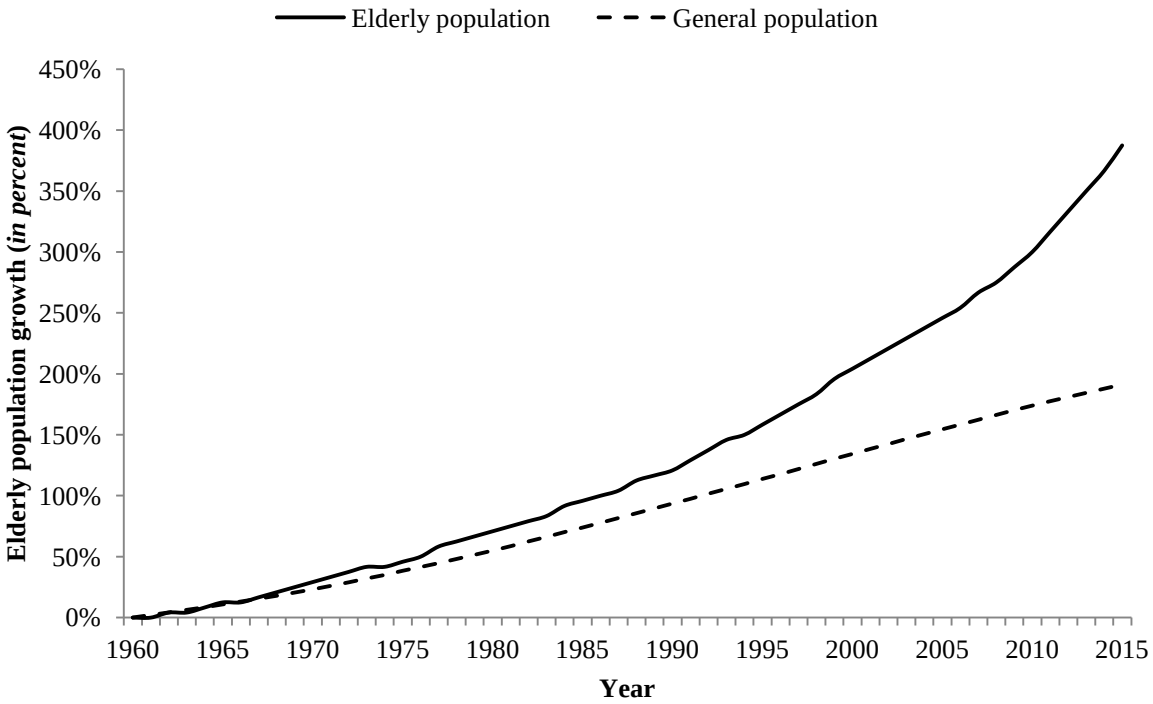

Figure 6. Indian elderly population growth compared to general population growth between 1960 and 2015 (The World Bank, 2018b)

The United Nations Population Division forecast indicates that India's population aged 50 and older will reach 34% by 2050 (UNPD, 2011), while the share of Indians 60 years and older will surpass the number of children aged 14 and younger by 2042 (Chatterji, 2008). Bloom (2011), however, points out that the burden of old-age dependency will be more than offset by the decline in youth dependency, driven by lower fertility rates. Nevertheless, as the population ages, a declining pool of working-age adults needed to support the elderly population will change as well. The 1961 census revealed, for instance, that out of every 100 older adults, approximately 11 were dependent on working family members, a steadily increasing figure that reached 14 by Census 2011 (Table 2), with the ratio projected to increase further to 31 per 100 by the mid-century.

The sex ratio of male to female older adults, on the other hand, has reversed over the past two census cycles, with the proportion now being in favor of older females. Such projections, however, often mask regional variations, with fertility rates in southern states being twice as low as those of their northern counterparts. Consequently, the ratio of working-age to the non-working-age population will differ among the states, leading to unequal effects of the changing age structure across the country (Ibid.).

Table 2. Indicators of aging for the Indian population for census years 1961-2011 (Bakshi and Pathak, 2016)

Census year	Number of older adults	Percentage of older adults in the population of India	Old-age dependency ratio (per 100 adults)	Sex ratio among older adults (per 1,000 older males)
1961	24,712,109	5.63	10.56	929
1971	32,699,731	5.97	11.47	938
1981	43,167,329	6.49	12.04	960
1991	56,681,640	6.80	12.19	930
2001	76,622,321	7.47	13.08	1,029
2011	103,849,040	8.61	14.22	1,033

Note: Original source is the single year age returns provided by the Census of India reports.

Perhaps the most visually appealing way of perceiving the changes in age structure are through population or age pyramid, which shows the distribution of age groups in a population. Figures 7 and 8 demonstrate the enormity of the shift in case of India, from pyramid-shaped and relatively young to coffin-shaped and notably older population.

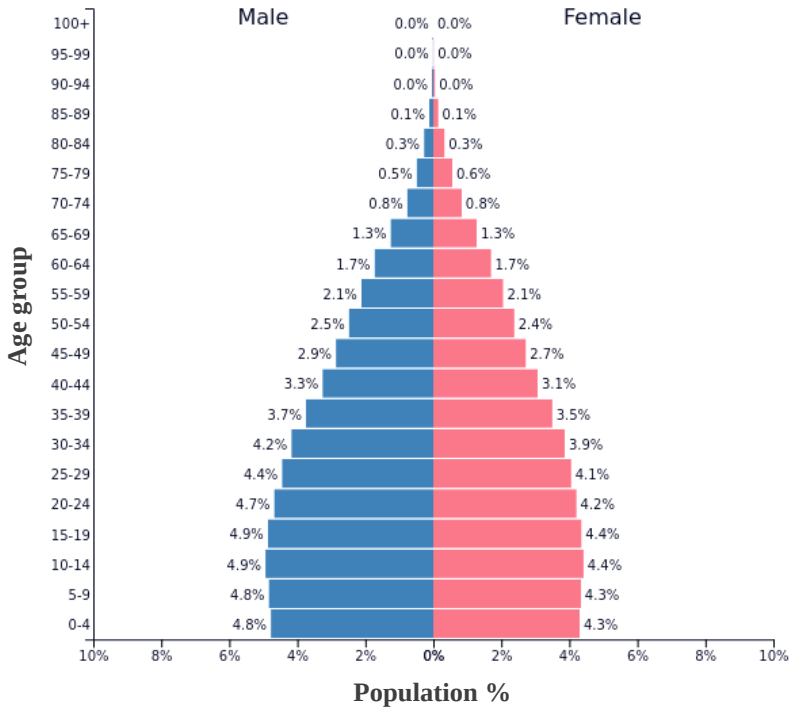

Figure 7. Estimated Indian population pyramid in 2018 (The World Bank, 2018b)

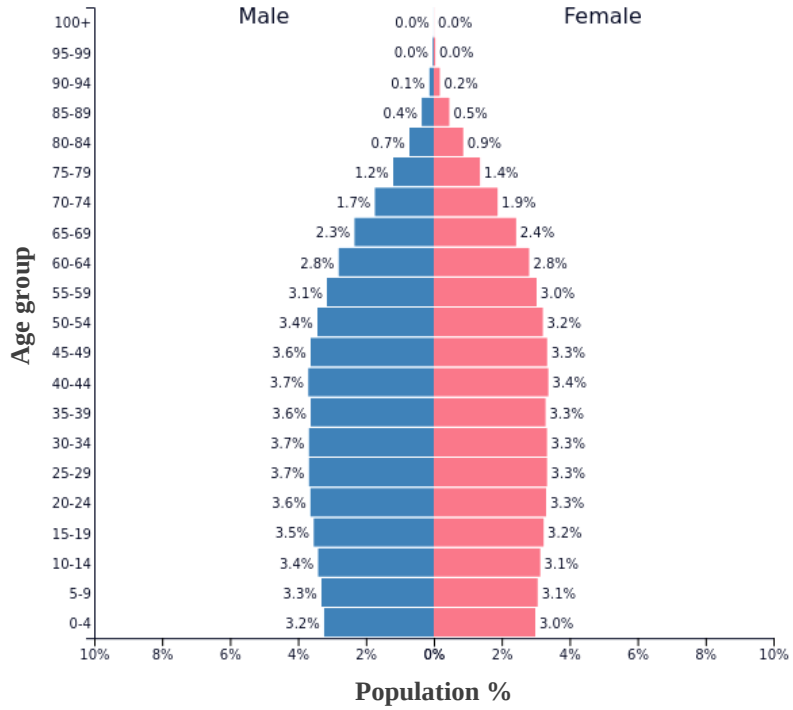

Figure 8. Estimated Indian population pyramid in 2050 (The World Bank, 2018b)

3.3. The social cost of population aging

Population aging comes at a price to society as health care and social security expenditures tend to increase, forcing governments to choose between higher taxes and a reduced role in providing those services. Social security systems are becoming increasingly vulnerable due to misalignment between the extension in the pension period and the extension of the active labor period or a rise in pension contributions. The life expectancy at birth for the world, for example, was about 52.5 years in 1960 and 71.7 years in 2015 (The World Bank, 2018b), an increase of over 19 years in just over five decades. Meanwhile, the retirement age has changed only marginally, from 65 years in 1960 to 66 in 2017 in the United States (Carroll, 2010), and from 58 to 60 for the same period in India (Hindustan Times, 2006).

Aging is predicted to have an impact on pension schemes in at least two ways: (1) there will be more beneficiaries and (2) they will draw the benefits over a much longer period (Scardino, 2009). Guaranteeing adequate income for the older population without overburdening the younger age groups will be one of the biggest challenges. The pension systems will have to be reformed and workers encouraged to remain in the labor market longer. The countries with a social security system financed through pay-as-you-go (PAYG) systems will be particularly under pressure, as they function best when the relative number of contributions and beneficiaries is stable. The bottom line is that there will be an increasingly high number of persons reaching retirement age compared with the number of active workers.

The official retirement age in India's formal sector, however, varies between 55 and 65 years (Rajan, 2010), with no age limit set for people working in the country's informal sector. The country's overwhelming agricultural base supports such division by absorbing and maintaining human population even at older ages. Unlike the manufacturing and service sectors, the agricultural sector does not require skilled labor, thus making it possible for a sizable portion of economically active older adults to participate. The situation in India is representative of what is currently observed across developing world in general (Chen, Jones and Domingo, 1989; Choe, 1989; Nasir and Ali, 2000; Perera, 1989), with over 90% of workers having worked in the informal sector during the 1980s, 1990s and early 2000s (Rajan, 2010). Consequently, a significant part of the workforce is denied any retirement benefits, making them financially dependent at older ages.

As populations age, particularly those of developing countries, social protection needs to be secured and extended, which requires substantial tax base. The ratio of retired population to working-age population is closely monitored and frequently used measure in the global social protection debate. Industrialized countries are generally expected to shift from today's level of about four or five workers for every retired person to just two by 2050. According to the United Nations Population Division report, the current ratio could only be sustained if the retirement age was increased to over 75 years (UN, 2000), a scenario which is unlikely to materialize. Consequently, public spending on retirement benefits is expected to increase substantially worldwide over the next 50 years (Sigg, 2005). The cost in OECD countries, for instance, is currently around 10% but is expected to stabilize at 17% within three decades.

Japan, Korea, and Singapore, as representatives of the developed world in Asia, already have many of the institutional elements crucial for aging societies in place. Moreover, the governments of these countries are stable, efficient and experienced in managing public healthcare systems and pension schemes. At the same time, their developed financial systems guarantee secure economic environment for workers to save and build wealth to meet the needs at the end of the life (Park et al., 2012). This is, however, not the case for most of the Asian nations, India included.

Not all experts, however, are concerned with population aging. Mullan (2000) points out that emphasis is often placed on the looming pension crisis and sustainability of economic growth, even though it is generally recognized that longer life expectancy is one of the greatest achievements of the twentieth century. The common belief that population aging will adversely affect existing pension plans and that public pay-as-you-go programs must be replaced by private pension funds is challenged as both schemes require the same economic conditions to ensure sustainability, namely economic growth and wealth creation. Barr (2002) shows that, from an economic point of view, demographic change is not a strong argument for a shift towards funding and that private pension programs may turn out to be less efficient due to higher administrative costs.

Mullan touches upon the trend of population aging by concluding that by 2050 demographic balance will have been restored in most of the industrialized countries and percentage of elderly population settled at around 30%. Less developed countries, however, are expected to reach that balance with a delay, although through a faster demographic transition. Mullan

notes that for many developing countries, the current demographic structure dominated by younger population should be, in fact, considered a window of opportunity which could lead to accelerated economic growth.

Demographic dividend, however, depends on country managing to lower its birth rates and having its young dependent population grow smaller in relation to the working-age population. This would mean fewer people to support and an opportunity for economic growth if the appropriate social and economic policies are developed and sufficient investments made. Demographic transition has been slow in many of the world's least developed countries, with millions of women unable to choose the number, timing, and spacing of their children (Gribble and Bremner, 2012). In those countries, children and adolescents make up a disproportionately large part of the population but can have substantial economic potential if adequate investment is made in their health and education and new economic opportunities stimulated for them.

Mullan also challenges claims that population ageing (1) threatens economic growth, by suggesting that economic growth is driven by factors which are not significantly affected by population ageing, (2) is a significant burden on society and that benefits should be reduced, by showing that developed countries are sufficiently productive to create wealth needed to accommodate the ageing population, and (3) leads to higher healthcare costs and greater dependency, by reminding that ageing is not an illness and that most older people are neither sick nor dependent. Mullan argues that social and economic changes over the next 35 years are often understated and that there is no reason to suppose that the same degree of change will not continue as over the past half a century. Many of today’s projections, however, are prepared under the assumption that social security systems will remain unchanged in the future (Sigg, 2005). The fact remains though that with fewer people of working age, and consequently lower tax base and tax collection, economic growth will be slower as less money is available for spending on things that help the economy grow (Jain, 2016).

Sustainability of social security systems may be improved through job promotion or by reversing the trend toward early retirement, subject to the right policies being implemented. A job promotion, for instance, could drive labor market participation higher and partially offset the decline in labor supply caused by population aging (Clark et al., 2010). High labor market participation is considered just as important as economic growth by Mullan, although the

exact effects would vary depending on country's unemployment rate, average retirement age, the population of working women, birth rate, and the number of immigrant workers.

Reversing the trend toward early retirement, on the other hand, would moderate the paradox in which people live longer and enjoy better health, yet the retirement age remains unchanged or increases only marginally. Moreover, effective retirement age is, on average, significantly lower than the statutory threshold, which often results in companies using early retirement as a cost-effective and socially acceptable way of laying off workers (OECD, 2006). Aligning the effective retirement age with the statutory requirements instead of rising the legal pension age could moderate the issue, especially as the latter is often met with considerable resistance (Ebbinghaus, 2006).

Keeping the working population active for longer should, therefore, be a priority as it could drive economic growth, defer payments of pensions, unemployment, and disability benefits, and increase the tax base. As stated in the World Population Ageing 1950-2050 report (UN, 2001), the challenge for the future is "to ensure that people everywhere can grow old with security and dignity and that they can continue to participate in social life as citizens with full rights". At the same time "the rights of old people should not be incompatible with those of other groups, and reciprocal intergenerational relations should be encouraged."

3.4. The social security system of India and retirement options for an aging population

The Constitution of India recognizes state's duty to "make effective provision for securing the right to work, to education, and to public assistance in case of unemployment, old age, sickness and disability, and in other cases of undeserved want" (Pylee, 1979). Chronic unemployment, underemployment, and extreme deprivation inherent in country's social structure, however, are extending the vulnerability beyond the risks typically covered by the social security systems existing in the more developed countries (Kulkarni et al., 2015). To that end, provided sustenance to those who cannot work due to temporary or chronic reasons is often insufficient and untimely.

The original pension system of India, introduced by the British after the Indian struggle for independence in 1857, discouraged the employees from saving for their post-retirement life. The faulty Pension System Act of 1857 was thus soon replaced with the Indian Pension Act of

1871, which also marked the beginning of regular increases in pension intended to offset inflationary pressures. The universal social security system for the elderly was still off the table, like in many other developing countries of the time. Select government officials were the first to receive the pension benefits, as set by the Royal Commission on Civil Establishments in 1881, with further revisions introduced through Government of India Acts of 1919 and 1935, eventually leading to retirement benefits for all public-sector employees.

After the country's independence in 1947, several funds were set up by the Indian Government to extend the coverage to private sector employees. Retirement schemes today include (1) central provident fund, which is a compulsory, retirement savings program managed by the government for the benefit of its citizens, (2) gratuity programs, which pay out a sum of money to an employee once terminated, contingent upon meeting eligibility criteria such as a minimum five years of service, and (3) pension plans, through which employer contributes to a pool of funds set aside for worker's future benefit. Whereas provident fund and gratuity programs provide a lump sum amount at the time of retirement, pension plans typically make monthly payments to retired beneficiaries. Employee Provident Fund (EPF), introduced in 1995, along with a few smaller provident funds, currently constitute the largest social security program in India, covering approximately 10% of the active workforce. Workers contribute 10-12% of their monthly salaries to the fund and are repaid along with accumulated interest at the time of retirement.

Older adults in India are generally not well prepared to live or make financial arrangements by themselves. More developed countries, as mentioned earlier, have policies in place to make elderly citizens more self-sufficient and independent. China, which has always relied on adult children caring for aging parents, is shifting its focus towards alternative arrangements for providing elderly care. The country's Elder Care Home Without Walls program now makes government-paid service providers available to elderly citizens through local government. Similarly, Japan's mandatory Long-Term Care Insurance scheme (LTCI) institutionalizes home-help and rehabilitation services and makes them available to all adults above 65 years of age with diagnosed physical or mental impairment, regardless of income level or family support. Singapore, on the other hand, requires that all employees contribute 18.5% of their income to country's Central Provident Fund, the benefits of which can be used post-retirement. European countries use a combination of the above schemes, and along with

their own versions of government-run provident funds, include retraining and life-long learning programs to keep their older workers employed (Gangopadhyay, 2016).

Most of the programs introduced by the Indian government to accommodate the aging population had limited success. The 1991 United Nations General Assembly was an important milestone, resulting in the adoption of the United Nations Principles for Older Persons, which ushered governments into a new era and forced them to incorporate principles of independence, dignity, care, participation, and self-fulfillment of the elderly. The following year, India's Ministry of Social Justice and Empowerment introduced an Integrated Programme for Older Persons (IPOP) (Government of India, 2015a), making citizens 60 years and older eligible to receive basic amenities such as food, shelter, healthcare, and other welfare services. The scheme also extended financial support to non-governmental organizations (NGOs) and voluntary organizations which operate and maintain old-age homes and health clinics for the elderly. A host of government ministries have implemented various initiatives since 1992 to provide additional benefits to elderly citizens, some of which have either not been implemented nationwide or have failed due to lack of resources.

Central Sector Scheme of Integrated Programme for Older Persons (IPOP), set up in 1992 and revised in 2008 by the Ministry of Social Justice and Empowerment, aims at improving the quality of life of elderly population by providing food, shelter, and medication, in cooperation with government institutions, NGOs, and local organizations. The scheme also provides support for rebuilding and maintenance of nursing homes and other types of elderly care centers. Maintenance and Welfare of Parents and Senior Citizens Act enacted in 2007, in addition to IPOP, protects the elderly by requiring of their children to provide care to their parents once they reach 60 years of age. The Act also empowers the elderly to revoke property transfers in case they are neglected by their children (Gangopadhyay, 2016).

Although the government has already announced amendment to national pension policy, extending the right to pension to all age-eligible adults regardless of employment or sector status (Government of India, 2015a), as of 2015, the Atal Pension Yojana Scheme, program specifically geared towards unorganized-sector workers, had barely a million subscribers - far below the year-end goal of 200 million enrollments. While such low participation rates may seem difficult to explain, especially considering the monthly contribution of just INR 42 (about $0.6), it highlights just how difficult it may be to convince the low-income and low-

literacy households to save for retirement when more pressing everyday activities occupy their attention (Seth, 2015).

The universal systems of old age social security, typical for developed countries, is beyond the reach of most developing economies. Although achievable, universal coverage calls for a significant increase in tax rates or substantial cuts in other social programs, which again may adversely affect the poor and marginalized. According to James (1999), "universal old-age benefit is a luxury that developing countries cannot afford, nor is it the best use of their limited public resources." On the other hand, tying old age benefits to contributions, which is likely to be financially sustainable, is not applicable in developing countries as it would create a large group of uninsured or partially insured who would be left in poverty in their old age. A multi-pillar system, currently in use in some Latin American countries, is a compromise solution consisting of a contributory pillar and a redistributive public pillar financed from government general revenues (Kulkarni et al., 2016).

At the same time, chronic unemployment and poverty make it difficult for most of the population in poor countries to save for the future. Building the contributory system is limited by the informal employment sector, low female work participation, the reluctance of people to contribute due to their short-term view about the future, and their preference to invest in their children as the source of old age security. Similarly, developing and financing non-contributory component of the multi-pillar system through general revenues is constrained by high tax evasion, difficulties in collecting taxes from small enterprises, and low government enforcement capabilities.

Considering such limitations, India could benefit from a multi-pillar system of social security tailored for the elderly, with a (1) government-funded program for the poorest of the poor who cannot contribute, (2) partially contributory program for the marginally poor, supplemented by public resources, and (3) fully contributory scheme that directly matches contributions with benefits for the organized sector (Kulkarni et al., 2016). Similarly, in terms of elderly health care, improvements may be realized through (1) extended current health insurance schemes offering whole life coverage and no limit on entry age, (2) uniform insurance policies at affordable premiums, offered by all insurance companies, and (3) community based or cooperative models of health insurance (Agarwal et al., 2016). Grameen Bank in Bangladesh, village credit societies in some African countries and Self-Employed

Women's Association (SEWA) in India, have all tried to guide informal sector to adopt social insurance schemes that would help the poor in times of uncertainty. Table 3 outlines current programs and schemes aimed at elderly welfare in India.

Table 3. Overview of current programs and schemes aimed at elderly welfare in India (Agarwal et al., 2016; Kulkarni et al., 2016)

Sector	Scheme	Characteristics	Year of implementation
Health	National Program for Health Care of the Elderly	Community-based primary health care, with improved geriatric health services at district hospitals (specialized facilities for elderly at 100 district hospitals), and 8 dedicated regional medical institutions for tertiary-level medical care.	2010-2011
	Rashtriya Swasthya Bima Yojana	Health insurance coverage for households below the poverty level (including the elderly), and hospitalization coverage up to INR 30,000 ($462) for most diseases requiring hospitalization.	2008
	National Initiative on Care for Elderly	Courses for preparing skilled professionals to provide services to the elderly are provided.	2000
	Private insurance	Special health insurance schemes for senior citizens, offered by a host of private health insurance providers.	Varies
Finance	Incentives under Income Tax Act of 1961	Seniors citizens pay income tax on income only above INR 300,000 ($4,615) per year, with the limit for citizens 80 years and older being INR 500,000 ($7,692) (limits are periodically revised).	1961
	Concessions	Senior citizens enjoy 40-50% concessions on railway travel (40% for men and 50% for women), 50% discount on Air India airfares, and discounted tickets for public road transport.	Varies
	Senior Citizen Savings Scheme	Senior citizens are eligible for tax deduction under section 80C of the Income Tax Act as well as higher interest rates for savings accounts at national banks.	2004
Social	National Policy for Older Persons	Encourages individuals to make provision for their old age, families to take care of their elderly, and NGO	1999

		and voluntary organizations to supplement the care provided by families. It also provides healthcare facilities to vulnerable elderly and promotes research and training facilities for geriatric care.	
	Maintenance and Welfare of Parents and Senior Citizens Act	Obligates children and heirs to provide support to senior citizens and parents by monthly allowance (up to INR 10,000 ($154)).	2007
	Integrated Program for Older Persons	Provides basic amenities like shelter, food, medical care, and entertainment. Financial assistance is provided to NGOs (90% of project cost) for maintenance of old-age homes, respite-care homes, and continuous-care homes, mobile medical units, daycare centers for Alzheimer's disease patients, etc.	1992
	Indira Gandhi National Old Age Pension Scheme	Central government assistance of INR 200 ($3.1) per month to people in the 60-79-year age group and INR 500 ($7.7) to people above 80 years of age belonging to below-poverty-line households.	2007
	Indira Gandhi National Disability Pension Scheme	Provides pension of INR 300 ($4.6) per month to destitute with severe or multiple disabilities, who do not receive a pension from other sources.	2009
	Annapurna Scheme	Provides senior citizens 65 years of age or older, who are not covered by Indira Gandhi National Old Age Pension Scheme, a 35 kg of foodgrains per person per month.	2000-2001
	Indira Gandhi National Widow Pension Scheme	Pension of INR 200 ($3.1) per month to widows in the 40-59-year age group belonging to the below-poverty-line category. After reaching 60 years of age, the subscribers become eligible for Indira Gandhi National Old Age Pension Scheme.	2009
	National Family Benefit Scheme	Central assistance of INR 20,000 ($308) provided to the below-poverty-line household after the death of the head of household, who was in the 18-59-year age group.	1998
Development	Mahatma Gandhi National Rural	The Act guarantees 100 days of employment a year to any rural household whose adult members are	2006

	Employment Guarantee Act	willing to do unskilled manual work.	
Pension	National Pension System	The objective is to provide retirement income to all citizens. Initially introduced for government employees, as of May 2009, it is available to all citizens, including unorganized sector workers.	2004
	Swavalamban Scheme	Introduced for unorganized workers, with the government contributing INR 1,000 ($15.4) to each eligible subscriber who contributes a minimum of INR 1,000 ($15.4) and maximum INR 12,000 ($185) per year.	2010-2011

Note: Exchange rate of 65 INR for 1 USD was used.

Many of the schemes, however, are not reaching their targeted populations. Even in states where these programs were implemented, the utilization rates remain low due to poor public awareness (Alam et al., 2012). For instance, just 78% of older adults were aware of Indira Gandhi National Old Age Pension Scheme, 71% were familiar with Indira Gandhi National Widow Pension Scheme, while only 39% of respondents knew about Annapurna food scheme.

According to Building Knowledge Base on Population Ageing in India (BKPAI) survey conducted in seven Indian states, out of 40% of elderly who were aware of the concessions on railway transportations, only 9% were making use of the same (Kulkarni et al., 2016). When viewed by the wealth quintile, only 4% of the lowest quintile used the benefit. Similarly, pro-poor income taxes and higher interest rates were used primarily by the better off. It is, therefore, the outreach of such programs that is crucial for effecting substantial change for the elderly in India. At the same time, there are numerous inefficiencies in administering such programs, including (1) the lack of stakeholder participation in formulating policies (Gokhale, 2011), (2) multiplicity of schemes and implementing agencies, (3) improper program implementation (Mutalik and Shah, 2011), (4) variations in age criteria, (5) issues regarding eligibility criteria, with the process being too complex for the poor and illiterate rural elderly, (6) fraud and fake cases, (Irudaya Rajan, 2001), and (7) bribery.

In the age of technology, however, new opportunities are making it possible for project implementers to reach scattered elderly populations in remote rural areas or those with limited

mobility. Services such as TeleHealth, which include call centers offering health advice and support to older adults, have already had some success in high-income countries (World Health Organization 2007; Cimperman et al., 2013), with TeleHealth centers tailored for women already in place in India and Pakistan (Symington, 2013).

The Pension Parishad, an initiative to ensure universal pension to all workers in India, has proposed a universal and non-contributory old age pension system with a minimum monthly pension of not less than 50% the minimum wage or INR 2,000 ($30.8), whichever is higher (Dogra, 2013). The monthly pension should also be indexed to inflation and increased every few years, in the same manner as currently done for government officials.

The group cites several examples of low and middle-income countries where universal or near-universal non-contributory old age pension system has been adopted, pointing out that it would increase the purchasing capacity of the elderly and stimulate economic activity in small-scale and labor-intensive enterprises. Bolivia, for instance, has a gross domestic product (GDP) just 40% higher than India, yet manages to pay a pension of approximately INR 1,500 ($23.1) per person. Similarly, Lesotho, with a per capita GDP a third lower than that of India, operates a pension scheme which pays INR 2,300 ($35.4) per month per person. Kenya, on the other hand, pays an equivalent of INR 1,250 ($19.2) per person per month, yet the country's GDP per capita is only half of India's. Even neighboring Nepal, with the per capita GDP only a third of India's provides a pension of INR 313 ($4.8) per month.

The cost of implementing the Pension Parishad scheme, however, would amount to INR 2.5 trillion per year ($38.5 billion), or 1.4% of country's 2018 estimated nominal GDP, with the amount likely to be lower after excluding the elderly who are already receiving a pension. In comparison, the current cost of India's safety net is around 2% of GDP (Weigand and Grosh, 2008), with the spending on targeted, unconditional cash transfers which cover the elderly, widows, and disabled, accounting for less than 4% of that amount (Dutta, Howes and Murgai, 2010). Similarly, the spending on schemes comparable to the one proposed by Pension Parishad, such as Indira Gandhi National Old Age Pension Scheme and Annapurna Scheme, amount to less than 0.6% of the government revenue expenditure (Irudaya Rajan, 2001), implying the low priority of elderly care despite multiple government initiatives. Public spending on pension programs, therefore, remains a significant topic in social policy discussions.

At the same time, even though income security is crucial, it cannot be considered a substitute for adequate food and health services provided to the elderly. In that context, equal importance should be given to schemes such as the National Programme for Health Care of the Elderly and Annapurna scheme. Farahani, Subramanian, and Canning (2010) have made the case for extended health care by linking the increased survival rates of the elderly population to public health care spending, with every 10% increase in government spending leading to 3% decrease in deaths among the elderly, women, and children. A separate study by Yip and Mahal (2008), however, revealed significant disparities in access to health care for poor Indians and those living in rural areas, concluding that funding is only part of the story. Lastly, even after accounting for all elements with potential adverse impact and employing best case practices, effective and regular monitoring is indispensable.

3.5. Changing the socioeconomic status of older adults and the role of family and community networks

Unlike western societies, the Indian society is collectivistic, placing a strong emphasis on interdependence and co-operation, with family being the center of the social structure (Chadda and Sinha Deb, 2013). Families in India have a plurality of forms which vary according to social class, ethnicity, and personal choice. The joint family system, as one of the most distinctive features of Indian culture, constitutes a large undivided family with multiple generations living together in a common residence. Within such an extended family system, adults are expected to continue to live with their parents or in-laws, ensuring their care and support in old age (ILO, 2011a).

This tradition has nevertheless undergone profound changes over the past few decades, even in rural areas where approximately 67% of India's population lives (The World Bank, 2018b). As the joint family system continues to change, the elderly Indians may find themselves in a, particularly precarious situation. Although legal provision designed to empower the elderly to claim dependence on their children exists (Diwan and Kumar, 1984), as mentioned earlier, few parents choose to exercise their rights.

According to 2005-2006 National Family Health Survey, 78% of elderly Indians live within the same household as their children, 14% live with their partner, while only 5% live alone (Kumar et al., 2011). The percentage of elderly living with a spouse or alone, however, has

doubled since the early 1990s, while the percentage of those living with their adult children has increased by 7%. Aside for more obvious reasons such as lower fertility rates and rural-to-urban migration, it is the changes in societal norms that appear to be driving the trend.

A survey by Ramamurti and Jamuna (2005) revealed a 40% decline among adult children who believe it is their duty to care for their parents, from 91% in 1984 to 51% in 2001. This may not necessarily spell trouble for the elderly as evidence points out that even when they live apart, adult children and their elderly parents remain economically and socially interdependent (Husain and Ghosh, 2011). Bloom (2011), however, argues that in the future, family-based support will not be able to support the increased numbers of elderly citizens.

Strong family and community ties have traditionally been the sources of immediate support to their members, particularly in developing countries where social security programs are not well developed. As Indian society maintains a strong aversion toward institutional elderly care, cultural traditions continue to play a role in the life of elderly Indians. Such networks provide unofficial transfers of resources, also called intergenerational transfers (IGTs), from working and able members to the inactive and deprived part of the population. Bakshi and Pathak (2016) report that the direction of IGTs can be upward (from children to parents), downward (from parents to children), or lateral (from sibling to sibling), and in the form of time, money, and goods.

Bloom et al. (2010), on the other hand, divide the elderly coping mechanism into three components, namely the public transfers, private transfers, and asset-based reallocations, with different levels of development calling for different ways of dealing with age reallocations. In China, approximately a fifth of the elderly spending deficit is funded by their families. In Thailand, the estimate is around 33%. In more developed countries such as Japan and South Korea, the elderly are fully self-financed, while in India the net private transfers are negative for those aged 65 and older. This suggests that older family members contribute in other ways not measured by labor force participation or generated income. The conclusion is particularly true for rural households where most of the agricultural activities are subsistence-based. This is confirmed by other studies citing that the higher percentage of elderly and women in urban areas does lead to higher expenditures due to their lower incomes (and lack of alternative ways to contribute).

The social role of older adults changes once younger generations take over the responsibilities that were once performed by the older adults. Such changes often have a profound impact on the autonomy of the elderly, which is reflected in their ability to make decisions about matters that affect their lives. Kabeer (1999) reports that the process of empowerment is about making choices, and in the case of older adults, autonomy in decision making reflects that power. The vulnerability can thus be overcome if the older adults have sufficient power to still make decisions, implying that powerless elderly need to be empowered (Bakshi and Pathak, 2016).

Declining health accentuates the transition as the average yearly per capita expenditure on health care is almost four times higher for older residents (INR 2,890 or $43) compared to younger adults (INR 770 or $11) (Bloom et al., 2010). This is facilitated by the fact that approximately 47% of elderly Indians have at least one chronic disease such as asthma, angina, arthritis, depression, or diabetes (Chatterji, 2008), with the prevalence of diabetes and hypertension predicted to increase as population ages. At the same time, 33% of the elderly have undiagnosed hypertension, while more than a quarter are underweight. This highlights the prevalence of non-communicable diseases, most of which go undiagnosed and remain untreated, as well as the differences in access to health care (Alwan et al., 2010; Mahal, Karan, and Engelgau, 2010).

Increased urbanization further disrupts traditional family patterns by gradually decreasing the proportion of people living in rural areas. As younger family members migrate to towns and even foreign countries, the older generation typically loses the support of their children. Another influencing factor, which affects older people in urban areas more than in rural, is the increased participation of women in paid employment outside the home (Ramanujam et al., 1990). On one side, this opens opportunities for grandparents to care for the children and help manage day-to-day tasks. On the other hand, the women, who are traditional caregivers, will no longer be available for that role, leaving the elderly to fend for themselves. Another less often mentioned factor of the well-being of older people is the quality of a relationship the person has maintained with his or her family throughout life, as it becomes difficult to improve relationships in the later period.

Family support becomes especially necessary once the elderly person becomes single due to the death of a marriage partner. As the incidence of widowhood is much higher among females, they are in greater need of family and community resources. The proportion of

widows and widowers in India, however, has been on a decline since 1961, partly due to relaxation of the taboos against remarrying and partly due to increasing life expectancy.

At the same time, the increasing longevity gap between elderly males and females suggests that the Indian elderly population is growing increasingly female. The 1950 ratio of elderly females to males of 50.8% has reached 52.5% in 2015 and is projected to further increase to 53% by mid-century. In the above-80-years segment, the ratio is forecasted to increase from the current 55-56% during the same period (United Nations, 2015). The country-wide trend, however, masks significant heterogeneity between individual states. The half-year difference in Bihar, for instance, and the 4.1-year difference in Rajasthan, implies that different states will have to deal with different gender profiles in their elderly populations, and will likely require tailored policies and programs from their local governments (United Nations, 2015).

The prevalence of widowhood is an oblivious and potentially crippling side effect of sex ratio imbalance across India. In 2012, approximately 8% of elderly Indian males 60-64 years of age were widowed compared to 35% of females. At the same time, as much as 60% of females 80 years of age and older were widowed, compared to 27% of elderly males within the same age group (Desai et al., 2015). Elderly widowed females often suffer from income insecurity due to inheritance law which favors sons over daughters (Dey et al., 2012; Sathyanarayana et al. 2014), experience higher morbidity due to both communicable and non-communicable diseases, yet are significantly less likely to seek medical attention (Agrawal and Keshri, 2014).

Elderly women are also disadvantaged when it comes to education and literacy, relative to their male counterparts. According to IHDS-II survey, as of 2012, 78% of elderly women were illiterate, compared to 45% of elderly men (Desai et al., 2015). The disparity is particularly notable when compared to younger age cohorts, as both sexes in the 15-64 age group have nearly identical literacy rates (63% for females and 64% for males). Due to such differences, older women find it more difficult to learn about health risks and government benefits. Women were also more likely to report poor health, to be widowed, and less educated, which is consistent with the findings of other studies. Elderly households are facing additional hardships as almost four-fifths have no running water in the house, 73% have no refrigerator at home, 15% have no electricity, while more than a third do not have private toilet facility.

Elderly abuse, reported by as much as 50% of elderly people in India, is another reason for stronger family and community support (Govil and Gupta, 2016), even though increased geographical mobility, changing family patterns, diseases, natural disasters, as well as underemployment, poverty, and destitution, are all placing major strains on their capacity (Sigg, 2005). Agewell Foundation, however, reports that around two-thirds of elderly are neglected by their families, while a third have experienced physical and verbal abuse. Moreover, around a quarter of senior citizens reported being exploited by their family members, in most cases due to financial and emotional reasons. High illiteracy rates further increase elderly exposure to abuse, with studies showing that older citizens with at least eight years of education are more likely to avoid abuse (Gangopadhyay, 2016).

Ironically, the family support system which has always been available to society's older members is one of the reasons why a state-financed pension in India has remained limited. Some policymakers are supporting the revival of the joint family system through legal reform which would force adult children to care for their aging parents and relatives (Kanti Sahu, 2010). Bimal Kanti Sahu, Insurance Commissioner of the Employees' State Insurance Corporation in India, warns that such policies may be counterproductive and further aggravate the situation. Others have suggested that the working population should be encouraged to save for their retirement, either through public or private programs. It is likely, however, that a balanced approach between traditional familial and community support system and self-support in the form of pension will be needed. With less than a quarter of the world's population having access to social security (van Ginneken, 2002), the state-supported mechanism could reinforce informal channels by stepping in when larger contingencies happen.

The challenge of caring for the elderly is not just an issue for Indian families but also for families in most of developing countries across Asia, Africa, and Latin America. Like India, these countries are dealing with rapid population growth and overstretched resources, the problem which is compounded by the fact that most of the elderly work within informal sectors and are excluded from the official social security programs. As stated by the International Labor Organizations' social security expert team, well-designed programs have proven to be "very effective in preventing poverty and social insecurity throughout an individual's entire life cycle" (ILO, 2011b). Social spending, therefore, should not be viewed as a hindrance to economic development but as rather necessary for economic growth.

The ILO's team of experts also noted that a well-designed basic social security package is affordable in virtually all countries. In their concluding remarks, they urge the governments of developing countries to roll out universal social security schemes, as if nothing is done, those nations may soon have to deal with a growing number of elderly people living in poverty. It is also important, according to Bimal Kanti Sahu, to recognize just how much the aging population has contributed in their younger days to the development of their countries, and act accordingly to ensure that elderly citizens live out their lives with dignity.

3.6. The necessity to work post retirement

Elderly in India continue to work well after the retirement for a multitude of reasons, one of them being that economically active older adults are more favorably treated by their respective families (Yadava et al., 1996). Older family members, particularly in lower-income households, are aware of their dependency (Alam, 2006), which is often compounded by the changes in their physical mobility and chronic health conditions. A substantial portion of older males, in turn, opt to remain employed after they retire, with the percentage being higher for older males living in rural areas (57-61%) than for older males in urban areas (33-42%). Majority of older females, in contrast, remain engaged in domestic duties (41-44% in rural areas and 47-52% in urban areas) (Bakshi and Pathak, 2016).

Nevertheless, elderly labor force participation for both sexes has been declining for decades, which is in line with the trends in more developed countries (Figure 9). Withdrawing from labor force ahead of legal-age retirement, however, has important implications for one's income and lifestyle. While labor income in the majority of developing Asian economies drops below consumption level between the age of 55 (China) and 58 (Thailand), older workers in more developed Asian nations such as Indonesia and Philippines continue enjoying increasing labor income later in life (Mason and Lee, 2011). Delayed retirement could mitigate old-age dependency in rapidly aging countries such as India, although Lee and Ogawa (2011) report that the effects of delayed retirement for those in 65-74 age group would be negligible as their activity rate is already high. The real issue, they infer, seems to be low productivity, which makes the benefits of working longer less important. The authors conclude that improving the productivity of older workers should be the primary mechanism for securing higher incomes at older ages.

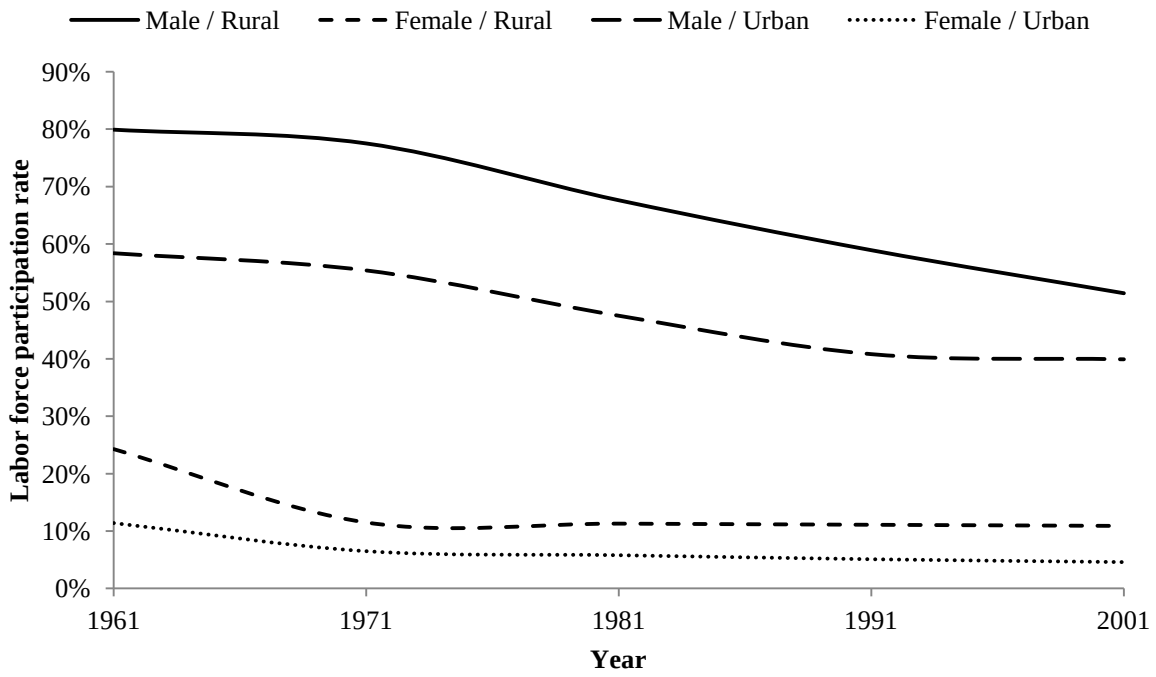

Figure 9. Labor force participation for people aged 60 or more years, by place of residence and gender (Bakshi and Pathak, 2016)

Higher rural employment rates reflect the fact that large agricultural economies and rural areas, in general, absorb older workers more consistently compared to more industrialized and manufacture-based economies. Higher employment rates in rural areas are also driven by higher land ownership, as discernible from employment categories compiled by Bakshi and Pathak (2016) (Table 4). As much as 41% of elderly males in rural areas are self-employed, compared to 22% in urban parts of the country. Similarly, casual wage labor accounts for 13% of elderly male employment in rural areas and only a quarter of that figure in urban areas. Regular salaried or wage employment, however, is more readily available in towns and cities, accounting for 4 percentage point higher employment there. Similar differences were observed for older females, although to a lesser degree. It appears that the percentage of working elderly women is more than twice as high in rural areas than in urban and that a higher percentage of them are employed as domestic help in rural areas than in the cities.

On the unemployed side, the most pronounced difference is between the older male recipients of rent, pension, and remittance in rural and urban areas. More than a third of urban elderly receive such provisions, compared to only 9% of their rural counterparts. For older females, the percentage difference for this category is much smaller (9% and 6%, respectively). There

are no significant differences across other unemployed elderly male categories. For elderly females, on the other hand, the most notable difference is in the type of work done, which does not constitute actual employment. While a higher percentage of older unemployed females who live in urban areas attend to domestic duties (43% vs. 29%), older women in rural areas tend to be engaged in additional activities other than day-to-day household work (14% vs. 5%).

Table 4. Sample percentage of working older adults in India during 2004 (Bakshi and Pathak, 2016)

Categories	Categories of employment as per the survey	Rural males	Rural females	Urban males	Urban females
Older adults in the workforce	Self-employed: Own account worker	40.63	3.43	21.74	2.42
	Self-employed: Employer	1.52	0.49	1.13	0.02
	Self-employed: Helper	3.39	5.71	1.72	1.92
	Regular salaried or wage employee	1.16	0.19	4.80	1.16
	Casual wage labor: public work	0.03	-	0.03	0.00
	Casual wage labor: another type of work	12.76	6.06	3.42	1.98
	Not working but seeking for work	0.03	0.05	0.08	-
	Subtotal of older adults in the workforce	59.52	15.93	32.92	7.50
Older adults not in workforce	Attended educational institution	0.08	0.30	0.28	0.27
	Attended domestic duties only	1.25	29.27	1.76	43.35
	Domestic duties plus other	0.47	14.41	0.43	4.99
	Recipients of rent, pension, remittance	9.39	5.68	35.16	9.45
	Not able to work due to disability	5.19	3.73	3.72	3.02
	Beggars, prostitutes, etc.	0.19	0.22	0.09	0.24
	Others	23.92	30.47	25.64	31.18

Note: Original source is the sixtieth round of the National Sample Survey.

At the same time, the proportion of elderly who report being financially dependent has declined as well for both sexes and across almost all age groups (Table 5). Nevertheless, the elderly females remain significantly more dependent than older males, as already noted earlier. The dependence is driven partially by longer lifespan and associated higher chance of widowhood (due to the cultural practice of Indian men marrying women younger than themselves), partially due to discrimination and lack of care from the family, and in part due

to limited rights to the property. Special attention is therefore needed in securing appropriate support and care for older females (Rajan and Gayathri, 2017).

Table 5. The proportion of older adults who are reported to be financially dependent, by age group (Bakshi and Pathak, 2016)

Age group	1986-1987		1995-1996		2004	
	Males	Females	Males	Females	Males	Females
60-64	.38	.89	.35	.83	.33	.82
65-69	.49	.94	.44	.88	.45	.86
70-74	.64	.96	.60	.92	.59	.90
75-79	.70	.98	.68	.93	.65	.91
80-84	.78	.98	.75	.97	.74	.91
85-89	.81	.97	.71	No data	.78	.92
90-94	.88	No data	.86	No data	.89	.96
95+	.91	No data	.85	No data	.86	No data

Note: Original sources are the 42nd, 52nd, and 60th rounds of the National Sample Survey.

Financial dependence correlates with, among other variables, the employment status of the elderly (Table 6). The effect is striking for both elderly males and females, with employed older males reporting up to three times higher independence (76%) compared to their unemployed peers (26%). The older females reported an even more extreme five times higher financial independence (47%) compared to those who are not part of the workforce (9%). Moreover, the elderly who are partially dependent on others also reported higher independence when working, although the effect is not as pronounced. The overall trend, based on three separate surveys, is that of higher financial independence, for both fully and partially independent categories of elderly, although more for older females than males.

Aside from employment status, property ownership also affects the financial dependence of the elderly, with the odds in favor of those who own property being 2.06 compared to the elderly without any property. Similarly, in terms of partial independence, the odds of those who own property are 1.28 times higher than for the elderly who do not possess any assets (Bakshi and Pathak, 2016). Only 28% of elderly males and 11% of elderly females in India own more than an acre of land (4,047 m^2). Moreover, there is a significant gap in the ownership of land (51% of males and 24% of females), housing (80% of males and 46% of females) and savings (32% of males and 15% of females) between sexes, which explains the overall higher financial dependence of older females.

Table 6. Sample proportion working (1) and not working (0) older males and older females with their reported state of financial dependence (Bakshi and Pathak, 2016)

Category	1986-1987				1995-1996				2004			
	Males		Females		Males		Females		Males		Females	
	1	0	1	0	1	0	1	0	1	0	1	0
Not dependent on others	.76	.17	.35	.04	.74	.21	.74	.21	.76	.26	.47	.09
Partially dependent on others	.19	.14	.43	.09	.21	.15	.21	.15	.18	.12	.30	.09
Dependent on others	.05	.69	23	.87	.05	.64	.05	.64	.06	.62	.23	.82

Note: Original sources are the 42nd, 52nd, and 60th rounds of the National Sample Survey.

3.7. Major studies on population aging and workforce participation

There are currently two major studies and sources of data on aging and workforce participation in India, (1) the Census of India 2011 (Government of India, 2015b), and (2) UNFPA's Report on the status of elderly in select states of India 2011 (Alam et al., 2014). Both studies were carried out at about the same time, with the former encompassing entire population of India and latter relying on a sample of about 10,000 elderly respondents.

The Census of India, for instance, reveals that 42% of adults 60 and older and 22% of adults 80 and older still participate in the workforce. Furthermore, it provides a breakdown by urban and rural area, individual states, gender, and time spent working during the reference period, and makes a distinction between cultivators, agricultural laborers, household industry workers, and others. However, (1) it doesn't indicate what type of agricultural activities are performed by the respondents, (2) what sort of effort is required in performing them, or (3) what constitutes respondent's everyday involvement in agriculture. At the same time, (1) it relies on self-reported figures rather than measured values, (2) doesn't account for differences in land ownership and household size when reporting work participation by age, and (3) uses age ranges rather than individual age in most datasets. Such high-level overview is suitable for high-level decision making. When it comes to understanding the exact impact aging has on agriculture, a more detailed approach is preferred. Above-identified gaps are therefore the core of proposed research.

The UNFPA report offers a comparable level of detail. It mentions, for example, that about 47% of India's rural elderly remain in the workforce, with more than 70% of them citing economic necessity, rather than personal preference, as their main reason for remaining in the workforce. It further reveals that majority of workers are in the 60 to 69 age group, that more than 80% of them are main workers (defined as persons working six or more months during the year preceding the date of enumeration), and that work participation is considerably higher for men than for women. Nonetheless, it suffers from the same lack of detail as the Census of India, thus supporting the case for a more elaborate and focused study.

CHAPTER 4: RESEARCH APPROACH AND METHODS

4.1. Study area and data collection

The research focuses on smallholder farmers within Lakhisarai, one of the thirty-eight districts of Bihar state (Figure 10). The 472-village district in eastern India is made up of seven sub-divisions, with headquarters and major administrative centers situated in Lakhisarai, along with two additional municipal towns (Government of India, 2015a). The district is spread across 1,228 km^2 and can be divided into hilly, flood-prone, and plain areas, intersected by the three main rivers: Ganges, Kiul, and Harohar. Around 59% of all land is irrigated (51,304 hectares), with additional 9,631 hectares classified as a cultivable wasteland, while 3,305 hectares are under forests.

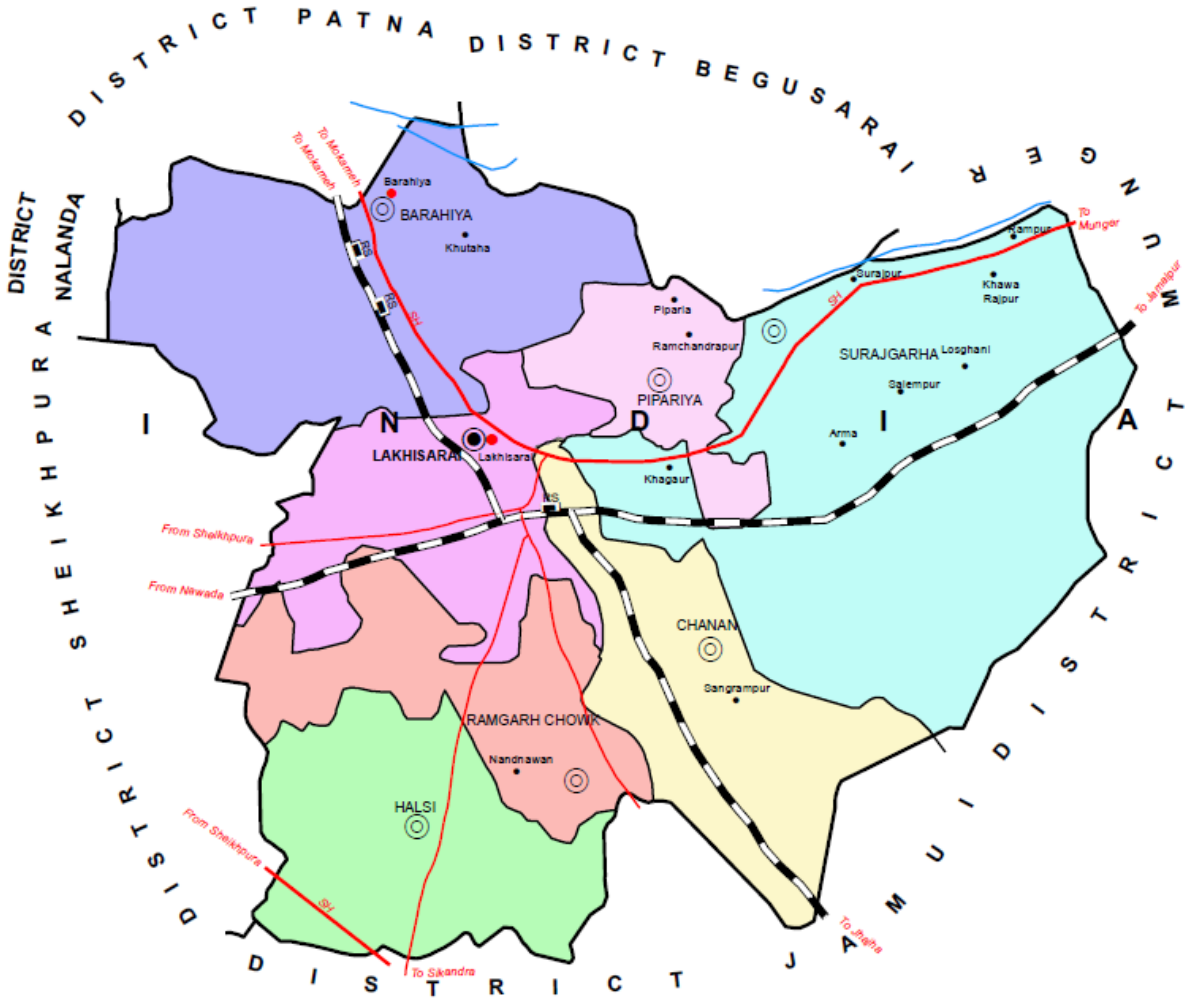

Figure 10. Sub-division of Lakhisarai district, Bihar, India (Government of India, 2015b)

The district is situated at one of India's poorest states, with 34% of the population living below the poverty line (12 percentage points above the national average). It is home to just over a million people, predominantly Hindus, 85% of which are situated in rural areas. The population density of 815 inhabitants per square kilometer is slightly below the average for the state of Bihar (1,102 per km^2), while the literacy rate of 62% is considerably above the state average of 47% (the lowest literacy rate of all Indian states). As much as 67% of the population are non-workers, around 20% are part of the workforce (31% of males and 8% of females), while 12% are marginal workers. Almost half of them are agricultural workers (work on another person's land), 24% are cultivators (work on their own land or that of the government or private persons or institutions), while only 4% work in the industry.

The target population for the purpose of this study is defined as heads of households whose primary occupation is agriculture. Head of the household status is assigned to a person running the household and looking after qualified dependents. The household must also be located at the person's home and the person must pay more than 50% of the costs involved in running the household. Both requirements are stated at the beginning of the questionnaire and used as elimination questions.

As the study aims at achieving the results with 95% confidence interval and 5% margin of error, about 400 surveys were collected, a target chosen based on the availability of resources, region's geographical setting, and local transportation options. An additional 200 elderly household member samples were gathered as well and contrasted against the main batch of samples in several regression analyses. The research was carried out with the help of five local student-researchers during a two-week period in November 2017. Incidentally, the fourth quarter also marks the end of the south-west monsoon season in Indian sub-continent and overlaps with winter rice harvest - the country's main rice growing season. Dozens of other crops are harvested at about the same time, including millet, maize, soybean, sugarcane, and others, providing a wealth of opportunities for surveying.

Simple random sampling was used to select 12 villages within Lakhisarai district so that each village has an equal and known chance of being selected (Yates et al., 2008). A general overview of chosen villages, including geographical area, number of households, and the total population is provided as well (Table 7). While the Indian villages vary considerably in size,

the average of 552 households per village and resulting sampling frame of 2,948 households (12 villages x 552), should provide sufficient basis for surveying.

Table 7. Selected villages within Lakhisarai district (Government of India, 2015b)

Name	Sub-district	Total area (km^2)	Households	Population
Paharpur	Barahiya	1.57	220	1,507
Jajwara	Pipariy	1.75	211	1,410
Bar	Surajgarha	1.47	189	987
Mohanpur	Surajgarha	1.23	86	688
Modnipur	Surajgarha	1.00	381	2,128
Nandpur	Surajgarha	0.53	293	1,730
Chamghara	Lakhisarai	1.23	339	1,981
Khirho	Lakhisarai	1.27	125	871
Mahulia	Chanan	1.43	210	1,449
Balahpur	Chanan	0.73	217	1,336
Dudi	Ramgarh Chowk	2.36	355	2,203
Ballopur	Halsi	3.35	430	3,250
Total		**17.92**	**3,056**	**19,540**

In the field, systematic sampling was used to select every fifth house, the method applied as it allows sample size to be targeted. If the household was unavailable for the interview, the surveyor would skip the next four houses and move on to the fifth. No incentives were given due to potential bias (Gideon, 2012), and no repeat visits were made due to time and resource constraints. The approach generated the pool of approximately 611 potential respondents, thus providing the base large enough should some households be unavailable or unwilling to participate.

4.2. The role of a semi-structured questionnaire

The questionnaire consisting of six interrelated sections was used to collect data on (1) demographics, (2) ownership, (3) income, spending and savings, and (4) agricultural work (Appendix A). The semi-structured questionnaire was used as it offers the advantage of interviewing a relatively large number of respondents in a quick, easy and efficient manner, thus making it a reliable way of conducting research. On the other hand, (1) semi-structured questionnaire makes complex issues and opinions difficult to capture and evaluate, (2)

respondents could misunderstand some of the questions, and (3) close-ended questions restrict respondent's answers to categories considered important by the researcher. Nevertheless, the positivist approach and application of primarily quantitative instead of qualitative methods of research allowed for the collection of statistically useful information about the researched topic, making it a vital instrument by which statements will be made about targeted population.

The questionnaire is composed of 31 close-ended, multiple choice questions, and 4 open-ended questions. Multiple choice questions, as the name suggests, offer the respondent several options to choose from, while open-ended questions come with no predefined categories (Bechhofer and Paterson, 2000). Multiple choice questions used in the questionnaire vary from simple yes or no questions to more elaborate questions offering up to 14 choices. All multiple-choice questions, however, are logical, easy to understand, and designed to test comprehension and critical thinking, not just recall. For instance, asking to identify the most important piece of agricultural equipment prompts the respondent to consider all equipment within the household, their use, and finally their importance.

Open-ended questions, on the other hand, ask the respondent to answer in his or her own words. For example, asking to name the three most important activities performed during the past month instructs the respondent to rethink activities performed and report three most prominent ones. Some of the open-ended questions, namely the ones related to the difficulty of reported agricultural activities, also come with a five-point Likert scale, universally considered one of the most reliable ways to measure opinions, perceptions, and behaviors (Brace, 2008). The scaled questions offer five options ranging from "very easy" to "very difficult" and are essential for constructing the work intensity indices. The four open-ended questions also come with two sub-questions each, inquiring whether the motorized equipment was used to perform reported activities and if yes, whether the interviewee owns the equipment.

The questionnaire begins with two elimination questions intended to verify the respondent's primary occupation and status within the household. The first question ascertains respondent's engagement in agriculture, while the second confirms the respondent's fitness to answer remaining questions. It continuous with 6 demographic questions, inquiring about farmer's age, the number of household members, and the number of dependents, defined as persons

aged 18 and younger and 60 and older. The age range was deliberately chosen to accommodate some 40% of children who opt to pursue secondary (high school) education typically lasting up to the age of 18 (The World Bank, 2011), and farmers aged 60 and older, even though official retirement age varies across states and occupations (56-60), but not gender. Responses are meant to form the effective base for further questions and demonstrate whether larger households advance or retard a decline in agricultural involvement, and how the number of dependents affects a household's income and spending.

The next section collects details on household ownership, including house, land, equipment, and animal ownership. The questions are meant to be used as proxy variables for estimating household wealth and help reveal whether higher land ownership advances or retards a decline in agricultural involvement. The section is followed by income, spending and savings set of questions. Although expressed in units of currency, answers to these questions are potentially less reliable compared to ownership questions due to reluctance on respondent's side to reveal their true financial situation (Tourangeau and Yan, 2007). The phenomenon, especially observable when interviews are carried out in public venues, was confirmed during author's own experience in Bangladesh, where contradictory answers in terms of income, spending, and saving were frequently recorded.

Agricultural work section, as questionnaire's core, consists of 15 questions inquiring about (1) farmer's work experience and diversity, (2) months during which work is most and least demanding, including hours worked, (3) most important activities performed during those months, including their difficulty, and (4) whether work is performed on farmer's land, helping friends and family, or as hired labor. The questions are sub-divided into a set of questions devoted to recurring activities performed every year, and a set related to activities performed only recently, namely within the past month. Such an approach is meant to assure that all relevant activities are captured and included in the research.

Additional four questions stated at the end of the questionnaire are used for collecting the data on household members who are not heads of households and are 60 years of age or older. Such a set-up is used to produce comparable results for senior household members and obtain insight into how agricultural work differs between active and seemingly passive agricultural workers, without the need to repeat all above-described questions.

4.3. The role of accelerometer-based devices

The experimental part of the research involves distributing accelerator-based devices, also known as step trackers (part of the fitness tracking family of devices), to 200 randomly selected respondents, and measuring their motion while performing common agricultural activities (Appendix B). Each session will be recorded using a step-tracking device, worn by the respondent, and activity chart, filled by the interviewer. Such an approach allows for visual identification of the beginning and the end of each activity and excludes any idle time during the session.

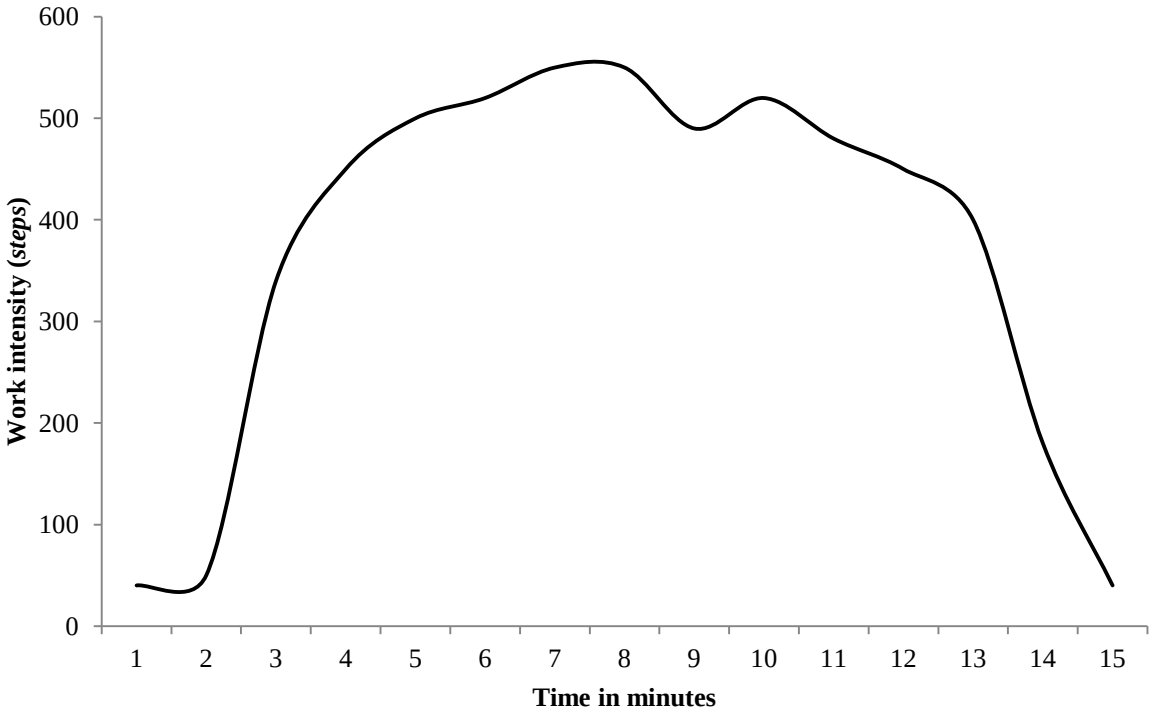

Figure 11. Tracking work intensity in the field (author)

Figure 11 shows a 15-minute work intensity simulation for rice harvesting. It accounts for the probability that the respondent may not be fully engaged in the activity throughout the session, with the likelihood of taking a break, talking to an interviewer, or switching to another task. The high areas in Figure 11 represent the session phases which will be used to construct the work intensity index for each activity. The low areas, on the other hand, stand for atypical work brakes, usually not part of the activity, and as such are excluded from the calculation. The final product of such an endeavor is a work intensity index by activity, respondent's age, and gender. Although Figure 11 showcases a 15-minute sample, only 10

minutes of effective work will be captured and used in the analysis. This reflects the exploratory nature of the study, aimed at setting the base for further research.

Fitness trackers are therefore a critical part of the experimental phase of research. Although there is a great multitude of options to choose from, they can all be classified as either accelerometers or heart rate monitors. The following passages explain the strengths and weaknesses of each type, thus justifying the choice of the accelerator-based device over heart rate monitors, and step tracking over heart rate or calorie monitoring (Figure 12).

Figure 12. Fitbit Charge 2 - fitness tracker used in the study to track movement (Fitbit, 2018)

Accelerometer-based monitors rely on predictive equations using the body's acceleration in different directions to report steps, distance, and energy expenditure. Fitbit, NikeFuel, and Jawbone are examples of accelerometer-based wristbands (Fairman, 2016). Heart-rate monitors, on the other hand, use equations based on age, height, gender, physical activity level, and resting heart rate to estimate the average heart rate and the number of calories spent. Garmin, Omron, TomTom, and Polar are popular choices within this segment.

Heart rate monitors can further be divided into wrist-worn and chest-strapped monitors. Chest-strapped heart devices consist of two parts: a transmitter attached to a belt worn around

the chest, and a receiver worn on the wrist. As the heart beats, an electrical signal is transmitted through the heart muscle, making it contract. Transmitter part of the heart rate monitor then picks up the signal through the skin and sends the data to the wrist receiver which displays the heart rate. The device emulates a real electrocardiogram (EKG) machine by measuring electrical pulse. Most common issues faced by users include the need to (1) properly position and tighten the strap, which makes it uncomfortable for most wearers, (2) have a fair amount of moisture between the sensor and skin at all times, as the lack of moisture affects the device's readings, and (3) eliminate electrical interference from static electricity generated by synthetic clothes.

Wrist-worn devices, on the other hand, use light to track the blood flow. The optical sensors placed on the back of the watch illuminate the capillaries with a light emitting diode (LED), allowing a sensor adjacent to the light to measure the frequency at which blood is pumped (a.k.a. the heart rate). The readings are then translated into beats per minute (BPM) (Profis, 2014), requiring that the wearer remains still, meaning no talking, moving, muscle-tensing, or even sweating. There's another complication: by the time blood reaches the capillaries in the wrist, it has already slowed down to a rate that doesn't quite reflect the true heart rate, especially while performing high-intensity activities. Moreover, the accuracy can also be reduced by light leaking in and affecting the sensor.

Chest-strapped heart-rate monitors are therefore more accurate than wrist-worn equivalents, and generally better at estimating energy expenditure compared to accelerometer-based devices. Polar heart rate monitor, for instance, accurately estimates energy expenditure while running, rowing, and cycling for males, although it overestimates energy expenditure by as much as 12% for females (Dannecker et al., 2013). When used at higher intensities such as interval training, however, the accuracy of heart-rate measurements decreases (Crouter et al., 2003). The generalized heart-rate equations are to blame since although they make the device applicable to a much wider audience, they also significantly limit the device's accuracy.

Other factors may influence the truthfulness of recorded values, including the stress rate of a person wearing the device, excitement level, body temperature, and even hydration status, as these may affect the heart rate and energy expenditure. For example, measuring heart rate in Lakhisarai in July, when it is 33°C and 90% humidity will increase the heart rate, similarly as when exercising in a dehydrated state. Fitness status can also alter the accuracy of these

monitors, with fitter individuals having overall lower exercising heart rate at any given intensity, compared to unfit individuals (Wang et al., 2017).

Accelerometer-based monitors, much like their heart rate equivalents, are known to overestimate or underestimate energy expenditure (calorie counting) by some 10-15% compared to laboratory-based standards, depending on the device (Lee et al., 2014; Diaz et al., 2015). The mode of exercise plays an important role as well, with precision typically declining as intensity increases (Sasaki et al., 2014). These devices come with a 3-axis accelerometer to track movement in every direction. Some of them are also equipped with a gyroscope as well as to measure orientation and rotation. This type of gearing allows them to track the movement and convert raw data into steps.

Most studies agree that accelerometer-based monitors are accurate when it comes to counting steps, however. Evenson et al. (2015) in their review of 22 studies on validity and reliability of consumer-wearable activity trackers, reported Pearson correlation higher than 80% for Fitbit and Jawbone devices in laboratory-based step counting studies. Seven studies focusing on inter-device reliability using Fitbit demonstrated the consistently higher inter-device reliability of step counting for walking and running.

In a field-based setting, two studies comparing accelerometry-assessed physical activity against tracker measurements had one report high Spearman correlation of 86% for Fitbit device, while the other had more mixed results for Fitbit and Jawbone. Additionally, a study by Paul et al. (2015) confirmed that step counting devices may be used among elderly population, as shown in their 2-minute walk test, leading the authors to conclude that the Fitbit tracker used in the test is sufficiently accurate to be used among community-dwelling older adults to monitor and give feedback on step counts.

Measuring steps or movement, therefore, eliminates the bias associated with hearth and calorie measurement, as raw data is recorded and used as-is, without any additional conversion. Although the tracker might dismiss a small movement of the wrist and not include it as a step, the accuracy can be improved by entering personal information such as age, gender, height, and weight of a person, and by wearing the device on the same wrist (Nield, 2017), as done in this study. Accelerometer-based devices are thus more suitable for tracking agricultural activities as compared to heart rate equipment or gadgets tracking energy

expenditure. They are comparatively more accurate, easier to use in the experiment, and relatively inexpensive, and as such the tool of choice.

4.4. Constructing work intensity and agricultural involvement indices

Two broad sets of work intensity indices will be constructed: one using a semi-structured questionnaire, and the other based on data collected using accelerator-based devices. While the former will rely on approximately 400 head of household and 200 elderly household member samples, the latter will be calculated using about 200 in-field samples. The questionnaire-based work intensity indices will thus encompass a much wider array of agricultural activities and levels of difficulty, as reported by farmers, while the device-based work intensity indices will focus on seasonal activities, as captured by the interviewers.

The two datasets will also be correlated to test whether motion tracking devices can be used to estimate work intensity for most commonly performed agricultural activities. Comparability principle requires that both variables use comparable scales, which calls for data normalization. While the self-reported difficulty of agricultural activities relies on a five-point Likert scale, and as such has a range of 1-5, the in-field measured intensity has no pre-set upper and lower limits. As an alternative, a maximum measured value for each activity-plant combination is used, resulting in comparable difficulty percentages. For example, if the maximum reported activity difficulty for binding rice straws is 894, while the activity difficulty reported by an individual farmer is 554, then the age-specific percentage difficulty for that activity would be 62% (554/894*100).

Methodology-wise, the questionnaire-based indices rely on a set of questions inquiring about the most important activities performed by farmers during the busiest month of the year, the least busy month, and the month immediately preceding the interview (October). Such an approach allows for a single overarching intensity index to be developed, which would encompass all three categories (busy, least busy, and the preceding month).

Individual work intensity indices for each of the activities are constructed using the below formula, where WII is the work intensity index and ADL_n stands for activity difficulty level (1). The lowest level of difficulty, termed *very easy*, is assigned number one. The next level, labeled *easy*, is assigned number two, and so on up to number 5, which corresponds to *very*

difficult. Under such setup, should respondent rate all three activities as *easy*, the total score (index) would be 2 (6/3), and following the same logic, should all three activities be rated as *very difficult*, the final index would be 5 (15/3). Constructing any other sub-index by farmer's age or gender, or individual agricultural activities, for instance, then becomes a matter of simply pivoting the data.

$$WII = \frac{ADL_n}{n} \quad (1)$$

Work intensity indices developed using raw data recorded by accelerator-based devices are conceptually the same, with the sole exception being the data source, namely the self-reported activity difficulty levels for the questionnaire, and recorded data in case of accelerator-based devices. At the same time, agricultural involvement index is calculated as part of the H_{oa} hypothesis testing, defined as a product of the average hours worked during the three documented months and self-reported difficulty of performed agricultural activities during those months, where *AI* is agricultural involvement, AHW_3 represents average hours worked during the three documented months, and AD_3 is the average self-reported difficulty of performed activities during the three documented months (2).

$$AI = AHW_3 \; x \; AD_3 \quad (2)$$

The complication of normalizing categorically different scores for average hours and average activity difficulty is avoided by aggregating the criteria using simple multiplication. This step removes a good deal of subjectivity in the analysis as it eliminates the need to make a choice of normalization type (Tofallis, 2014).

4.5. Calculating the cost of aging

The cost of aging will be derived using reported household expenses, the number of elderly household members, and their age. The average age of elderly household members will be calculated, along with the average household member cost of living. The simple linear regression using the two variables, where former is independent and latter dependent, should provide support for the H_{0j} hypothesis predicting that higher average age of elderly household members should lead to higher average household expenses. The second hypothesis (H_{0k}),

stating that higher number of retired household members should correspond to higher average household expenses, will be assessed as well, using the number of elderly persons within the household as an independent variable.

Figure 13 illustrates the dynamics of household expenses as the average elderly household member age increases and is meant to represent the expected outcome of the H_{0j} hypothesis.

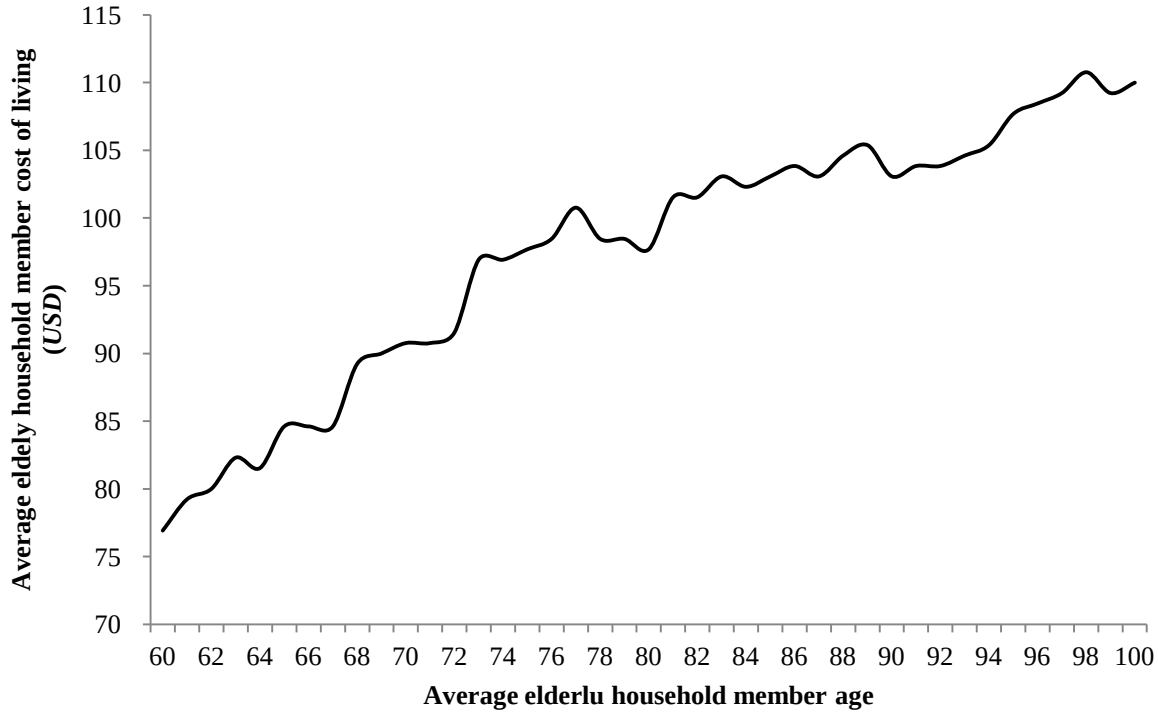

Figure 13. Cost of aging by age (simulation) (author)

4.6. Statistical data analysis

Samples collected using semi-structured questionnaire and accelerator-based devices will be structured, normalized, and formatted in Microsoft Office, and analyzed using simple and stepwise multiple linear regression in SPSS 23 statistical package. Some of the questions to be answered using regression analysis include (1) how does aging impact landless vs. land-rich rural households in terms of household income and expenses, (2) does household size and structure (number of dependents) affect household income and expenses, and (3) how agricultural involvement impacts household income and expenses, among others. Regression analysis thus becomes crucial for understanding collected data and making interferences about

the population. Table 8 lists all variables used in the analyses, along with a note on the number of samples available for each regression.

Table 8. List of dependent and independent variables used in regression analyses

Variable	Variable classification	Unit of measure	Number of samples
Farmer's age†	Independent	Year	388
Household size	Independent	Person	388
Number of elderly household members	Independent	Person	388
Number of children within household	Independent	Person	388
Number of dependent household members	Independent	Person	388
Average age of elderly household members	Independent	Age	388
Average age of children within household	Independent	Age	388
Land ownership	Independent	Acre	388
Household income	Dependent	000 USD	388
Household expenses	Dependent	000 USD	388
Agricultural involvement index†	Dependent*	Index number	388
Agricultural intensity index†	Dependent*	Index number	388
Hours worked†	Dependent*	Hour	388
Years of education	Independent	Year	388
Age at first agricultural employment	Independent	Year	388
Years of working outside agriculture	Independent	Year	388

Note 1: Variables marked with an asterisk (*) can function as both dependent and independent variables.
Note 2: Variables marked with a dagger (†) are also used for analyzing the elderly household member section.

Simple linear regression can be defined as a statistical technique that attempts to explore and model the relationship between two or more variables. Similarly, stepwise multiple regression is a semi-automated process of creating a model by successively adding or removing variables based on the t-statistics of estimated coefficients. The aim of the analysis is to include as few variables as possible since each unnecessary regressor decreases the precision of the estimated coefficients and predicted values (NCSS, 2015).

There are two methods of stepwise multiple regression: the forward method and the backward method (Hill and Lewicki, 2006). The forward method begins with no variables in the model and proceeds forward by adding one variable at a time. The backward method includes all predictor variables into the model first and then removes variables that do not significantly predict anything on the dependent measure, one at a time. Some of the principal drawbacks of

stepwise multiple regression include bias in parameter estimation, inconsistencies among model selection algorithms, and inappropriate focus or reliance on a single best model (Whittingham et al., 2006).

Both regression methods, however, underestimate certain combinations of predictors as they add or remove variables in certain order, thus selecting a combination of independent variables that are determined by that order. Moreover, the R-squared values are biased too high compared to the population, the test statistics do not have the correct distribution (p-values are biased too small, standard errors are biased too low, confidence intervals are biased too wide), regression coefficients are biased too high, even with a single predictor, and when there is multicollinearity, variable selection becomes arbitrary (Harrell, 2001). For those reasons, it is advised to use stepwise multiple regression analysis in exploratory research only.

In a general simple linear regression equation (3), y is the response variable, x is the explanatory variable, β_1 the intercept, β_0 the slope, and u_i is the residual (random error component) that is being minimized. The betas are called regression coefficients and the slope β_0 can be interpreted as the change in the mean value of y for a unit change in x.

$$y = \beta_0 + \beta_1 x + u_i \tag{3}$$

In multiple linear regression equations (4), y is the value of the dependent variable, x_1, x_2, x_3, …, x_k are independent variables, β_0 the slope, β_1, β_2, β_3, …, β_k are regression coefficients analogous to the slope in the linear regression equation, while u_i is the residual and assumed to be zero (California State University, 2015).

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + u_i \tag{4}$$

One of the four basic assumptions of both simple and multiple regression analysis, which justify the use of linear regression models for purposes of inference or prediction, is that the relationship between dependent and independent variables is linear. The most convenient way to verify linearity of tested variables is to graph the variables using a scatter plot, which places observed variable on the vertical (y) axis and predicted variable on the horizontal (x) axis, or alternatively, residual variable on the vertical (y) axis (the bit that's left when the predicted value is subtracted from the observed value) and predicted variable on the horizontal (x) axis.

Since the latter eliminates the visual distraction of a sloping pattern, it is considered a better plot and as such will be used in the analysis (Duke University, 2018). In case the scatter plot reveals the non-linear relationship between variables, the natural logarithm of the dependent variable will be used instead. As violations of linearity may cause the predictions to be in serious error, especially when extrapolated beyond the range of the sample data, scatter plot will thus be the first step in the regression analysis.

Statistical independence of the errors is the second of the four assumptions that will be tested. Although violations of independence are more important in time series and typically rely on Durbin-Watson statistic, they are applicable for cross-sectional data as well (as is the case of this study). To test for non-time-series violations of independence, it is suggested to look at the plot of residual variable on the vertical (y) axis and independent variable on the horizontal (x) axis. The residuals should be randomly and systematically distributed around zero under all conditions, with no correlation between consecutive errors.

Homoskedasticity, as the third assumption, describes a situation in which an error term remains roughly the same across all values of a predictor variable. Heteroscedasticity within data will, therefore, be tested as a violation of homoscedasticity, existing when the error term size varies significantly across values of a predictor variable (Kaufman, 2013). In case dependent variable appears to be heteroscedastic, and simultaneously strictly positive and with the size of the errors proportional to the size of the predictions, a log transformation will be applied to the dependent variable.

Testing for the normality of error distribution, as the final of the four checks, is performed to ensure that the model coefficients are significantly different from zero. The test is employed as in some instances the error distribution is skewed due to a few large outliers which can exert a disproportionate influence on parameter estimates. This implies that if the error distribution is significantly non-normal, the confidence intervals will be too wide or too narrow as a result. Normal probability plot of the residuals, as the standard regression analysis output, will, therefore, be used, with the expectation that if the distribution is normal, the points on a plot should fall close to the diagonal reference line.

Aside from the four basic linear regression assumptions, the normality of each variable ought to be assessed as well, typically using skewness (normal distribution has a skewness of 0) and

kurtosis z-value (should be between -1.96 and +1.96) (Cramer, 1998; Cramer and Howitt, 2004). While skewness measures the probability distribution asymmetry of a real-valued random variable about its mean (a measure of variable's symmetry, or lack of it), kurtosis stands for the degree to which distribution deviates sharply from the central peak to the tails, or slopes more gently, as compared to the normal distribution (Cohen and Brooke, 2004). Both statistics are, however, overly dependent on the sample size, with even several hundred data points failing to produce a reasonable estimate of the true kurtosis and skewness. Consequently, to avoid misleading results due to low sample size, a histogram as a measure of data's distribution will be used instead.

For multiple linear regression analysis, the Variance Inflation Factor (VIF) indicator will be included to assure that the abovementioned regression assumptions are followed. VIF is used as a multicollinearity check, with a value greater than 10 suggesting the presence of multicollinearity (Berry and Feldman, 1985). It tests for exact linear relationships among sample values of the explanatory variables and in case they are highly correlated with each other (correlation coefficients either very close to 1 or to -1), it flags the problem of multicollinearity.

Sample size, Pearson correlation, adjusted R-squared, ANOVA F-statistic, beta, and 95.0% confidence interval for the beta will be reported as part of every statistically significant output ($p<.05$). While Pearson correlation tracks linear correlation between variables, returning values between +1 (positive correlation) and -1 (negative correlation), with 0 implying no correlation (Stigler, 1989), adjusted R-squared explains the variance in dependent variable by measuring how close the data is to the fitted regression line (Frost, 2013).

ANOVA, on the other hand, tests whether means of several groups or populations are equal and whether differences between the means are statistically significant (Rutherford, 2001). ANOVA is a t-test extension for independent samples, preferred over multiple t-tests due to a higher probability of making a type I error (incorrect rejection of a true null hypothesis) with an increased number of groups. ANOVA F-statistic, as the ratio of the mean squares, will be larger when there is more variability between the groups than within the groups and will be smaller (close to 1) when variability between groups and within groups is approximately equal. Lastly, beta coefficients are used to compare the relative strength of predictors within a model and are considered the most valuable output of an analysis. They measure dependent

variable's sensitivity to changes in an independent variable, with a beta of 0 indicating that changes in an independent variable cannot be used to predict changes in the dependent variable (Baum, 2006).

Stated hypotheses will be assessed in an above-described manner using regression analysis. What is tested is that H_1 is likely true. There are essentially two possible outcomes, either reject H_0 and accept H_1 due to compelling evidence in the sample in favor of H_1 or do not reject H_0 due to insufficient evidence to support H_1. Failure to reject H_0, however, does not mean that the H_1 is true. The outcome of linear regression does not indicate that H_0 should be accepted, it rather means that there is no sufficient evidence to support H_1.

4.7. Statistical analyses structure

Descriptive statistics derived from data collected using the main questionnaire will be presented first, followed by a sub-section on elderly data and movement tracking devices. Average, minimum, maximum, and standard deviation statistics will be included in all three cases. Regression output using the main questionnaire data is introduced next, along with regression results for data on elderly farmers. The measured agricultural intensity of performed activities will also be regressed with activities reported by farmers of comparable age. In all cases, only statically significant regression outputs will be reported. At the same time, as part of each simple linear regression, linearity between dependent and independent variables will be checked, along with the statistical independence of the errors, homoskedasticity, the normality of the error distribution, data's distribution, and multicollinearity in case of multiple linear regression analyses. Table 9 lists all regressions to be performed, along with dependent and independent variable specification and reference to which hypothesis is being tested. Regressions marked with an asterisk do not test any pre-defined hypothesis.

Table 9. List of performed regressions, variables, samples, and hypothesis identifiers

Independent variable	Dependent variable	Hypothesis tested
Farmer's age	Agricultural involvement index	H_{0a}
Farmer's age	Agricultural intensity index	H_{0b}
Farmer's age	Hours worked	H_{0c}
Farmer's age	Household income	*
Farmer's age	Household expenses	*
Household size	Agricultural involvement index	H_{0g}
Household size	Agricultural intensity index	H_{0h}
Household size	Hours worked	H_{0i}
Household size	Household income	*
Household size	Household expenses	*
Number of elderly household members	Household income	*
Number of elderly household members	Household expenses	H_{0k}
Number of children within household	Household income	*
Number of children within household	Household expenses	*
Number of dependent household members	Household income	*
Number of dependent household members	Household expenses	*
Average age of elderly household members	Household income	*
Average age of elderly household members	Household expenses	H_{0j}
Average age of children	Household income	*
Average age of children	Household expenses	*
Land ownership	Agricultural involvement index	H_{0d}
Land ownership	Agricultural intensity index	H_{0e}
Land ownership	Hours worked	H_{0f}
Land ownership	Household income	*
Land ownership	Household expenses	*
Agricultural involvement index	Household income	*
Agricultural involvement index	Household expenses	*
Agricultural intensity index	Household income	*
Agricultural intensity index	Household expenses	*
Hours worked	Household income	*
Hours worked	Household expenses	*
Years of education	Household income	*
Years of education	Household expenses	*
Years of working outside agriculture	Household income	*
Years of working outside agriculture	Household expenses	*

CHAPTER 5: RESULTS AND DISCUSSION

5.1. Descriptive statistics

Table 10 presents descriptive statistics, including the average, minimum, maximum, and standard deviation for respective variable data, based on the main section of the questionnaire, and supplemented by the elderly section data. Additional measures are provided, where applicable, to give a more accurate estimate of the variable in question. For instance, while the average number of elderly household members for the entire population is 0.7, the actual average, measured for households that have elderly members, is 1.3.

Table 10. Descriptive statistics for select variables (main questionnaire and elderly section)

Variable	Avg.	Alt. Avg.	Max	Min	Std. Dev.
Farmer's age	44.7	-	98.0	18.0	11.4
Household size	8.5	-	40.0	1.0	5.1
Number of elderly household members	0.7	1.3	5.0	-	0.8
Number of children within household	3.0	3.4	20.0	-	2.4
Number of dependent household members	3.7	3.9	23.0	-	2.6
Average age of elderly household members	68.2	-	100.0	60.0	7.9
Average age of children	8.9	-	17.0	1.0	4.5
Land ownership	2.1	2.5	75.0	-	4.6
Household income	1.1	-	37.8	-	2.2
Household expense	1.3	-	39.5	0.2	2.3
Household savings	-0.2	-	1.2	-3.5	0.4
Agricultural involvement index	30.5	-	57.1	10.3	7.8
Agricultural intensity index	3.7	-	4.8	2.4	0.5
Hours worked (all months)	8.3	-	15.0	2.3	1.9
Hours worked (busiest month)	10.4	10.4	17.0	4.0	2.1
Hours worked (least busy month)	5.6	6.2	16.0	-	3.4
Hours worked (preceding month)	8.8	8.8	18.0	1.0	2.8
Years of education	7.6	11.1	24.0	-	6.3
Age at first agricultural employment	19.2	-	51.0	7.0	6.4
Years of working outside agriculture	2.9	8.8	30.0	-	6.2
Farmer's age	67.2	-	100.0	60.0	6.8
Agricultural involvement index	14.1	30.3	70.0	-	17.8
Agricultural intensity index	1.9	4.0	5.0	-	2.0
Hours worked	6.7	8.3	15.0	-	3.6

Collected data highlights significant variation between sub-districts and villages, as reflected in the standard deviation statistic. District demographics, for example, reveal that while the average age of surveyed farmers was 44.7 years, the actual age varied between 18 and 98 years. Similarly, household size, number of children, elderly, and dependent household members, and their respective ages were all characterized by relatively high standard deviations. The average age of elderly family members of 68.2 years was perhaps the only exception, as the standard deviation for this variable was only 7.9. Regardless of the variation among households, the working-age adults and children together constituted an overwhelming 92.1% of all household members, with the elderly adults accounting for just under 8%. At the same time, over 88% of all heads of households were below 60 years of age, indicating that the aging process is still in the infancy phase.

Figure 14. Interviewing an elderly Lakhisarai farmer outside of his home (author)

In terms of land ownership and household income, expenses, and savings, the standard deviation is almost twice as large as the average statistic, indicating an even higher inequality across the three dimensions. Figure 15 visualizes just how significant disparity between the

households is, with quintiles showing the percentage of land in possession of each of the five wealth groups, ranked from the poorest to the richest. Overall, 14.4% of households were landless, with 61.6% being marginal farmers with less than a hectare of land (2.47 acres).

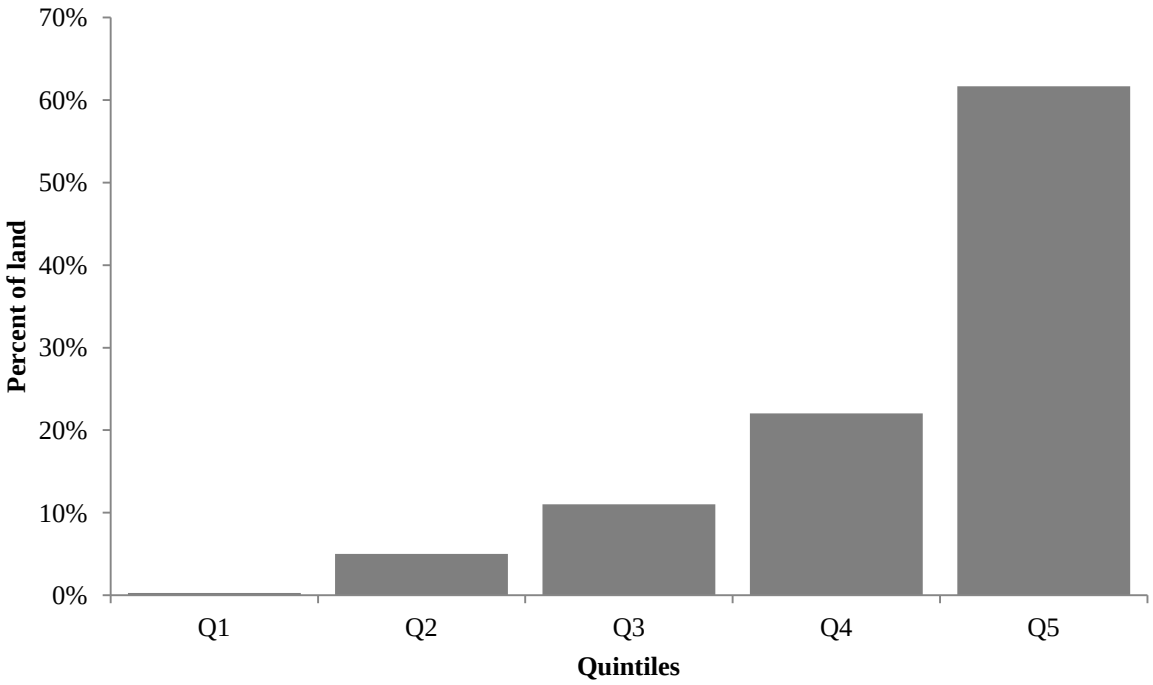

Figure 15. Land ownership in Lakhisarai district by quintiles (author)

Machinery, equipment, and animal ownership showed comparable patterns, as detailed in Table 11. It should be noted that farmers were asked to identify a single most important piece of agricultural equipment and animal they owned, thus potentially underreporting any other items they may possess (typical of wealthier households). Nevertheless, as much as 64.9% of surveyed farmers reported owning no equipment whatsoever, and as in the case of land ownership, the most important pieces of equipment, such as tractors and cultivators, were owned by a handful of farmers. Irrigation equipment, as the most common piece of machinery, was owned by only a quarter of all households, partially due to cost factor and partially due to the inadequate parcel and overall land size, which made the purchase difficult to justify. As for the animal ownership, most households owned one or more cattle, kept mainly for milk and as a coping mechanism during adverse times. In terms of house ownership, on the other hand, an overwhelming 99% of all farmers reported owning their homes.

Table 11. Machinery, equipment, and animal ownership (*percent*)

Item	Percent of surveyed farmers who own it
Tractor (four wheels)	2.3
Cultivator (two wheels)	4.1
Harvester (two wheels)	-
Rice transplanter (walking)	-
Rice weeder (walking)	-
Grain dryer	-
Grain miller	0.8
Grain thrasher	1.3
Irrigation equipment	25.0
Seed drill	-
Plough	0.5
Harrow	-
Sprayer	1.0
Other	-
Doesn't own equipment	64.9
Cattle	82.2
Fish	-
Goat/sheep/pigs	3.9
Poultry	-
Other	-
Doesn't own animals	13.9

Similarly, the top 20% of households accounted for 58% of all income and 52% of all expenses in the district (Figure 16). It is thus not surprising that 65.6% of households had an outstanding debt. The high concentration of land, machinery, animals, income, expenses, and savings is a worrisome sign, as it may act as a barrier to introducing a unified welfare policy, retirement scheme, or food security programme. It could also hinder any attempts at reviving cooperative movement due to the lack of homogeneity among surveyed households. Not even the years of education, commonly regarded as an equalizing component, could bridge the gap, again, due to significantly high differences in educational attainment. An average farmer, for instance, was found to have just under 8 years of formal education, with age having no bearing on educational attainment whatsoever.

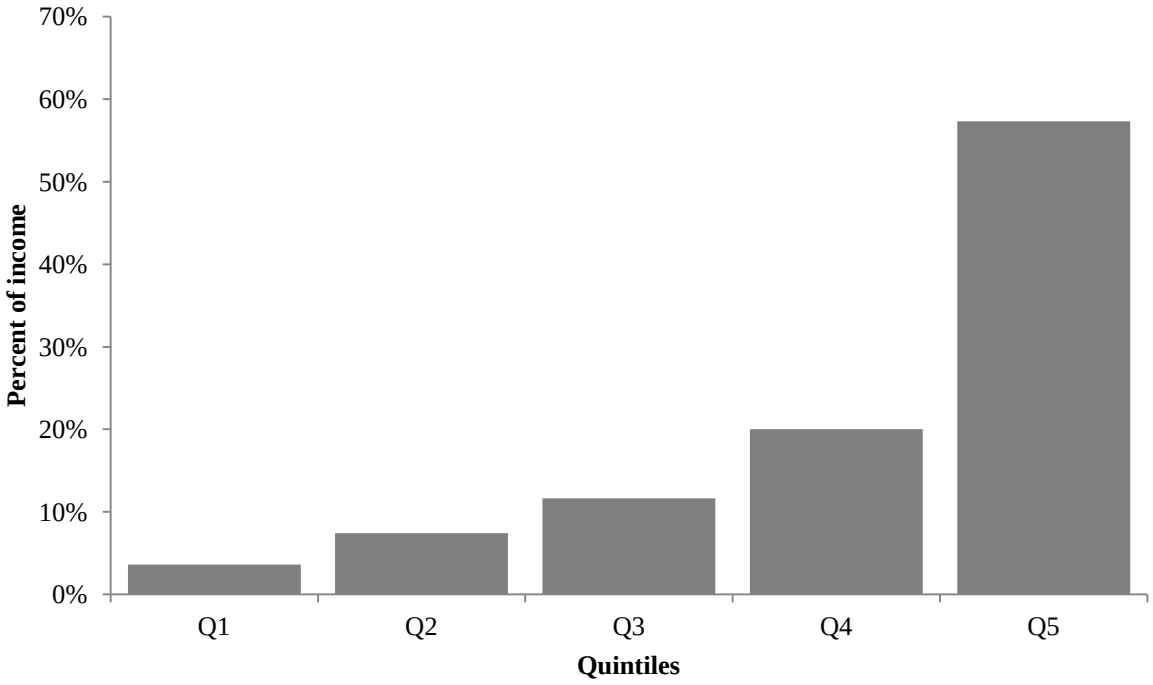

Figure 16. Income distribution in Lakhisarai district by quintiles (author)

Agricultural involvement and intensity indices, along with the average hours worked, however, are among the most significant descriptive statistics. They not only reveal how long, how intense, and how hard did the farmers work over the past year (in that order), but they are also useful in performing regression analyses and when drawing comparisons. They reveal, for instance, that the surveyed farmers had worked, on average, 5.6 hours per day during the least busy month of the year (May, followed by April), and 10.4 hours during the busiest month (November, followed by July). Regarding the physical difficulty of performed activities, an average ranking of 3.7 corresponds to "overall difficult", with an overwhelming majority of surveyees opting for "difficult" or "moderate" intensity labels when describing individual activities. It is, however, the agricultural involvement index, that combines the previous two measures and synthesizes the effort made during the past year. The standard deviation in all three cases remained comparably low, except in the case of hours worked during the least busy month, chiefly due to a high number of farmers without any work.

Contrasting the three above-mentioned measures for heads of households and elderly farmers shows a great deal of dissimilarity across all three variables. Agricultural involvement and intensity indices for elderly farmers, for example, are twice as low as that of their younger counterparts, while the average hours worked are lower by a third compared to the younger

generations. At the same time, the standard deviation statistic is drastically higher for the elderly group, since a much larger number of elderly adults are unable to work. Nevertheless, if the average hours of only those who have reported working are taken into consideration (90% of the sample), the 6.7 hours average increases to 8.3, thus shrinking the gap between the two cohorts. Figure 17 shows how the agricultural involvement and intensity indices and the average hours worked stack up for the elderly and the heads of households. It is interesting to note that, on average, those elderly farmers who did work have worked almost as hard as surveyed heads of households (agricultural involvement index), slightly more intense (agricultural intensity index), and equally as many hours.

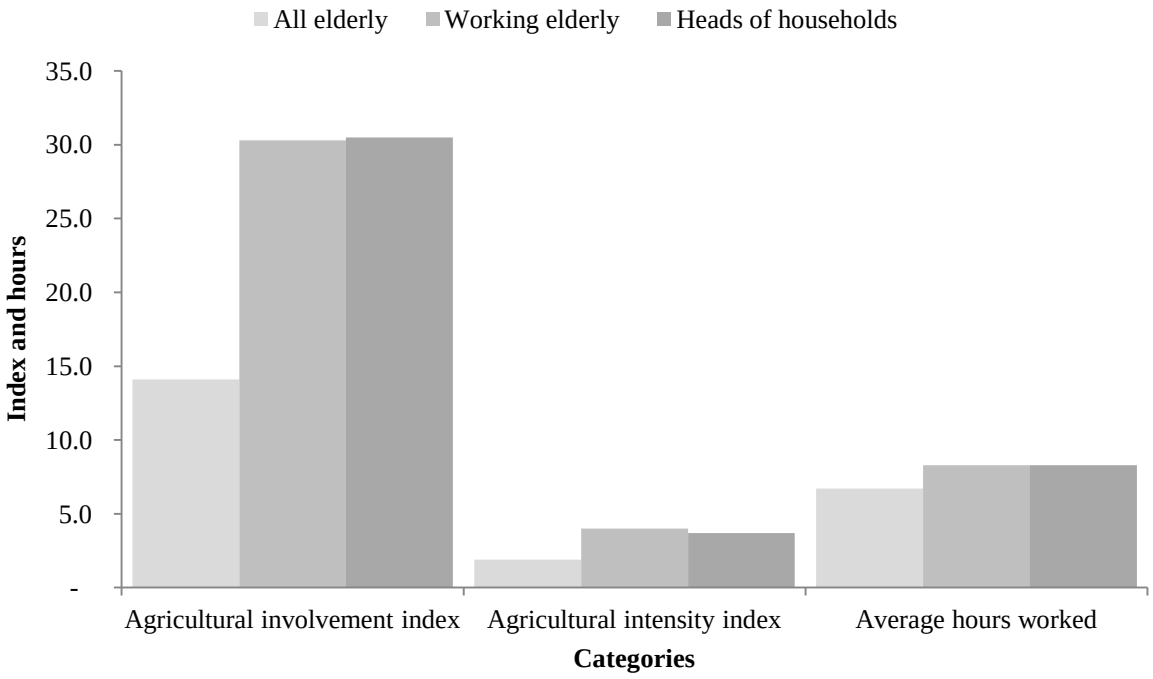

Figure 17. Comparison of hours worked, agricultural intensity and involvement for elderly farmers and heads of households

This is partially due to the inclusion of elderly heads of household, as 11.6% of surveyees were 60 years or older, and partially due to methodology used for heads of households, which averages data for the busiest, the least busy, and the preceding month, as opposed to methodology used for the elderly farmers which considers only the preceding month, which also happens to be the busiest month of the year. Lastly, as results for all three months are averaged for the heads of households, consequently, the farmers who have worked during the busiest month and the preceding month, but not during the least busy month of the year

(8.5%), would skew the results and lead to overall lower averages. In summary, the slightly inflated averages for the elderly surveyees and slightly underrated results for heads of households, produce a deceiving sense of equality in efforts by both parties.

Plotting hours worked, agricultural intensity index, and agricultural involvement index against farmer's age, however, help further explain how observed variables correlate (Figure 18).

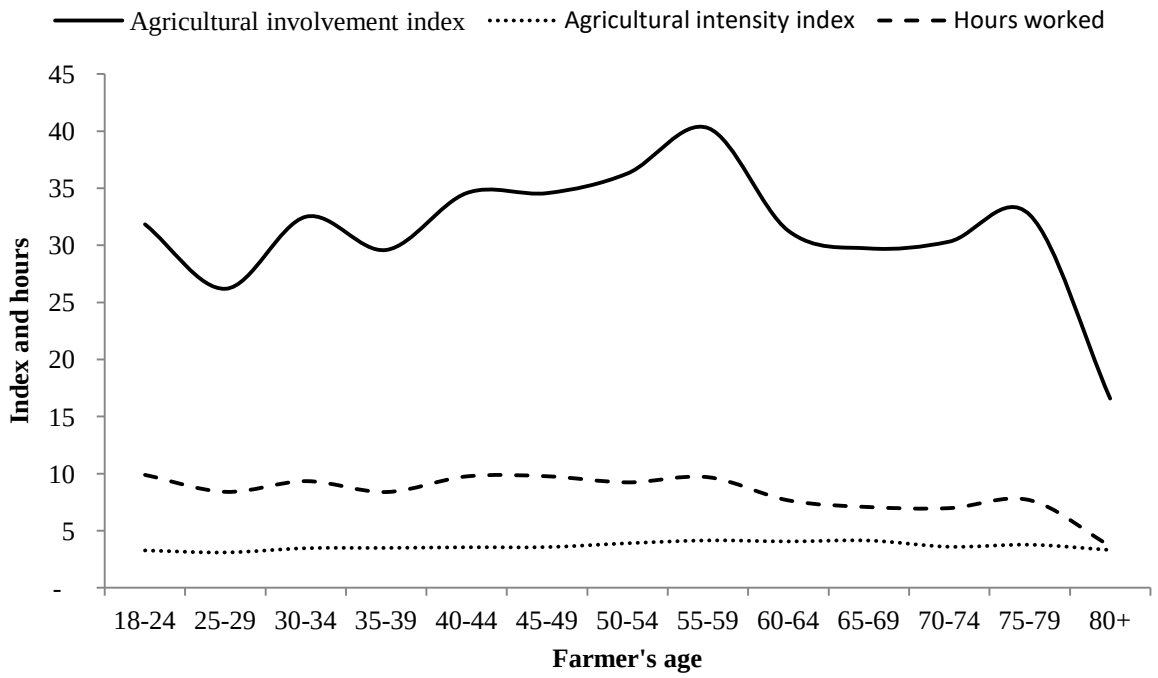

Figure 18. Comparison of hours worked, agricultural intensity and involvement by age group

Due to comparability issues, relatively small dataset, and to avoid the above-mentioned complications associated with different methodological approaches, the average head of household data was combined with the average elderly farmer data for the preceding month and male farmers only (there were only a handful of female heads of household and elderly farmers). Moreover, data were grouped in age brackets to avoid volatility that comes with a low sample size (e.g. there were five farmers aged 47 and only one aged 44), resulting in smoother age lines.

Interpreting the results, on the other hand, requires caution. Starting from the agricultural intensity index (the fine-dotted line at the bottom), it may be inferred that the intensity of work increases and peaks in the 65-69 age group. Such an explanation, however, is contrary

to common sense as younger farmers are expected to work more intensely than their older counterparts. To understand the phenomenon, the framing of the question needs to be considered. The questionnaire asks the respondents to name the three most important agricultural activities performed during the month in question and indicate how physically demanding each of the activities is. It is not hard to imagine that the older farmers would have ranked the same activities as more difficult, simply because they do become more laborious as the person ages, which in fact would have skewed the data in favor of elderly farmers.

Hours worked (the middle, dotted line), therefore, is used as the next best indicator to represent farmers' intensity of work. Unlike the agricultural intensity index, it shows an unambiguous decline in hours worked for the 60-64 age group and onwards, which is in line with the expectations. The results for the age group 18-59 varied between the low of 8.4 and the high of 9.9, with the 18-24 age group working the longest (an average of 9.9 hours per day), followed by the 40-44 and 45-59 age groups (9.8 hours per day).

Finally, the agricultural involvement index (the top, full line), being the product of the previous two measures, accurately reflects how hard have farmers worked within each age group. It is imperative to note that by multiplying the hours worked (as a more accurate measure of agricultural work) and agricultural intensity index (as a less reliable indicator), it is the hours worked that have more weight, simply by being, on average, a much higher multiplier than the agricultural intensity index. For example, an average agricultural intensity index for three activities may be 3.9, but the farmer may have worked 12 hours, giving the hours worked a much bigger weigh in calculating agricultural involvement index. Accordingly, agricultural involvement index acts as a bridge between the two component indicators.

Table 12 describes work from another perspective by categorizing it according to the month in which it took place. Around three-quarters of Lakhisarai district farmers have worked on their own land, or in case they had no land or were marginal farmers, tended to their own animals. Comparing November and July, the two busiest months of the year, to May and April, the two least busy months, reveals unusual shrift from having approximately equal percentage of farmers helping their family and friends and working as hired labor during the busy months, to having more polarized results where almost all of them are working either on their own land or as hired labor during May and April. Seasonality of performed activities

explains the shift, as friends and relatives tend to request help during the peak season and have much less work during the low season when farmers typically try to find work outside agriculture (33.5% of farmers have worked in sectors other than agriculture at one point in their lives). In contrast, elderly farmers have reported working predominantly on their own land, which is understandable considering their age and health.

Table 12. Work categorization by the busiest, the least busy, and the preceding month (main questionnaire and elderly section) (*percent*)

Category	Busiest month	Least busy month	Preceding month
Worked on one's own land	76.0	70.9	78.4
Helped family and friends on their land	12.4	2.3	9.8
Worked as hired labor	11.6	18.3	11.9
Worked on one's own land	-	-	85.6
Helped family and friends on their land	-	-	4.4
Worked as hired labor	-	-	9.9

Note: Preceding month output is calculated only for those elderly farmers who have reported working.

The reported difficulty of individual agricultural activities allows for a more granular type of analysis, such as the most commonly performed activities, their average difficulty, and their age-specific difficulty, derived by calculating average difficulty for pre-set age groups. Table 13 lists all reported activities for both heads of households and elderly farmers, for all observed months, and accompanying analysis output. The sample size is enclosed as well, as in the case of some agricultural activities (e.g. composting, tilling), very few farmers have reported performing them. Moreover, some activities, often with low sample sizes, were marked with an asterisk to highlight that the activity in question has not been reported by all 13 age groups (i.e. *18-24*, *25-29* … *80+*).

This has a bearing on how results are interpreted, as having a relatively broad range of ages omitted limits the value of reported results. Lastly, several age groups were marked with a dagger (†) to represent activities for which multiple age groups had identical scores, in which case the older age group was chosen for the "easiest at age group" category, while the younger age group was selected for the "most difficult at age group" category. For example, if both age group 18-24 and 25-29 listed "applying pesticide" as the activity they consider easiest to perform, it would be the older group that gets included in the table. The idea is to

determine up to what age are certain activities considered easy, and vice versa, up until what age are certain activities considered difficult.

Table 13. List of agricultural activities with the average and age-specific difficulty rating

Agricultural activity	Sample size	Average difficulty	Easiest at age group	Most difficult at age group
Applying fertilizer	256	3.4	30-34	70-74
Applying pesticide	195	3.6	†25-29	75-79
Binding straws	120	4.0	18-24	70-74
Building grain storage*	23	3.0	40-44	60-64
Composting*	3	2.3	†60-64	35-39
Harvesting	437	4.3	25-29	80+
Hired labor*	43	4.5	25-29	60-64
Irrigating	501	3.4	25-29	80+
Milling*	26	3.5	35-39	80+
Planting	505	3.8	25-29	75-79
Plowing	357	3.4	18-24	80+
Producing*	2	3.5	70-75	65-69
Seeding*	8	4.1	18-24	†50-54
Selling*	6	3.0	†50-54	†45-49
Taking care of animals	332	3.6	18-24	75-79
Taking care of farm*	80	3.0	45-49	80+
Threshing	41	3.9	18-24	65-69
Tilling*	3	4.3	†50-54	45-49
Transporting	52	4.7	18-24	†50-54
Weeding	156	4.3	25-29	55-59
Winnowing*	1	5.0	No data	65-69

Note 1: Activities marked with an asterisk were not reported by all 13 age groups.
Note 2: Activities marked with a dagger (†) represent activities for which multiple age groups had identical scores.

The table singles out transporting as the single most difficult agricultural activity performed by Lakhisarai district farmers, with winnowing omitted due to low sample size. Harvested and tied-up rice straws were the most commonly transported agricultural produce, carried typically on top of a person's head or back. The activity was observed to be performed indiscriminately by all members, regardless of age or gender. Although the average reported difficulty for this activity was 4.7 (very difficult), it varied between age groups, from 4.0 for 18-24-year-olds, to 5.0 for their 50-59-year-old counterparts.

Weeding, tilling, and harvesting shared the second place with an average difficulty of 4.3. As in the case of transporting, and in fact most recorded activities, it was the younger age groups who identified those activities as easier to perform. Only in case of composting, rope making, produce selling, and tilling, did the older age groups prevail. Apart from tilling, it can be argued that these activities are not entirely agricultural, although certainly agriculture-related. Moreover, they appear to be more of a temporary occupation for the elderly population rather than an actual activity on which the family depended.

Figure 19. Female Lakhisarai farmers threshing sun-dried rice straws (author)

Not surprisingly, composting, produce selling, and taking care of the farm were identified as the easiest activities to perform. Planting, irrigating, and harvesting were the most often performed tasks, accounting for 46% of all recorded activities. Wheat and rice, at the same time, were the most commonly planted (27% and 30%, respectively), irrigated (54% and 27%, respectively), and harvested crops (84% and 5%, respectively). In fact, rice was the most often reported crop (48%), followed by wheat (20%) and potato (4%). Taking care of animals, cattle, in particular, was mentioned in 11% of cases. Rice and wheat, as such, are the main

crops and primary coping mechanism of Lakhisarai district farmers, followed by cattle rearing.

5.2. Regression findings

5.2.1. The impact of age, land, and household size on agricultural involvement, intensity, and hours worked

Regression output details results and discussion points in terms of set objective and aims, with each of the hypothesis addressed in the order in which it was specified in the introductory section. The H_{oa} hypothesis, stating that agricultural involvement declines with age, is discussed first (Table 14). Agricultural involvement, in this context, was defined as the product of average hours worked during the three documented months and self-reported difficulty of performed agricultural activities during those months. Agricultural involvement, as such, is further broken down to its components, namely the self-reported difficulty of performed agricultural activities, also known as agricultural intensity index, and the hours worked, yielding two additional hypotheses: H_{0b} and H_{0c} (Tables 16 and 17).

Table 14. Simple linear regression output for *farmer's age* as an independent variable

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Agri. involvement index	388	.29	.08	34.48	.195	.130	.260
Agri. intensity index	388	.71	.50	381.72	.028	.025	.031

Note: Agricultural involvement index variable is used to test the H_{oa} hypothesis, while agricultural intensity index variable is used to test the H_{0b} hypothesis.

The regression results for agricultural involvement index as dependent variable reject the H_{oa} hypothesis in favor of H_{1a}, as the model predicts an increase in agricultural involvement index value of 0.195 with each additional year of age. The same is valid for agricultural intensity index (H_{0b}), while the regression output for hours worked was not statistically significant and was thus excluded. Although the model explains a mere 8% of the variation in the response variable for agricultural involvement index, it fares significantly better for the agricultural intensity index, explaining as much as 50% of the variation. Moreover, the confidence intervals for B are much narrower for agricultural intensity index variable, thus highlighting the model's reliability in this instance.

The above-mentioned finding, however, may not lead to a legitimate conclusion. As mentioned in the descriptive statistics section, interpreting results for agricultural involvement, intensity, and hours worked requires caution. While the regression output for agricultural intensity index, for instance, implies that the intensity of work increases with age, such explanation is contrary to common sense as younger farmers are expected to work more intensely than their older counterparts. The basis for inconsistency lies in the framing of the question, which asks respondents to name the three most important agricultural activities performed during the month in question and indicate how physically demanding each of the activities is. As older farmers tend to rank the same activities as more difficult due to their subjective bias, the reported difficulty appears to be increasing with age, resulting in skewed data and the false perception that older farmers work harder and more intense.

If the abovementioned data collection peculiarity is accounted for, and the output is interpreted in the opposite direction, then the results would read as follows: the lower the reported intensity of work, the higher the work intensity index. To accommodate this change, agricultural intensity index values were temporarily inverted (1/index value), and regression analysis repeated. This time around, the model predicted a slight decline in agricultural intensity index value with each additional year of age, as expected, while retaining its predictive power. Under such settings, the H_{oa} hypothesis is supported, while the H_{1a} hypothesis is rejected (Table 15).

Table 15. Simple linear regression output for *farmer's age* as an independent variable

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Agri. intensity index	388	-.68	.45	322.27	-.002	-.002	-.002

Note: An inverted version of agricultural involvement index was used in this regression.

The data, however, cannot be transformed and interpreted in such an arbitrary way as it goes against the natural meaning of the data itself. The more suitable alternative to agricultural intensity index, as pointed out in the descriptive statistics section, is hours worked variable, as it unambiguously shows how many hours per day, on average, did a person spend working. Regression results for this variable (H_{0c} hypothesis), however, turned out to be statistically insignificant, rendering them unusable. It can thus be deduced that the age has no bearing on how many hours do farmers spend working each day, which is an interesting finding

considering that, on average, elderly farmers worked less than their younger counterparts (6.7 vs. 8.3 hours), with the decline in hours worked with age clearly observable in Figure 18.

On the other hand, it is now easier to comprehend why elderly farmers tend to report working more intensely than their younger counterparts: (1) partially due to the statistically insignificant link between the age and hours worked, and (2) partially due to their personal bias when reporting difficulty of performed activities. When these two effects are considered together, it makes sense that an elderly farmer will subjectively, and possibly objectively, experience the same activity as more intense than a younger farmer would, thus reporting higher difficulty levels for the same activity. The H_{0b} hypothesis, for those reasons, remains open to speculation until a more focused study is conducted and more conclusive evidence obtained.

The two supporting hypotheses, H_{0d} and H_{0g}, testing whether land ownership and household size, respectively, would have an impact on hours worked, agricultural involvement and intensity, proved statistically insignificant in the first case, and exhibited extremely low predictive power in the second. This implies that although land ownership is not a statistically significant determinant of how hard, intense or long a farmer works, household size does have a minuscule yet detectable influence on those categories. Having a larger household, therefore, suggests that the head of the household would be working harder and longer hours.

Table 16. Simple linear regression output for *household size* as an independent variable

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Agri. involvement index	388	.15	.02	8.52	.224	.073	.375
Hours worked	388	.15	.02	8.70	.056	.019	.093

5.2.2. Measured vs. reported agricultural intensity

A significant portion of the research involved using accelerator-based devices, also known as fitness trackers, to objectively measure the intensity of common agricultural activities by tracking farmers' movements as they perform them. The expectation is that more physically intense activities would result in higher work intensity measurements, and vice versa, with an assumption that intensity of performed activities would decrease with age (i.e. fewer and

slower movements), as tested using H_{0l} hypothesis. Moreover, to make sense of the measurements, recorded data is also correlated with the self-reported difficulty of comparable agricultural activities and farmer's age.

Figure 20. Lakhisarai farmer harvesting rice while wearing Fitbit Charge 2 (author)

Regression analysis source data included any activity with at least 10 samples, resulting in four separate activities for male farmers, as measurements for female farmers did not meet the set criteria (76% of all measurements involved male farmers). Binding rice straws, harvesting rice, plowing potato, and threshing rice were thus used in the regression, with binding rice straws being the only statistically significant variable.

Table 17. Simple linear regression output for *farmer's age* as an independent variable

Recorded intensity of agricultural activity	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Binding straws (rice)	55	-.29	.07	4.98	-5.110	-9.704	-.516

Note 1: Recorded agricultural intensity for male farmers only is used due to low sample size for female farmers.

Despite model's low predictive power, the results support H_{0l} hypothesis, with work intensity predicted to decline with each additional year of age. The finding supplies an objective proof for declining intensity of work for elderly farmers, thus demystifying the paradoxical results of H_{0b} hypothesis testing (i.e. intensity of work increases with age).

Figure 21, on the other hand, shows the correlation between the measured and reported intensity of select agricultural activities by age group. It highlights six age-activity-plant combinations with 90% or higher correlation and four additional ones with 80-89% correlation. Older farmers (40-79 age groups) prevailed in 7 out of 10 cases, suggesting higher consistency of reported and observed intensity for older age groups. The finding is not entirely unanticipated as the standard deviation for 40-79-year-olds is slightly lower compared to the 10-39 age groups. Nevertheless, as 75% of the combinations had correlations below 90%, it could be that the six favorable combinations had higher correlations purely by chance. The low explanatory power of the above-described regression model supports this notion, leading to the conclusion that there is, in fact, unconvincing proof of the measured intensity of agricultural activities matching the reported intensity.

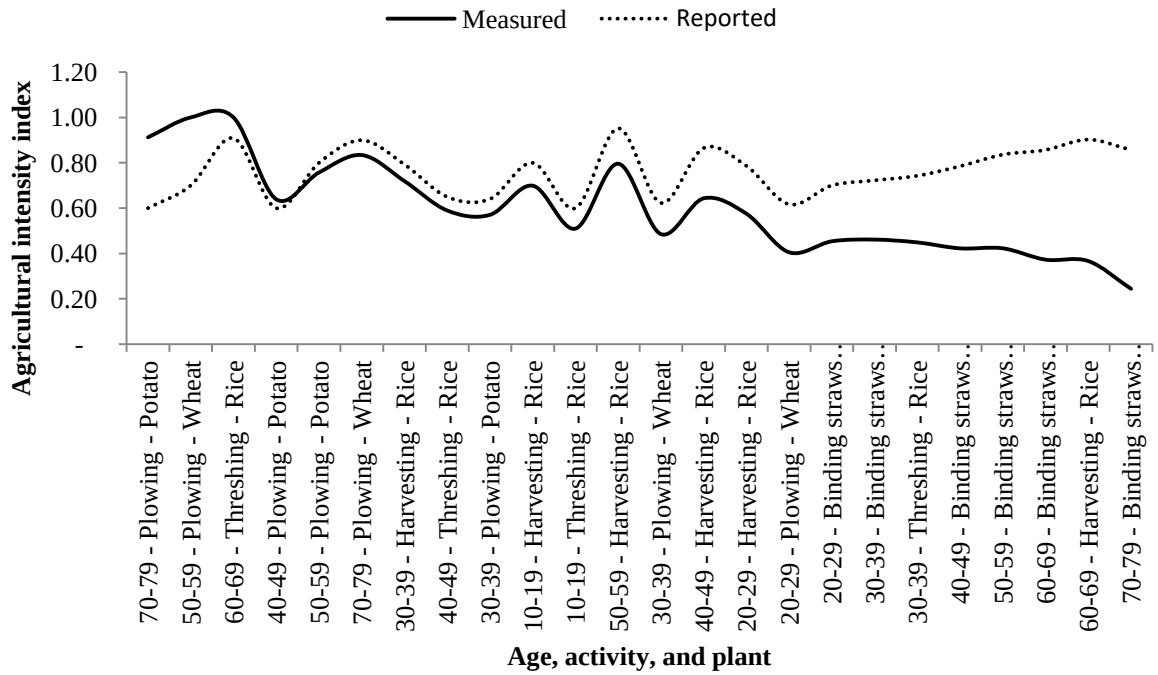

Figure 21. Measured vs. reported intensity of select agricultural activities by age group (author)

This, however, does not discredit the fitness tracker measurements, as the subjectively perceived intensity of various agricultural activities may indeed be different from the actual case measured by steps or movements, or even burned calories and heart rate, for that matter.

5.2.3. The estimated cost of aging

The third research objective involves estimating the cost of aging for individual households after farmer's involvement in agriculture ends or reaches a certain threshold. Two separate hypotheses are considered for this purpose: (1) H_{0j}, testing whether the age of elderly household members affects household costs, and (2) H_{0k}, testing whether the number of elderly household members has any bearing on household costs (Table 18).

Table 18. Simple linear regression output for the *average age of elderly household members* (†) and *number of elderly household members* (*) as independent variables (*log-level*)

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Household expenses*	388	.27	.07	30.89	.120	.078	.163
Household expenses†	388	.19	.03	14.57	.002	.001	.003

Although the predictive power of regression models is notably low, both H_{0j} and H_{0k} hypotheses are supported, with the average age and number of elderly household members expected to increase household expenses: 12% with each additional elderly household member, and 0.2% with each additional year in the age of elderly household members. One, however, cannot consider the effects of aging on household expenses without considering the effects on household income.

Table 19 shows the positive correlation between independent variables and household income, highlighting the predicted 14.3% increase in household income with each additional elderly household member. Compared to the increase in household expenses, household income is expected to increase by 2.3 percentage points faster with each additional elderly household member. The finding not only debunks the commonly held notion that elderly are net negative contributors to a household budget but also points out to a rather unexpected role they play within rural households. Nevertheless, the extremely low explanatory power for

both models, calls for caution when interpreting the findings, with a separate study and higher sample size needed to reach more conclusive results.

Table 19. Simple linear regression output for the *average age of elderly household members* (†) and *number of elderly household members* (*) as independent variables (*log-level*)

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Household income*	388	.28	.08	33.59	.143	.095	.192
Household income†	388	.20	.04	16.65	.002	.001	.003

5.2.4. Supplementary regression output

While the abovementioned regression models address specific research questions, as defined by the hypotheses, this section introduces a host of regression analyses involving household income and expenses and several independent variables. Farmer's age, land ownership, years of education, household size, number of children within the household, and number of dependent household members, along with agricultural involvement and intensity indices, hours worked, years of working outside agriculture, and the average age of children within the household.

Many of the regression models proved statistically insignificant, while a few others had extremely low predictive power. The few that do explain a satisfactory percentage of variation in dependent variables are given more attention. Table 20 is an example of the first two instances, with farmer's age having no bearing on household income (it is statistically insignificant), and only minuscule influence on household expenses. The model paints a rather bleak picture for Lakhisarai farmers, as the hopes of having higher income in later phases of life are not supported by collected data. Moreover, household expenses are expected to increase with age, making the aging process a dreaded one.

Table 20. Simple linear regression output for *farmer's age* as an independent variable (*log-level*)

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Household expenses	388	.11	.01	4.42	.003	.000	.006

Higher land ownership, on the other hand, is expected to increase household income by about 5.4% with each additional acre of land. Household expenses are predicted to rise as well, although by 0.6 percentage points slower (Table 21). In a state where approximately half of the population are marginal or landless farmers, the land is not only a source of income but also a significant coping mechanism. This makes the rising household expenses with increasing land ownership a rather unusual finding. One potential explanation involves the costs of agricultural inputs, as farmers with larger land size tend to expand production and hire workers. Another explanation considers capital expenditures on agricultural equipment or durable household goods, characteristic for households with larger land ownership. Although the low sample size does not allow for control variables, it does seem that owning more land comes at a price.

Table 21. Simple linear regression output for *land ownership* as an independent variable (*log-level*)

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Household income	388	.64	.41	263.90	.054	.048	.061
Household expenses	388	.65	.42	280.32	.048	.043	.054

Like land ownership, although less surprising, the more years of formal education the farmer has, the higher the expected household income and expenses. Likewise, Table 22 points out to 2.4% predicted increase in household income and 2% increase in household expenses with each additional year of education, worth approximately as much as half an acre in additional land. The comparison, however, is merely symbolic, as college education invariably leads to higher income. At the same time, the sample average of 7.6 years does not include enough cases with higher education, thus potentially skewing the household income prediction towards the lower end of the educational attainment spectrum.

Table 22. Simple linear regression output for *years of education* as an independent variable (*log-level*)

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Household income	388	.39	.15	70.92	.024	.019	.030
Household expenses	388	.36	.13	58.96	.020	.015	.025

The following three tables display conceptually similar regression models, with similar predictive powers, Pearson correlations, and confidence intervals. Moreover, in all three cases household income and expenses are expected to increase, and in all cases, except for a number of children within a household variable, household income is predicted to increase faster than household expenses. Regression results are, therefore, consistent with the previous findings and complementary descriptive statistics.

Table 23. Simple linear regression output for *household size* as an independent variable (*log-level*)

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Household income	388	.31	.10	42.18	.024	.017	.031
Household expenses	388	.33	.11	48.44	.022	.016	.029

Using the household size as an independent variable (Table 23), and considering that an average surveyed household consists of 8.5 household members, 4.8 of which are adults, household income is predicted to increase along with household expenses, simply by the virtue of having more working-age adults. Likewise, having more elderly household members, as confirmed by the H_{0j} and H_{0k} hypotheses, may also contribute to a household budget, thus further supporting regression findings. Moreover, household income, as in previous cases, is expected to increase at a faster rate than the household expenses.

Regression output for the number of dependent household members as an independent variable, exhibits similar patterns, although the expected increase in household income is slightly lower than the expected increase in household expenses (Table 24). The results, however, are plausible despite model's low predictive power, as household dependents as a group include both the elderly household members (which are net contributors) and the

children (which are net beneficiaries). This specific combination of contributing and non-contributing household members could, therefore, explain the slower predicted increase in household income over expenses, compared to regression output using household size as an independent variable.

Table 24. Simple linear regression output for *number of dependent household members* as an independent variable (*log-level*)

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Household income	388	.21	.04	17.47	.031	.016	.046
Household expenses	388	.23	.05	21.65	.030	.017	.043

Table 25 furnishes similar arguments although it is the household expenses this time that are predicted to increase faster than the household income. This is, again, in line with expectations, as children are typically net beneficiaries, and as such a drain on the household budget. All three models are therefore internally consistent and plausible.

Table 25. Simple linear regression output for *number of children within household* as an independent variable (*log-level*)

Dependent variable	N	Pearson corr.	Adjusted R-squared	ANOVA F	B	95.0% confidence interval	
Household income	388	.14	.02	7.46	.023	.006	.039
Household expenses	388	.17	.03	10.93	.024	.010	.038

Lastly, agricultural intensity and involvement indices, along with hours worked, years of working outside agriculture, and average age of children within household, have all proved to be statistically insignificant in explaining the variation within household income and expenses. Surprisingly, working harder, more intense, or longer has, therefore, no bearing on household income or expenses. Equally surprising is that working in sectors outside agriculture has no impact on either of the dependent variables, especially if the work is performed aboard. Although not as unanticipated, the age of children likewise has no effect, implying that households with older, almost able-to-work children do not necessarily earn or spend more than their counterparts with newborn children. These five difficult-to-explain instances could simply mean that a larger sample size is needed. Otherwise, they may come

across as too discouraging, knowing that the effort put into work and the choice of work itself have insignificant or no correlation with household earnings or expenses.

5.3. The synthesis

Many of the reported descriptive and regression outputs are along the lines of expected and previously reported studies. Some are, on the other hand, quite revealing, while others remain unexplained. The synthesis section provides an overview of the most significant findings, commentary on how those findings relate to an existing body of research, where appropriate, and cautionary advice about potential limitations when interpreting data. Below is a series of statement-findings, with descriptive statistics presented first, followed by regression findings.

Aging is, at present, not as alarming issue as often portrayed: With less than 8% of household members being 60 years or older, and more than 88% of heads of households being 59 years or younger, aging is expected to remain a manageable issue in India for foreseeable future. Moreover, as the older farmers continue to be physically active well after they retire, improving their productivity could have substantial effects on their wellbeing and financial independence. The notion doesn't necessarily agree with the overly optimistic predictions made by Lee et al. (2011), Bloom (2011), Mullan (2000), Alders and Broer (2004), and Hock and Weil (2012), although it does lessen the gravity of the aging process in India. Nevertheless, as the consensus on the impact of ageing is overall negative, as advocated by Davies and Robert (2006) and Tyers and Shi (2007), rethinking the social security system and how Indian farmers age should be the focus of welfare programs over the next three decades, as pointed out by Alam et al. (2014) and Agrawal (2012). The extent to which predictions materialize will depend upon the health and mobility of an aging population, and indirectly, on the medical breakthroughs and technological and economic development of the country.

Although practically all rural residents own their homes, approximately 61.6% of them are marginal farmers with less than a hectare (2.47 acres) of land, while 14% are completely landless. Similarly, 65% of households do not own agricultural equipment and thus depend on the wealthy few who can afford to invest in motorized machinery. The reported landlessness, however, is almost three times higher compared to the 5.3% for the state of Bihar, citied in the National Sample Survey Office's Household Ownership and Operational Holdings in India report (NSSO, 2013). The reported percentage for marginal farmers, on the other hand, is

considerably lower than NSSO's 89% (which had increased by 17.3 percentage points since 1971). Other, less impartial studies, such as the one commissioned by the Communist Party of India, reported a staggering 60.7% landlessness rate among rural household within the same state (DNA India, 2014). The soundness of methodological approach, however, is in favor of the NSSO projection.

Income in rural areas is heavily concentrated: The top 20% of households account for 58% of all income and 52% of all expenses. Such extension of land and equipment consolidation inadvertently increases household debt, with approximately 66% of households having an outstanding loan. The Gini coefficient of 33.9 confirms the country's inequality standing. At the same time, the National Sample Survey Office reports that the wealthiest 1% now own 28% of all wealth within a country, an increase of 17 percentage points since 1991. The report by Credit Suisse, however, puts the estimate at 58% (The National, 2017), an alarming increase from 36.8% in 2000. The rising inequality may slow down the poverty reduction efforts and undermine the sustainability of economic growth. The process, however, is not inevitable, as there are at least two main areas where policy changes could have an impact: progressive taxation and the social spending on public services such as education, health and social security (WEF, 2016b). At the same time, occasional farmer debt forgiveness initiatives, particularly during the election years, should be avoided, and focus shifted toward increased productivity and global competitiveness.

There are profound differences among younger and older farmers: Younger farmers (<60) were found to work twice as hard and intense as their older counterparts, with the average hours worked being by a third higher compared to the older generations. Younger farmers were also the ones who reported most of the agricultural activities as easier to perform, with a limited number of exceptions seemingly easier for the elderly cohort. However, as most elderly farmers remain part of the workforce well after they retire, as pointed by Elferink and Schierhorn (2016), government effort should be focused on improving the productivity of elderly farmers.

There is a significant variation among surveyed villages: The demographic and social differences within India, as described by Duraisamy and Mahal (2005), are not only apparent among individual states but are also observable at the village level, as revealed by the standard deviation statistic for several reported variables. The size of the country and

associated climate and other geographical specifics are accountable for part of this diversity. The Paharpur village respondents, for instance, have reported working, on average, 7.4 hours, as compared against the average of 8.3 for the district, citing heavy rains and the swelling nearby Ganges river as the reason for not being able to plant during the current season. Such examples highlight the need for more granular policies, tailored to specific regions.

The overall difficulty of performed activities is 3.7/5: This translates to "overall difficult," with transporting produce being the single most difficult activity, followed by weeding, tilling, and harvesting. Most farmers reported performing these activities manually, which explains their position on the difficulty list. Accordingly, focusing mechanization efforts on these activities could potentially bring substantial benefits to the farmers. A study in neighboring Bangladesh, comparing costs of select rice-farming operations performed using motorized equipment and manual labor, showed cost reductions ranging from 85% in case of rice transplanting to 92% for weeding (Milovanovic and Smutka, 2018). Similar economic efficiency gains may be achieved for other activities, thus further extending the benefits.

Planting, irrigating, and harvesting are the most often performed tasks: These three activities alone account for 46% of all reported activities. Not surprisingly, composting, produce selling, and taking care of the farm were identified as the easiest activities to perform. At the same time, wheat and rice are the most often planted, irrigated, and harvested crops, making them the primary coping mechanism, along with cattle rearing.

Agricultural involvement and intensity of work are wrongly predicted to increase with farmer's age: The importance of how survey questions are framed is quite apparent in this case. The intention of using activity difficulty to understand how farmers work proved unsuccessful as older farmers tend to perceive some of the activities as more difficult compared to their younger counterparts, thus reporting higher difficulty levels. Consequently, the interpretation that older farmers are working more intensely proved inaccurate. Inverting the agricultural intensity index values appears to resolve the issue, although it goes against the natural meaning of the data itself and as such cannot be used. Hours worked, on the other hand, although demonstrating a clear downward trend in the descriptive statistics section, proved statistically insignificant in the liner regression output. It may, therefore, be said that although the hours worked tend to decline as farmer's age increases, there is no statistically significant relationship between the variables.

Farmer's age and land ownership have no bearing on how many hours farmers work: The regression models proved statistically insignificant, leading to rather unorthodox and potentially contradictory conclusions. This is especially true if the differences among the older and younger farmers reported in the descriptive statistics section are considered.

Household expenses increase with the average age and number of elderly household members: 12% with each additional elderly household member, and 0.2% with each additional year in the age of elderly household members. Bloom et al. (2010) validate the finding with a notion that declining health of elderly farmers increases the average yearly per capita expenditure on health care (almost four-fold). On the other hand, the 14.3% increase in household income with each additional elderly household member points out to a faster increase in household income than in expenses, and highlights the fact that elderly are net contributors to the household budget.

There is no conclusive proof that fitness trackers can be used to predict work intensity: The low explanatory power of the associated regression model supports this notion, leading to the conclusion that there is, in fact, unconvincing proof of the measured intensity of agricultural activities matching the reported (subjective) intensity. This is despite relatively high accuracy of Fitbit devices, as reported by Lee et al. (2014), Diaz et al. (2015), and Evenson et al. (2015), even for the elderly population (Paul et al., 2015). Sasaki et al. (2014), however, remind that the mode of exercise plays an important role, with precision typically declining as intensity and complexity increase. Therefore, while running measurements would have been reasonably accurate, tracking activities with inconsistent movements, such as harvesting and weeding, may lead to inconclusive results, despite high correlations between some of the reported and measured values, which now seem coincidental.

As many regression models proved statistically insignificant, a brief overview of other notable findings is presented: (1) farmer's age had no effect on household income, (2) higher land ownership is expected to increase household income and expenses, (3) the more years of formal education the farmer has, the higher the expected household income and expenses.

5.4. Theoretical and practical contributions and recommendations to policymakers

In his 1903 work on science and hypothesis, Poincare writes that "science is facts, just as houses are made of stone… but a pile of stones is not a house, and a collection of facts is not necessarily science." Whetten (1989) re-interprets Poincare's maxim and reminds that "insights come from demonstrating how the addition of a new variable significantly alters our understanding of the phenomena by re-organizing our causal maps."

The key benchmark for evaluating research is, therefore, to what degree it improves both the current theoretical understanding of a chosen topic and the practice in the field. The nature and focus of research will ultimately determine the weighing of the two forms of contribution, with arguments being made that even "theory light" research should be considered a valid contribution (Avison and Malaurent, 2014). Oates (2006) concurs by stating that "new arguments, facts, patterns or relationships, could be considered sufficient contributions without theory building beyond this," while Petre and Rugg (2010) argue that "significant contribution" really implies "providing evidence to substantiate a conclusion that's worth making."

Oates also proposes a number of different knowledge contributions: a new or improved product, a new theory, a re-interpretation of an existing theory, a new or improved research tool or technique, a new or improved model or perspective, an in-depth study of a particular situation, an exploration of a topic, area or field, or a critical analysis. Similarly, Mathiassen et al. (2012) provide an entire taxonomy of knowledge contributions, which can be broadly classified as contributions to practice, and as theoretical contributions. Petre and Rugg (2010), on the other hand, make the contribution types understandable to a wide audience, with Table 26 offering a brief overview of their concept of knowledge contributions.

Considering the above, both practical and theoretical contributions of the performed research are presented, along with a brief interpretation of the results and their limitations. According to Oates, the contributions may qualify as an in-depth study of a particular situation, while under Petre and Rugg, they may pass as a confirmation and expansion of an existing model, as well as implementation of a theoretical principle. Moreover, the main points requiring further research are highlighted, and topic-specific recommendations to policymakers presented.

Table 26. A partial list of knowledge contributions according to Petre and Rugg (2010)

Contribution	Description
Re-contextualization of an existing technique, theory or a model	Applying a technique in a new context, testing a theory in a new setting, or showing the applicability of a model to a new situation.
Confirmation and expansion of an existing model	Assessing the effects of a change in condition and providing an experimental assessment of a specific aspect of a model.
Contradiction or falsification of an existing model or a specific aspect of a model	Providing a well-founded critique of existing theory or evidence, or correlating a number of existing studies to show patterns, omissions, or biases.
Combining two or more ideas	Showing that the arrangement reveals something new and useful.
Demonstrating a concept	Showing that something is feasible and useful or that something is infeasible and explaining why it fails.
Implementing a theoretical principle	Showing how it can be applied in practice, making ideas tangible, and highlighting what its limitations are.
Codification of the obvious	Providing evidence about "what everyone knows," and possibly providing evidence that the received wisdom is incorrect.

In terms of practical contributions, the results open a new way of studying farm work and point out to an objective way of measuring agricultural performance using fitness trackers. The results confirm the appropriateness of the approach as correlated measured and reported intensity of select agricultural activities show potential for practical use, even though the low explanatory power of regression models calls for further research. Measuring the performance using fitness trackers, for instance, could allow for compensation differentiation for agricultural laborers based on the actual work intensity rather than hours or days worked, thus enabling a more refined performance and compensation management and a balanced work division in agricultural cooperatives. Although it is unlikely that a worker would be paid based solely on data generated by a fitness tracker, it could serve as a supplementary mechanism to calculate a fairer remuneration. Harvesting one hectare of rice, for instance, resulting in a daily wage of INR 500, would be adjusted upwards for females due to their physical constitution requiring, on average, a higher number of movements compared to their male counterparts. Alternatively, the same approach could be applied to establish a benchmark across age groups, thus contributing to better workload distribution, and eliminating the need to wear the device throughout the day.

Theoretical contributions, on the other hand, can be more difficult to identify and conceptualize. The study adds to the body of research by presenting a more accurate

classification of agricultural activities performed in rural India, explaining at what age are farmers most and least active before retiring (18-24 and 35-39 age groups, respectively), at what age does their involvement in agriculture begin to notably decline (60-64 age group), what are the most often performed agricultural activities (planting, irrigating, and harvesting), which activities are considered difficult (transporting, weeding, and harvesting), and which are rated as relatively easy to perform (composting, produce selling, and taking care of the farm). The findings are relevant for formulating targeted social programs focused on the elderly population as they inform about key turning points in farmer's life and highlight agricultural activities that should be phased out at some point in farmer's life. Transporting, for instance, was consistently ranked as one of the most difficult activities to carry out, particularly by the elderly segment, thus implying that substituting such activity with a physically less demanding one, such as child care, food preparation, and education, could benefit the older farmers.

The research also contributes to an ongoing discussion on whether having an elderly family member affects household income and expenses by concluding that elderly are, in fact, net negative contributors to a household budget, with farmer's age having no bearing on household income. The findings have implications for policy making as their reach extends from households to communities, villages, and even states, suggesting that, financially speaking, ageing is not as threatening as commonly accepted. On the other hand, research confirms that having more years of educations and more working-age adults within household boosts household income, thus implying that household welfare could be made better by improving the productivity.

At the same time, inequality in income, land, and machinery ownership are highlighted in the study as primary threats to any programme aimed at mitigating the negative effects of rural ageing. Other studies complement the list by citing climate change, geographical specifics, crippling social cost of health care and social security expenditures, lower tax base, high tax evasion, and slower economic growth, as principal obstacles for introducing innovative solutions.

In the light of the above findings, and considering country's virtually irreversible demographic trends, an ongoing rural to urban migration, transition towards more nuclear family systems, and aversion toward institutional elderly care (as cultural traditions continue

to play a role in the life of elderly Indians), a region-appropriate self-empowerment and self-sufficiency programmes for elderly and ageing farmers should be developed. The justification lies in the necessity to accommodate the shift towards overall older population in the future and the changing needs of the growing number of elderly, the striving of younger adults to do better than their parents, often resulting in their migration to urban areas (and increased average age within rural areas), an ongoing generational separation, with the elderly family members living by themselves, and the preference of the same to live at their own homes instead within government-run facilities (an overall cheaper alternative).

Executing such complex and often conflicting objectives would require a specific set of actions starting with progressive taxation and improved tax collection, as without sufficient revenue government is forced to prioritize more vocal groups. The roadmap to achieve this goal is out of the scope of this study, however, it is a prerequisite for all steps to follow. Improved assistance programmes should be rolled out next in the form of public investment in agricultural mechanization and price floor schemes to provide the needed stability within the sector and increase productivity. Fertilizer, fuel, and electricity subsidies should be avoided as they unnecessarily increase the complexity, cost, and leakages within programmes. The focus of mechanization efforts, in particular, should be on the activities rated as most difficult to perform (transporting, weeding, and harvesting).

Concurrently, the pension system should be reformed and workers encouraged to remain in the labor market longer, thus bringing the universal and non-contributory old-age pension system within reach. As noted in the research, farmer's involvement in agriculture begins to significantly decline between 60 and 64 years of age, suggesting that assistance programs should be available starting with that age group. Although the multi-pillar system, currently in use in some Latin American countries, could be a compromise solution, the cost of implementing, maintaining, and monitoring such an operation for over a hundred million elderly citizens, most of whom are in rural areas and have limited mobility, would certainly increase the cost beyond sustainable. Thus implementing a minimum, region-specific, and indexed-to-inflation monthly pension of not less than 50% the minimum wage would be a more realistic and potentially transformative solution for rural elderly. In a similar way, improvements to elderly health care should be realized through extended current health insurance schemes, offering whole life coverage and no limit on entry age.

The non-contributory element of recommended steps stresses the importance of tax collection and necessity to reduce the complexity of dozens of overlapping social programs, most of which are underfunded, not well promoted, and consequently do not meet their objectives. It is an essential move needed to preserve and improve the welfare of rural elderly and ageing farmers, without resorting to borrowing funds on international markets. It remains to be seen though whether the technological breakthroughs, country's development, and global economic trends allow for such actions to be taken. More importantly, it is up to the policymakers to decide how much importance should be allowed for ageing farmers considering the welfare of their younger counterparts.

Unfortunately, although some efficiencies may be achieved and perhaps even a number of universal schemes for elderly developed, it is author's opinion that India is about to embark on, for the majority of its citizens, a very difficult and distressing path as its population ages. The silver lining, however, lies in gradually declining birth rates which are slowing down the population growth and consequently the magnitude of the approaching aging crisis, a step which should have been taken decades ago, and which would have made the population ageing challenge a much more manageable one.

CHAPTER 6: CONCLUSION

The contemporary history of India has been shaped by the workings of the British Empire. With the country facing accelerated population aging accompanied by a set of socio-economic changes and slower economic growth, some of the economic rationale and social programs reminiscent of the colonial rule are put to the test. Declining fertility, increasing longevity, and large cohorts advancing toward older ages have been some of the more vocal drivers of the change, with the shift toward more nuclear family systems exposing the elderly to the inefficiencies of the country's social and healthcare systems. At the same time, considering that agricultural sector has historically been the backbone of Indian economy, the shift by 2050 toward the state where approximately 300 million adults are over the age of 60, calls for better understanding of the implications of aging for agriculture and smallholder farmers.

The study thus addressed some of the more pressing and less explored questions on rural ageing using a semi-structured questionnaire and motion tracking devices, along with the standard descriptive statistics and regression analysis. It contributed to the body of research by presenting a more accurate classification of agricultural activities performed in rural India, explaining at what age are farmers most and least active before retiring (18-24 and 35-39 age groups, respectively), at what age does their involvement in agriculture begin to notably decline (60-64 age group), what are the most often performed agricultural activities (planting, irrigating, and harvesting), which activities are considered difficult (transporting, weeding, and harvesting), and which are rated as relatively easy to perform (composting, produce selling, and taking care of the farm). The findings are relevant for formulating targeted social programs focused on the elderly population as they inform about key turning points in farmer's life and highlight agricultural activities that should be phased out at some point in farmer's life.

The research also contributes to an ongoing discussion on whether having an elderly family member affects household income and expenses by concluding that elderly are, in fact, net negative contributors to a household budget, with farmer's age having no bearing on household income. The findings have implications for policy making as their reach extends from households to communities, villages, and even states, suggesting that, financially speaking, ageing is not as threatening as commonly accepted. Even though the position of the elderly population requires major improvements in terms of healthcare, living arrangements,

and social security, they still constitute a comparatively small portion of the overall population, easily absorbable by the current familial support system. Inequality in income, land, and machinery ownership, however, are highlighted in the study as a more immediate concern to any programme aimed at mitigating the negative effects of rural ageing.

In the light of the above findings, and considering country's virtually irreversible demographic trends, an ongoing rural to urban migration, transition towards more nuclear family systems, and aversion toward institutional elderly care, a region-specific, self-empowerment and self-sufficiency programmes for elderly and ageing farmers should be developed. Executing such complex and often conflicting objectives would require a specific set of actions starting with progressive taxation and improved tax collection, as without sufficient revenue government is forced to prioritize more vocal groups. Improved assistance programmes should be rolled out next in the form of public investment in agricultural mechanization and price floor schemes to provide the needed stability within the sector and increase productivity.

Concurrently, the pension system should be reformed and workers encouraged to remain in the labor market longer, thus bringing the universal and non-contributory old-age pension system within reach. As noted in the research, farmer's involvement in agriculture begins to significantly decline between 60 and 64 years of age, suggesting that assistance programs should be available starting with that age group. Thus implementing a minimum, region-specific, and indexed-to-inflation monthly pension of not less than 50% the minimum wage would be a more realistic and potentially transformative solution for rural elderly. In a similar way, improvements to elderly health care should be realized through extended current health insurance schemes, offering whole life coverage and no limit on entry age.

In terms of practical contributions, the results justify the use of fitness trackers as correlated measured and reported intensity of select agricultural activities show potential for practical use, even though the low explanatory power of regression models calls for further research. Measuring the performance using fitness trackers, for instance, could allow for compensation differentiation for agricultural laborers based on the actual work intensity rather than hours or days worked, thus enabling a more refined performance and compensation management and a balanced work division in agricultural cooperatives. Although it is unlikely that a worker

would be paid based solely on data generated by a fitness tracker, it could serve as a supplementary mechanism to calculate a fairer remuneration.

Lastly Table 27 summarizes results according to the stated hypothesis and supplementary household income and expenses regression outputs, with a brief commentary on reported results, where appropriate.

Table 27. List of statistically significant regressions analyses

Nº	Results
1	Agricultural involvement was predicted to increase with farmer's age. The results, however, are misleading, as older farmers tend to perceive some of the activities as more difficult compared to their younger counterparts.
2	Agricultural involvement was predicted to increase with household size.
3	Agricultural intensity was predicted to increase with farmer's age. Same limitations apply as in the case of agricultural involvement.
4	Hours worked were predicted to increase with household size.
5	Household expenses were predicted to increase with farmer's age.
6	Household income was predicted to increase with household size. It was also observed to increase faster than expenses.
7	Household expenses were observed to increase with household size.
8	Household income was predicted to increase with the number of elderly household members. It was also observed to increase faster than expenses, suggesting that the elderly are net contributors to the household budget.
9	Household expenses were predicted to increase with the number of elderly household members.
10	Household expenses were predicted to increase with the number of children within the household. They were also observed to increase faster than income.
11	Household income was predicted to increase with the number of dependent household members. It was also observed to increase faster than expenses.
12	Household expenses were predicted to increase with the number of dependent household members.
13	Household income was predicted to increase with the average number of elderly household members. It was also observed to increase faster than expenses, suggesting that the elderly are net contributors to the household budget.
14	Household expenses were predicted to increase with the average age of elderly household members.
15	Household income was predicted to increase with land ownership. It was also observed to increase faster than expenses.
16	Household income was predicted to increase with years of education. It was also observed to increase faster than expenses.
17	Household expenses were predicted to increase with years of education.

Note 1: Many of the above-described statistically significant regressions had notably low predictive power (Adjusted R-squared statistic), thus requiring caution when interpreting.

REFERENCES

Agarwal, A., Lubet, A., Mitgang, E., Mohanty, S., Bloom, D.E. 2016. *Population aging in India: Facts, issues, and options*. Discussion paper no. 10162. [Online], Available: http://ftp.iza.org/dp10162.pdf, [Accessed: 29 November 2017].

Agrawal, G., Keshri, K. 2014. Morbidity patterns and health care seeking behavior among older widows in India. *PLOS ONE*, 9(4): e94295.

Agrawal, S. 2012. Effect of living arrangement on the health status of elderly in India: Findings from a national cross-sectional survey. *Asian Population Studies*, 8(1): 87-101.

Ahuja, S., et al. 2006. Economic reforms in India: Task force report. [Online], Available: https://web.archive.org/web/20090207125338/http://harrisschool.uchicago.edu/News/press-releases/IPP%20Economic%20Reform%20in%20India.pdf, [Accessed: 14 January 2018].

Alam, M. 2006. *Aging in India: Socio-economic and health dimensions*. New Delhi, India: Academic Foundation.

Alam, M., James, K.S., Giridhar, G., Sathyanarayana, K.M., Kumar, S., Raju, S., Syamala, T.S., Subaiya, L., Bansod, D.W. 2012. Report on the status of elderly in select states of India, 2011. [Online], Available: http://www.isec.ac.in/AgeingReport_28Nov2012_LowRes-1.pdf, [Accessed: 19 December 2017].

Alam, M., Mazumdar, S., Chakravarty, I., Yadav, P. 2014. *The status of elderly in West Bengal, 2011*. New Delhi: United Nations Population Fund.

Alders, P., Broer, P.D. 2004. Aging, fertility, and growth. *Journal of Public Economics*, 89: 1075-1095.

Angus, M. 2003. *Development center studies the world economy historical statistics: Historical statistics*. Paris: OECD Publishing, ISBN: 9264104143.

Arokiasamy, P., Bloom, D., Lee, J. 2012. A longitudinal aging study in India: Vision, design, implementation, and preliminary findings. [Online], Available: https://www.ncbi.nlm.nih.gov/books/NBK109220/, [Accessed: 13 December 2017].

Avison, D., Malaurent, J. 2014. Is theory king? Questioning the theory fetish in information systems. *Journal of Information Technology*, 29(4): 327-336.

Bakshi, S., Pathak P. 2016. Aging and the socioeconomic life of older adults in India: An empirical exposition. *SAGE Open*, 6(1). DOI: 10.1177/2158244015624130.

Barr, N. 2002. Reforming pensions: Myths, truths, and policy choices. *International Social Security Review*, 55(2): 3-36.

Baum, C.F. 2006. *An introduction to modern econometrics using Stata*. College Station: Stata Press. ISBN: 1597180130.

Berry, W.D., Feldman, S. 1985. *Multiple regression in practice*. Thousand Oaks: SAGE Publications. ISBN: 9780803920545.

Blake, D., Mayhew, L. 2006. System in the light of population aging and declining fertility. *The Economic Journal*, 116: 286-305.

Bloom, D.E. 2011. Population dynamics of India and implications for economic growth. Harvard Program on the Global Demography of Aging working paper no. 65. [Online], Available: www.hsph.harvard.edu/pgda/working.htm, [Accessed: 11 December 2017].

Bloom, D.E., Mahal, A.S., Rosenberg, L., Sevilla, J. 2010. Economic security arrangements in the context of population aging in India. *International Social Security Review*, 63(3-4): 79-97.

Brace, I. 2008. Questionnaire design: *How to plan, structure and write survey material for effective market research*. London: Kogan Page. ISBN: 9780749450281.

Brendan, L.R., Sek, S.K. 2016. *The relationship between population aging and the economic growth in Asia*. AIP Conference Proceedings, Volume 1750, 21 June 2016.

Broadberry, S., Gupta, B. 2005. *Cotton textiles and the great divergence: Lancashire, India and shifting competitive advantage, 1600-1850*. International Institute of Social History. Department of Economics, University of Warwick.

California State University. 2015. Research methods: Multiple regression. [Online], Available: http://web.csulb.edu/~msaintg/ppa696/696regmx.htm, [Accessed: 6 April 2017].

Carroll, C. 2010. A short history of social security retirement ages. [Online], Available: http://dailysignal.com/2010/12/14/a-short-history-of-social-security-retirement-ages/, [Accessed: 15 April 2017].

Chadda, R.K., Sinha Deb, K. 2013. Indian family systems, collectivistic society, and psychotherapy. *Indian Journal of Psychiatry*, 55(2): S299-S309.

Chanana, B.H., Talwar P.P. 1987. Aging in India: Its socioeconomic and health implications. *Asia-Pacific Population Journal*, 2: 23-38.

Chandra, S. 2016. Three states hold the key. [Online], Available: http://indianexpress.com/article/opinion/columns/india-polpulation-family-planning-emergency-india-births-rate-total-fertility-rate-2914318/, [Accessed: 14 July 2017].

Chatterjee, S., Simonoff, J.S. 2013. *Handbook of regression analysis*. New Jersey: Wiley. ISBN: 9780470887165.

Chatterji, S. 2008. The health of aging populations in China and India. *Health Affairs*, 27(4): 1052-1063.

Chen, A.J., Jones, G.W., Domingo, L.J. 1989. *Aging in ASEAN: It's socio-economic consequences*. Singapore: Institute of Southeast Asian Studies.

Choe, E.H. 1989. *Population aging in the Republic of Korea*. Bangkok: Economic and Social Commission for Asia and the Pacific.

Cimperman, M., Brencic, M.M., Trkman, P., Mde, L.S. 2013. Older adults' perceptions of home TeleHealth Services. *Telemed J E Health*, 19(10): 786-790.

Clark, R.L., Ogawa, N., Kondo, M., Matsukura, R. 2010. Population decline, labor force stability, and the future of the Japanese economy. *European Journal of Population*, 6(2): 207-227.

Colin, J.C. 1997. *The coming oil crisis*. Multi-Science Publishing: Brentwood. ISBN: 0906588110.

Cramer, D. 1998. *Fundamental statistics for social research*. London: Routledge. ISBN: 9780415172042.

Cramer, D., Howitt, D. 2004. *The SAGE dictionary of statistics*. London: SAGE Publications. ISBN: 9780761941385.

Crouter, S.E., Albright, C., Bassett, D.R. 2004. The accuracy of polar S410 heart rate monitor to estimate energy cost of exercise. *Medicine and Science in Sports and Exercise*, 36(8): 1433-1439.

Cypher, J. 2014. *The process of economic development*. Abingdon: Routledge. ISBN: 9780415643283.

Dannecker, K.L., Sazonova, N.A., Melanson, E.L., Sazonov, E.S., Browning, R.C. 2013. A comparison of energy expenditure estimation of several physical activity monitors. *Medicine and Science in Sports and Exercise*, 45(11): 2105-2112.

Datt, R., Sundharam, K.P.M. 2009. *Indian economy*. New Delhi: S. Chand Group. ISBN: 9788121902984.

Davies, B.R., Robert III, R.R. 2006. Population aging, foreign direct investment and tax competition. SAID Business School, 1HPWP 07/10.

Deep Singh, K., 2016. India continues to climb World Economic Forum's competitive rankings, [Online], Available: https://blogs.wsj.com/indiarealtime/2016/09/28/india-continues-to-climb-world-economic-forums-competitive-rankings/, [Accessed: 4 April 2017].

Desai, S., et al. 2015. India Human Development Survey (IHDS). The University of Maryland and National Council of Applied Economic Research. [Online], Available: https://www.icpsr.umich.edu/icpsrweb/DSDR/studies/36151, [Accessed: 28 November 2017].

Dey, S., Nambiar, D., Lakshmi, J.K., Reddy, K.S. 2012. The health of the elderly in India: Challenges of access and affordability. [Online], Available: https://www.ncbi.nlm.nih.gov/books/NBK109208/, [Accessed: 30 November 2017].

Diaz, K.M., Krupka, D.J., Chang, M.J., Peacock, J., Ma, Y., Goldsmith, J., Davidson, K.W. 2015. Fitbit: An accurate and reliable device for wireless physical activity tracking. *International Journal of Cardiology*, 185: 138-140.

Diwan, P., Kumar, V. 1984. *Law towards stable marriages*. New Delhi: Seema.

DNA India. 2014. 60% rural families landless in Bihar, according to socio-economic survey by CPI-ML. [Online], Available: http://www.dnaindia.com/india/report-60-rural-families-landless-in-bihar-according-to-socio-economic-survey-by-cpi-ml-2035714, [Accessed: 30 January 2018].

Dogra, B. 2013. Pension Parishad raises hopes among the elderly. *Mainstream*, 51(15): 26-27.

Dominic, D., 2003. Dreaming with BRICs: The path to 2050. [Online], Available: http://www.goldmansachs.com/our-thinking/archive/archive-pdfs/brics-dream.pdf, [Accessed: 11 January 2018].

Duke University. 2018. Regression diagnostics: Testing the assumptions of linear regression. [Online], Available: http://people.duke.edu/~rnau/testing.htm, [Accessed: 14 April 2018].

Duraisamy, P., Mahal, A. 2005. Health, poverty and economic growth in India. In Health systems in India: Delivery and financing of services. National Commission on Macroeconomics and Health, Ministry of Health and Family Welfare, Government of India, New Delhi.

Dutta, P., Howes, S., Murgai, R., 2010. Small but effective: India's targeted unconditional cash transfers. *Economic and Political Weekly*, 45(52): 63-70.

Ebbinghaus, B. 2006. *Reforming early retirement in Europe, Japan, and the USA*. Oxford: Oxford University Press. ISBN: 9780199286119.

Eiras, M.G., Niepelt, D. 2012. Aging, government budgets, retirement and growth. *European Economic Review*, 56: 97-115.

Elferink, M., Schierhorn, F. 2016. Global demand for food is rising. Can we meet it? Harvard Business Review, April 7. [Online], Available: https://hbr.org/2016/04/global-demand-for-food-is-rising-can-we-meet-it, [Accessed: 22 October 2017].

Elgin, C., Tumen, S. 2010. Can sustained economic growth and declining population coexist? Barro-Becker children meet Lucas. *Economic Modeling*, 29: 1899-1908.

Eswaran, H., Reich, P.F., Beinroth, F.H. 1997. Global distribution of soils with acidity. p. 159-164. In Moniz et al. (Ed.) *Plant-soil interactions at low pH: Sustainable agriculture and forestry production*. Proceedings of the 4th International Symposium on Plant-Soil Interactions at Low pH. Belo Horizonte, Brazil, 17-24 March 1996.

Evenson, K., Goto, M.M., Furberg, R.D., 2015. A systematic review of the validity and reliability of consumer-wearable activity trackers. *International Journal of Behavioral Nutrition and Physical Activity*, DOI: 10.1186/s12966-015-0314-1.

Export.gov. 2017. India - Agricultural commodities. [Online], Available: https://www.export.gov/article?id=India-Agricultural-Commodities, [Accessed: 20 March 2018].

Fairman, C. 2016. Is your fitness tracker accurate? [Online], Available: https://www.bodybuilding.com/fun/is-your-fitness-tracker-accurate, [Accessed: 11 January 2017].

Farahani, M., Subramanian, S.V., Canning, D. 2010. Effects of state-level public spending on health on the mortality probability in India. *Health Economics*, 19(11): 1361-1376.

Fitbit. 2018. [Online], Available: https://www.fitbit.com/eu/home, [Accessed: 28 March 2018].

Food and Agriculture Organization of the United Nations (FAO). 2012a. World agriculture towards 2030/2050. [Online], Available: http://www.fao.org/docrep/016/ap106e/ap106e.pdf, [Accessed: 6 May 2017].

Food and Agriculture Organization of the United Nations (FAO). 2012b. The state of food and agriculture. [Online], Available: http://www.fao.org/docrep/017/i3028e/i3028e.pdf, [Accessed: 14 February 2017].

Food and Agriculture Organization of the United Nations (FAO). 2014. Impacts of foreign agricultural investment on developing countries: Evidence from case studies. [Online], Available: http://www.fao.org/3/a-i3900e.pdf, [Accessed: 29 September 2017].

Food and Agriculture Organization of the United Nations (FAO). 2015. Statistical database. [Online], Available: http://faostat3.fao.org/home/E, [Accessed: 17 May 2017].

Frost, J. 2013. Multiple regression analysis: Use adjusted R-squared and predicted R-squared to include the correct number of variables. [Online], Available: http://blog.minitab.com/blog/adventures-in-statistics-2/multiple-regession-analysis-use-adjusted-r-squared-and-predicted-r-squared-to-include-the-correct-number-of-variables, [Accessed: 18 May 2017].

Gangopadhyay, J. 2016. The trials of India's aging population. [Online], Available: https://thediplomat.com/2016/10/the-trials-of-indias-aging-population/, [Accessed: 12 December 2017].

Ghosh, S., Sarker, G., Bhattacharya, K., Pal, R., Mondal, T.K. 2017. Quality of life in the geriatric population in a community development block of Kishanganj, Bihar, India. *Journal of Krishna Institute of Medical Sciences University*, 6(1): 33-41.

Gideon, L. 2012. *Handbook of survey methodology for the social sciences*. Berlin: Springer. ISBN: 9781461438762.

Gokhale, S.D. 2011. *National and international efforts for promoting the situation of older persons: A review*. In Raju, S.S. 2011. Voice of the elderly in India. Delhi: B.R. Publishing Corporation.

Government of India. 2014a. Databook: GDP at factor cost at 2004-05 prices, share to total GDP. [Online], Available: http://planningcommission.nic.in/data/datatable/0306/table%203.pdf, [Accessed: 15 January 2018].

Government of India. 2014b. [Online], Available: http://planningcommission.gov.in/data/datatable/data_2312/DatabookDec2014%202.pdf, [Accessed: 8 February 2018].

Government of India. 2015a. An integrated programme for older persons. [Online], Available: http://socialjustice.nic.in/writereaddata/UploadFile/IPOP%202016%20pdf%20document.pdf, [Accessed: 14 December 2017].

Government of India. 2015b. Census of India 2011. [Online], Available: http://censusindia.gov.in/, [Accessed: 11 May 2017].

Government of India. 2017. Provisional estimates of annual national income, 2016-17 and quarterly estimates of gross domestic product, 2016-17. [Online], Available: http://pib.nic.in/newsite/PrintRelease.aspx?relid=163287, [Accessed: 3 March 2018].

Government of India. 2018a. Department of Commerce export - import data bank. [Online], Available: http://commerce.nic.in/eidb/default.asp, [Accessed: 2 January 2018].

Government of India. 2018b. Press note on second advance estimates of national income 2018-18 and quarterly estimates of gross domestic product for the third quarter (Q3) of 2017-18. [Online], Available: http://www.mospi.gov.in/sites/default/files/press_release/nad_pr_2eni_28feb18_0.pdf, [Accessed: 27 January 2018].

Govil, P., Gupta, S. 2016. Domestic violence against elderly people: A case study of India. *Advances in Aging Research*, 5: 110-121.

Green, B.M. 1978. *Eating oil: Energy use in food production*. Westview Press: Boulder. ISBN: 9780891582441.

Gribble, J., Bremner J. 2012. The challenge of attaining the demographic dividend. Washington D.C.: Population Reference Bureau. [Online], Available: http://www.prb.org/pdf12/demographic-dividend.pdf, [Accessed: 16 April 2017].

Guest, R.S., McDonald, I.M. 2003. Vintage versus homogeneous capital in simulations of population aging: Does it matter? *Applied Economics Letters*, 10: 149-153.

Harrell, F.E. 2001. *Regression modeling strategies*. Berlin: Springer. ISBN: 9781475734621.

Hill, T., Lewicki, P. 2006. *Statistics: Methods and applications*. Tulsa: StatSoft, Inc. ISBN: 1884233597.

Hindustan Times. 2006. Raise retirement age of BHEL staff: Trade union. [Online], Available: http://www.hindustantimes.com/india/raise-retirement-age-of-bhel-staff-trade-union/story-EBFUffvF30NQrRRu4kukYI.html, [Accessed: 26 May 2017].

Hock, H., Weil, N.D. 2012. On the dynamics of the age structure, dependency and consumption. *Journal of Population Economics*, 25: 1019-1043.

Husain, Z., Ghosh, S. 2001. Is health status of elderly worsening in India? A comparison of successive rounds of National Sample Survey Data. *Journal of Biosocial Science*, 43(2): 211-31.

India Brand Equity Foundation (IBEF). 2013a. Textiles. [Online], Available: https://www.ibef.org/industry/textiles.aspx, [Accessed: 22 January 2018].

India Brand Equity Foundation (IBEF). 2013b. The Indian agriculture sector: Investments, growth, and prospects. [Online], Available: https://www.ibef.org/download/Agriculture-Sector-04jan.pdf, [Accessed: 3 May 2017].

India Brand Equity Foundation (IBEF). 2018. [Online], Available: https://www.ibef.org/industry/services.aspx, [Accessed: 22 January 2018].

Inikori, I.J. 2002. *Africans and the Industrial Revolution in England*. Cambridge: Cambridge University Press, ISBN: 0521010799.

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate change 2014: Impacts, adaptation, and vulnerability. [Online], Available: https://www.ipcc.ch/report/ar5/wg2/, [Accessed: 3 May 2017].

International Labor Organization (ILO). 2011a. Social security and aging populations in developing countries. [Online], Available: http://www.ilo.org/global/publications/world-of-work-magazine/articles/WCMS_155304/lang--en/index.htm, [Accessed: 25 June 2017].

International Labor Organization (ILO). 2011b. *Social security for social justice and a fair globalization*. International Labor Conference, 100th Session, Report VI, Geneva, Switzerland, 2011.

International Labor Organization (ILO). 2017. Labor force, total: India. [Online], Available: https://data.worldbank.org/indicator/SL.TLF.TOTL.IN?locations=IN, [Accessed: 22 January 2018].

International Monetary Fund (IMF). 2018a. Report for selected countries and subjects: India. [Online], Available: http://www.imf.org/external/pubs/ft/weo/2017/02/weodata/weorept.aspx?pr.x=32&pr.y=7&sy=2016&ey=2018&scsm=1&ssd=1&sort=country&ds=.&br=1&c=534&s=NGDPD%2CPPPGDP%2CNGDPDPC%2CPPPPC&grp=0&a=, [Accessed: 14 January 2018].

International Monetary Fund (IMF). 2018b. Report for selected countries and subjects: India. [Online], Available: https://www.imf.org/external/pubs/ft/weo/2017/01/weodata/weorept.aspx?pr.x=8&pr.y=10&sy=2016&ey=2020&scsm=1&ssd=1&sort=country&ds=.&br=1&c=534&s=GGXWDG%2CGGXWDG_NGDP&grp=0&a=, [Accessed: 14 January 2018].

International Monetary Fund (IMF). 2018c. Report for selected countries and subjects: India. [Online], Available: https://www.imf.org/external/pubs/ft/weo/2017/01/weodata/weorept.aspx?pr.x=56&pr.y=4&sy=2016&ey=2020&scsm=1&ssd=1&sort=country&ds=.&br=1&c=534&s=GGR%2CGGR_NGDP%2CGGX%2CGGX_NGDP&grp=0&a=, [Accessed: 13 January 2018].

Jain, M. 2016. Five charts show how the elderly in India are growing - As is their dependence on young people. [Online], Available: https://scroll.in/article/807043/five-charts-show-how-the-elderly-in-india-are-growing-as-is-their-dependence-on-young-people, [Accessed: 30 June 2017].

James, E. 1999. *Coverage under old-age security programs and protection for the uninsured - what are the issues?* Policy Research Working Paper no. 2163. Inter-American Development Bank Conference on Social Protection, 4-5 February 1999, Washington D.C.

Jeffrey, G. Williamson, D.C. 2005. *India's deindustrialization in the 18th and 19th centuries*. [Online], Available: https://www.tcd.ie/Economics/staff/orourkek/Istanbul/JGWGEHNIndianDeind.pdf, [Accessed: 3 January 2018].

Kabeer, N. 1999. *The conditions and consequences of choice: Reflections on the measurement of women's empowerment*. UNRISD discussion paper no. 108. Geneva: United Nations Research Institute for Social Development.

Kanti Sahu, B. 2010. *Improvements in life expectancy and sustainability of social security schemes*. The 6th International Policy and Research Conference on Social Security, 29 September - 1 October 2010, Luxembourg.

Kardile, M.S., Peisah, C. 2017. Elder abuse by abandonment in India: A novel community awareness and intervention strategy. *International Psychogeriatrics*, 9(6): 1035-1036.

Kaufman, R. 2013. *Heteroskedasticity in regression: Detection and correction*. Thousand Oaks: SAGE Publications. ISBN: 9781452234953.

Khanal, A.R., Mishra, A.K. 2017. Enhancing food security: Food crop portfolio choice in response to climatic risk in India. *Global Food Security*, 12(1): 22-30.

KPMG. 2016. India economic survey 2015-16: Key highlights. [Online], Available: https://home.kpmg.com/content/dam/kpmg/pdf/2016/04/KPMG-Flash-News-India-Economic-Survey-2015-16%E2%80%93Key-Highlights-3.pdf, [Accessed: 12 April 2017].

Kulkarni, S., Raju, S., Bammidi, S. 2015. *Social Security for the elderly in India. Building knowledge base on aging in India: Increased awareness, access, and quality of elderly services*. Thematic paper 1. New York: United Nations Population Fund.

Kumar, S., Sathyanarayana, K.M., Omer, A. 2011. *Living arrangements of elderly in India*. International Conference on Challenges in Population Aging in Asia, 14-15 March 2011, New Delhi.

Lee, H.S., Mason, A., Park, D. 2011. Why does population aging matter so much for Asia? ERIA Discussion Paper Series, ERIA-DP-2011-04.

Lee, J., McGovern, M.E., Bloom, D.E., Arokiasamy, P., Risbud, A., O'Brien, J., Kale, V., Hu, P. 2015. Education, gender, and state-level gradients in the health of older Indians: Evidence from biomarker data. *Harvard University Program on the Global Demography of Ageing*, 19: 145-156.

Lee, J.M., Kim, Y., Welk, G.J. 2014. The validity of consumer-based physical activity monitors. *Medicine and Science in Sports and Exercise*, 46(9): 1840-1848.

Lisenkova, K., Merette, M., Wright, R. 2012. The impact of population aging on the labor market: Evidence from overlapping generations computable general equilibrium (OLG-CGE) model of Scotland. Discussion Papers in Economics no. 12-13, Strathclyde.

Litwin, H. 2007. Does early retirement lead to longer life? *Aging and society*, 27(5): 739-754.

Mason, A. 2005. Demographic transition and demographic dividends in developed and developing countries. United Nations Expert Group Meeting on Social and Economic Implications of Changing Population Age Structure, UN/POP/PD/2005/2.

Mathiassen, L., Chiasson, M., Germonprez, M. 2012. Style composition in action research publication. *MIS Quarterly*, 32(2): 347-363.

Miller, T. 2011. *The rise of the intergenerational state: Aging and development*. In Park, D., Lee, S.H., Mason, *Population aging and the generational economy*. Cheltenham: Edward Elgar Publishing. ISBN: 9781781952306.

Milovanovic, V., Smutka, L. 2018. Cooperative rice farming within rural Bangladesh. *Journal of Co-operative Organization and Management*, DOI: https://doi.org/10.1016/j.jcom.2018.03.002.

Mincer, J. 1974. *Age and experience profiles of earnings*. New York: Columbia University Press. ISBN: 0870142658.

Mullan, P. 2000. *The imaginary time bomb: Why an aging population is not a social problem*. London: I.B. Tauris.

Murphy, M. 2016. The effect of long-term migration dynamics on population structure in England & Wales and Scotland. *Population Studies*, 70(2): 149-162.

Mutalik, G., Shah, V. 2011. *Programmes and schemes for senior citizens of India: A review*. In Raju, S.S. 2011. Voice of the elderly in India. Delhi: B.R. Publishing Corporation.

Nasir, Z.M., Ali, S.M. 2000. Labor market participation of the elderly. *The Pakistan Development Review*, 39: 1075-1086.

National Institute of Open Schooling (NIOS). 2013. India and the world through the ages. [Online], Available: http://www.nios.ac.in/media/documents/SecSocSciCour/English/Lesson-05.pdf, [Accessed: 17 January 2018].

National Sample Survey Office (NSSO). 2013. Household ownership and operational holdings in India. [Online], Available: http://mospi.nic.in/sites/default/files/publication_reports/Report_571_15dec15_2.pdf, [Accessed: 4 January 2018].

Nayak, G. 2017. In a first since 1991, FDI flow takes care of CAD. [Online], Available: https://economictimes.indiatimes.com/markets/stocks/news/in-a-first-since-1991-fdi-flow-takes-care-of-cad/articleshow/58000640.cms, [Accessed: 14 February 2018].

NCSS. 2015. Stepwise regression. [Online], Available: http://ncss.wpengine.netdna-cdn.com/wp-content/themes/ncss/pdf/Procedures/NCSS/Stepwise_Regression.pdf, [Accessed: 22 March 2017].

Nield, D. 2017. How it works: We explain how your fitness tracker measures your daily steps. [Online], Available: https://www.wareable.com/fitness-trackers/how-your-fitness-tracker-works-1449, [Accessed: 23 March 2017].

Oates, B.J. 2006. *Researching information systems and computing*. Thousand Oaks: Sage Publications Ltd. ISBN: 9781412902243.

Park, D., Lee, S.H., Mason, A. 2012. *Aging, economic growth, and old-age security in Asia*. Cheltenham: Edward Elgar Publishing. ISBN: 9781781952306.

Paul, S.S., Tiedemann, A., Hassett, L.M., Ramsay, E., Kirkham, C., Chagpar, S., Sherrington, C., 2015. The validity of the Fitbit activity tracker for measuring steps in community-dwelling older adults. *BMJ Open Sport & Exercise Medicine*, DOI: 10.1136/bmjsem-2015-000013.

Perera, P.D.A. 1989. *Emerging issues of population aging in Sri Lanka*. Asian Population Studies Series No. 98. New York: United Nations.

Petre, M., Rugg, G. 2010. *The unwritten rules of PhD research*. Berkshire: Open University Press. ISBN: 9780335237029.

Pew Research Center. Remittance flows worldwide in 2016: India. 2018. Available: http://www.pewglobal.org/interactives/remittance-map/, [Accessed: 19 February 2018].

Poincare, J.H. 1903. *The science and the hypothesis*. Paris: E. Flammarion.

Profis, S., 2014. Do wristband heart trackers actually work? A checkup. [Online], Available: https://www.cnet.com/news/how-accurate-are-wristband-heart-rate-monitors/, [Accessed: 17 March 2017].

Pylee, M.V. 1979. *India's constitution*. Bombay: Asia Publishing House Ltd.

Rajan, I.S. 2001. Social assistance for poor elderly: How effective? *Economic and Political Weekly*, 36(8): 613-617.

Rajan, I.S. 2008. Social security for the elderly: Experiences from South Asia. London: Routledge. ISBN: 9780415445436.

Rajan, I.S., Balagopal, G. 2017. *Elderly care in India*. Berlin: Springer. ISBN: 9789811034398.

Rajan, S. I. 2010. Demographic aging and employment in India. Bangkok: International Labor Organization, Regional Office for Asia and the Pacific. [Online], Available: http://digitalcommons.ilr.cornell.edu/cgi/viewcontent.cgi?article=1090&context=intl, [Accessed: 30 March 2017].

Ramakrishnan, A. 2010. Rupee rally falters as oil rises to two-year high: India Credit. [Online], Available: http://www.livemint.com/Money/ARA9CZeNBnsvIokSOZc2yN/Rupee-rally-falters-as-oil-rises-to-the-highest-level-in-two.html, [Accessed: 19 February 2018].

Ramamurti, P.V., Jamuna, D. 2005. Will legislation help the care of older persons? *BOLD*, 16(1): 15-18.

Ramanujam, M.S., Gupta, R., Mamgain, R.P. 1990. Empowerment of women. *Manpower Journal*, 26, (48-80).

Rosenzweig, M.R. 1997. *Handbook of population and family economics, volume 1*. North Holland: Elsevier. ISBN: 9780444826459.

Rutherford, A. 2001. *Introducing ANOVA and ANCOVA: A GLM approach*. London: SAGE Publications. ISBN: 978-0761951612.

Sanderson, W.C., Scherbov, S. 2008. Rethinking age and aging. *Population Bulletin*, 63(4): 1-16.

Sasaki, J.E., Hickey, A., Mavilia, M., Tedesco, J., John, D., Kozey, K.S., Freedson, P.S. 2014. Validation of the Fitbit wireless activity tracker for prediction of energy expenditure. *Journal of Physical Activity and Health*, 12(2): 149-154.

Sathyanarayana, K.M., Giridhar, G., Kumar, S., James, K.S., Alam, M. 2014. Living arrangements of elderly in India: Policy and programmatic implications. *Cambridge University Press*: 74-95.

Scardino, A. 2009. *Improvements in life expectancy and sustainability of social security schemes*. International Conference of Social Security Actuaries and Statisticians, Ottawa, Canada, 16-18 September 2009.

Seth, D. 2015. Atal Pension Yojana likely to miss December target. [Online], Available: http://www.business-standard.com/article/economy-policy/atal-pension-yojana-likely-to-miss-december-target-115121600020_1.html, [Accessed: 30 December 2017].

Sharma, A. 2016. The changing agricultural demography of India. *International Journal of Rural Management*, 3(1): 27-41.

Shukla, R. 2010. *How India earns, spends and saves: Unmasking the real India*. New Delhi: SAGE Publications. ISBN: 9788132104766.

Sigg, R. 2005. A global overview of social security in the age of longevity. [Online], Available: http://www.un.org/esa/population/meetings/EGMPopAge/6_RSigg.pdf, [Accessed: 14 October 2017].

Staley, S. 2006. The rise and fall of Indian socialism: Why India embraced economic reform. [Online], Available: http://reason.com/archives/2006/06/06/the-rise-and-fall-of-indian-so, [Accessed: 11 January 2018].

Stigler, M.S. 1989. Francis Galton's account of the invention of correlation. *Statistical Science* 4(2): 73-79.

Symington, A. 2013. Pakistan's women can now dial-a-doc. [Online], Available: https://www.csmonitor.com/World/Asia-South-Central/2013/0808/Pakistan-s-women-can-now-dial-a-doc, [Accessed: 30 December 2017].

The Economist. 1997. That old Gandhi magic. [Online], Available: https://www.economist.com/node/107076, [Accessed: 20 January 2018].

The National. 2017. India may have worst income inequality levels for almost a century. [Online], Available: https://www.thenational.ae/world/asia/india-may-have-worst-income-inequality-levels-for-almost-a-century-1.628196, [Accessed: 14 April 2018].

The Organization for Economic Co-operation and Development (OECD). 2006. *OECD employment outlook: Boosting jobs and incomes*. Paris: OECD. ISBN: 9264023844.

The Wall Street Journal. 2013. India's food transportation ordeal. [Online], Available: https://www.wsj.com/news/articles/SB10001424127887324907204578187122310400706, [Accessed: 2 January 2018].

The World Bank. 2010. Employment in agriculture. [Online], Available: http://data.worldbank.org/indicator/SL.AGR.EMPL.ZS, [Accessed: 27 September 2017].

The World Bank. 2011. Education in India. [Online], Available: http://www.worldbank.org/en/news/feature/2011/09/20/education-in-india, [Accessed: 1 September 2017].

The World Bank. 2012. India: Issues and priorities for agriculture. [Online], Available: http://www.worldbank.org/en/news/feature/2012/05/17/india-agriculture-issues-priorities, [Accessed: 17 February 2018].

The World Bank. 2016. India's poverty profile. [Online], Available: http://www.worldbank.org/en/news/infographic/2016/05/27/india-s-poverty-profile, [Accessed: 7 February 2018].

The World Bank. 2017. Enabling the business of agriculture. [Online], Available: http://eba.worldbank.org/~/media/WBG/AgriBusiness/Documents/Reports/2017/EBA 2017-Report17.pdf, [Accessed: 13 January 2018].

The World Bank. 2018a. Doing Business 2018: Economy rankings. [Online], Available: http://www.doingbusiness.org/rankings, [Accessed: 19 January 2018].

The World Bank. 2018b. Data Bank. [Online], Available: http://databank.worldbank.org/, [Accessed: 8 March 2018].

Tofallis, C. 2014. Add or multiply? A tutorial on ranking and choosing with multiple criteria. [Online], Available: https://pubsonline.informs.org/doi/pdf/10.1287/ited.2013.0124, [Accessed: 23 March 2018].

Tosun, S.M. 2003. Population aging and economic growth political economy and open economy effects. *Economics Letters*, 81: 291-296.

Tourangeau, R., Yan, T. 2007. Sensitive questions in surveys. *Psychological Bulletin*, 133(5): 859-883.

Tripathi, S. 2006. Escaping the 'Hindu rate of growth'. [Online], Available: https://www.theguardian.com/commentisfree/2006/jun/13/escapingthehindurateofgro, [Accessed: 11 January 2018].

Tyers, R., Shi, Q. 2007. Demographic change and policy responses: Implication for the global economy. *The World Economy*, 30: 537-566.

United Nations (UN). 2000. World population prospects: The 2000 revision. [Online], Available: http://www.un.org/esa/population/publications/wpp2000/highlights.pdf, [Accessed: 22 May 2017].

United Nations (UN). 2001. World population aging: 1950-2050. [Online], Available: https://www.un.org/esa/population/publications/worldageing19502050/, [Accessed: 29 January 2017].

United Nations (UN). 2013. World population aging. [Online], Available: https://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2013.pdf, [Accessed: 2 May 2017].

United Nations (UN). 2015. *World population prospects: The 2015 revision*. Geneva: United Nations Department of Economic and Social Affairs Population Division.

United Nations (UN). 2016. Country Fact Sheets 2016. [Online], Available: http://unctad.org/en/Pages/DIAE/World%20Investment%20Report/Country-Fact-Sheets.aspx, [Accessed: 2 March 2018].

United Nations (UN). 2018. Comtrade Database. [Online], Available: https://comtrade.un.org/data, [Accessed: 19 February 2018].

United Nations Conference on Trade and Development (UNCTAD). 2016. *Robots and industrialization in developing countries*. Policy Brief, Volume 50. http://unctad.org/en/PublicationsLibrary/presspb2016d6_en.pdf.

United Nations Development Programme (UNDP). 2005. Human development report 2005. [Online], Available: http://hdr.undp.org/sites/default/files/reports/266/hdr05_complete.pdf, [Accessed: 18 July 2017].

United Nations Population Division (UNPD). 2011. World population prospects: The 2010 revision. [Online], Available: http://www.prb.org/Publications/Reports/2012/india-older-population.aspx/, [Accessed: 29 November 2017].

Uppal, S., Sarma, S. 2007. Aging, health, and labor market activity: The case of India. *World Health and Population*, 9(4): 79-97.

Valin, H., Sands, R.D., Mensbrugghe, D. van der, Nelson, G.C., Ahammad, H., Blanc, E., Bodirsky, B., Fujimori, S., Hasegawa, T., Havlik, P., Heyhoe, E., Kyle, P., Mason-D'Croz, D., Paltsev, S., Rolinski, S., Tabeau, A., Meijl, H. van, Lampe, M. von, Willenbockel, D. 2013. The future of food demand: understanding differences in global economic models. *Agricultural Economics*, 45(1): 51-67.

Van Ginneken, W. 2003. Extending social security: Policies for developing countries. [Online], Available: http://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/documents/publication/kd00061.pdf, [Accessed: 3 August 2017].

Verma, R., Dixit, P., Singh, A., Khurana, A., Kumar, M., Singh, R. 2017. Problems of the elderly age group in the rural area of Haryana (India): A community-based study. *Indian Journal of Public Health Research and Development*, 8(1): 204-209.

Walder, B.A., Doring, T. 2012. The effect of population aging on private consumption - a simulation for Austria based on household data up to 2050. *Eurasian Economic Review*, 2: 63-80.

Wang, R., Blackburn, G., Desai, M., Phelan, D., Gillinov, L., Houghtaling, P., Gillinov, M. 2017. The accuracy of wrist-worn heart rate monitors. *JAMA Cardiology*, 2(1): 104-106.

Weigand, C., Grosh, M. 2008. *Levels and patterns of safety net spending in developing and transitional countries' social protection*. Discussion Paper no. 817. Washington DC: The World Bank.

Whetten, D.A. 1989. What constitutes a theoretical contribution? *Academy of Management Review*, 14(4): 490-495.

Whittingham, M.J., Stephens, P.A., Bradbury, R.B., Freckleton, R.P. 2006. Why do we still use stepwise modeling in ecology and behavior? *Journal of Animal Ecology*, 75: 1182-1189.

World Economic Forum (WEF). 2016a. The Global Competitiveness Report 2016-2017. [Online], Available: http://www3.weforum.org/docs/GCR2016-2017/05FullReport/TheGlobalCompetitivenessReport2016-2017_FINAL.pdf. [Accessed: 2 April 2017].

World Economic Forum (WEF). 2016b. Inequality in India: what's the real story? [Online], Available: https://www.weforum.org/agenda/2016/10/inequality-in-india-oxfam-explainer/, [Accessed: 2 May 2018].

World Health Organization (WHO). 2007. Global age-friendly cities: A guide. Washington D.C.: World Health Organization. [Online], Available: http://www.who.int/ageing/publications/Global_age_friendly_cities_Guide_English.pdf, [Accessed: 14 December 2017].

World Trade Organization (WTO). 2016. Country profile: India. [Online], Available: http://stat.wto.org/CountryProfile/WSDBCountryPFView.aspx?Country=IN&Language=F, [Accessed: 3 March 2018].

Wu, C., Odden, C.M., Fisher, G.G., Stawski, R.S. 2016. Association of retirement age with mortality: A population-based longitudinal study among older adults in the USA. *Epidemiological Community Health*, 70: 917-923.

Yadava, K.N.S., Yadava, S.S., Sharma, C.L.N. 1996. A study of socioeconomic factors and behavioral problems of the aged persons in rural Northern India. *Demography India*, 25: 21-34.

Yates, D.S., Moore, D.S., Starnes, S.D. 2008. *The practice of statistics*. New York: W.H. Freeman. ISBN: 9781429245593.

Yip, W., Mahal, A. 2008. The health care systems of China and India: Performance and future challenges. *Health Affairs*, 27(4): 921-932.

Zabel, F., Putzenlechner, B., Mauser, W. 2014. Global agricultural land resources - A high-resolution suitability evaluation and its perspectives until 2100 under climate change conditions. *PLOS ONE*, 9(12): e114980.

APPENDIX A

Czech University of Life Sciences Prague
Faculty of Economics and Management
Kamycka 129, Prague, Czech Republic

Vladimir Milovanovic

Population Aging in Rural India · Lakhisarai · 2017

Introduction & Elimination Questions	Date:	Time:
Introduction checklist: - Thank you for agreeing to take part in our research - We are investigating how aging affects farmers and their everyday work - The questionnaire will take approximately 15 minutes to complete - Your answers are anonymous and will be used for research purposes only - The study is conducted by the Czech University of Life Sciences Prague		
1. Are you a farmer? (*verify that farming is a full-time occupation and a primary source of income, i.e. at least 50% of work hours are dedicated to farming and at least 50% of household income originates from farming*)	Yes	No
2. Are you head of your household? (*if not, assess whether the person is sufficiently knowledgeable to answer the questions*)	Yes	No

Demographic Questions	Gender:	M	F
1. How old are you?			
2. How many members does your household have?			
3. How many are 17 years of age and younger? (*if any, read question four*)			
4. Record the age of each person.			
5. How many are 60 years of age and older? (*if any, read question six*)			
6. Record the age of each person.			

Ownership Questions		
1. Do you own a house?	Yes	No
2. How much agricultural land do you own? (*record with units of measure*)		
3. What is the most important piece of agricultural equipment you own?		
Tractor (*four wheels*)	Grain dryer	Seed drill
Cultivator (*two wheels*)	Grain miller	Plough
Harvester (*two wheels*)	Grain thrasher	Harrow
Rice transplanter (*walking*)	Irrigation equipment	Sprayer
Rice weeder (*walking*)	Doesn't own equipment	Other:
4. What are the most important animals you own?		
Cattle	Goat/sheep/pigs	Poultry
Fish	Doesn't own animals	Other:

Income, Spending, and Savings Questions		
1. How much does your household make per month? (*Indian rupee*)		
2. How much does your household spend per month? (*Indian rupee*)		
3. How much does your household save per month? (*Indian rupee*)		
4. Do you have any debt?	Yes	No

Agricultural Work Questions (*interviewee is head of household and is >17*)		
1. How many years of formal education do you have?		
2. At what age did you first start working in agriculture?		
3. Did you ever work outside of agriculture? (*if yes, read question four*)	Yes	No
4. How many years did you work in sectors other than agriculture?		
5. During which month do you work the most? Consider time spent working on your land, helping your family and friends, and working as hired labor.		
6. What are the three most important agricultural activities you performed during that month? (*record type of activity, e.g. land preparation, planting, irrigation, fertilizer/pesticide application, weeding, harvesting, transportation, threshing, drying, milling, storing, and type of plant, e.g. rice, wheat, sugarcane*) Rank the activities based on how physically demanding they are and indicate whether motorized equipment was used and who owns the equipment.		
1)		
Very easy / Easy / Moderate / Difficult / Very difficult		
Did you use the motorized equipment?	Yes / No	Do you own it? Yes / No
2)		
Very easy / Easy / Moderate / Difficult / Very difficult		
Did you use the motorized equipment?	Yes / No	Do you own it? Yes / No
3)		
Very easy / Easy / Moderate / Difficult / Very difficult		
Did you use the motorized equipment?	Yes / No	Do you own it? Yes / No
7. How many hours did you work per day during that month? (e.*g. 7 am - 9 pm*)		
8. Did you work most of the time on your land, helping your family and friends, or as hired labor during that month?		
(a) Worked on my land		
(b) Helped family and friends on their land		
(c) Worked as hired labor		
9. During which month do you work the least? Consider time spent working on your land, helping your family and friends, and working as hired labor.		
10. What are the three most important agricultural activities you performed during that month? (*record type of activity, e.g. land preparation, planting, irrigation, fertilizer/pesticide application, weeding, harvesting, transportation, threshing, drying, milling, storing, and type of plant, e.g. rice, wheat, sugarcane*) Rank the activities based on how physically demanding they are and indicate whether motorized equipment was used and who owns the equipment.		

1)						
Very easy	Easy	Moderate		Difficult	Very difficult	
Did you use the motorized equipment?		Yes	No	Do you own it?	Yes	No
2)						
Very easy	Easy	Moderate		Difficult	Very difficult	
Did you use the motorized equipment?		Yes	No	Do you own it?	Yes	No
3)						
Very easy	Easy	Moderate		Difficult	Very difficult	
Did you use the motorized equipment?		Yes	No	Do you own it?	Yes	No
11. How many hours did you work per day during that month? (e.*g. 7 am - 9 pm*)						
12. Did you work most of the time on your land, helping your family and friends, or as hired labor during those months?						
(a) Worked on my land						
(b) Helped family and friends on their land						
(c) Worked as hired labor						
13. What are the three most important agricultural activities you performed during the past month? (*record type of activity, e.g. land preparation, planting, irrigation, fertilizer/pesticide application, weeding, harvesting, transportation, threshing, drying, milling, storing, and type of plant, e.g. rice, wheat, sugarcane*) Rank the activities based on how physically demanding they are and indicate whether motorized equipment was used and who owns the equipment.						
1)						
Very easy	Easy	Moderate		Difficult	Very difficult	
Was motorized equipment used?		Yes	No	Do you own it?	Yes	No
2)						
Very easy	Easy	Moderate		Difficult	Very difficult	
Was motorized equipment used?		Yes	No	Do you own it?	Yes	No
3)						
Very easy	Easy	Moderate		Difficult	Very difficult	
Was motorized equipment used?		Yes	No	Do you own it?	Yes	No
14. How many hours did you work per day during this month? (*e.g. 7 am - 9 pm*)						
15. Did you work most of the time on your land, helping your family and friends, or as hired labor during those months? Rank the categories based on time spent per category.						
(a) Worked on my land						
(b) Helped family and friends on their land						
(c) Worked as hired labor						

Agricultural Work Questions (*interviewee is not head of household and is ≥60*)						
1. How old are you?						
2. What are the three most important agricultural activities you performed during the past month? (*record type of activity, e.g. land preparation, planting, irrigation, fertilizer/pesticide application, weeding, harvesting, transportation, threshing, drying, milling, storing, and type of plant, e.g. rice, wheat, sugarcane*) Rank the activities based on how physically demanding they are and indicate whether motorized equipment was used and who owns the equipment.						
1)						
Very easy	Easy	Moderate		Difficult	Very difficult	
Was motorized equipment used?		Yes	No	Do you own it?	Yes	No
2)						
Very easy	Easy	Moderate		Difficult	Very difficult	
Was motorized equipment used?		Yes	No	Do you own it?	Yes	No
3)						
Very easy	Easy	Moderate		Difficult	Very difficult	
Was motorized equipment used?		Yes	No	Do you own it?	Yes	No
3. How many hours did you work per day during this month? (*e.g. 7 am - 9 pm*)						
4. Did you work most of the time on your land, helping your family and friends, or as hired labor during those months? Rank the categories based on time spent per category.						
(a) Worked on my land						
(b) Helped family and friends on their land						
(c) Worked as hired labor						

APPENDIX B

Czech University of Life Sciences Prague
Faculty of Economics and Management
Kamycka 129, Prague, Czech Republic

Vladimir Milovanovic

Population Aging in Rural India · Lakhisarai · 2017

Introduction & Elimination Questions	Date:
Introduction checklist: - Thank you for agreeing to take part in our research - We are measuring how aging affects farmers and their everyday work - The measurement will take approximately 15 minutes to complete - Recorded data will be used for research purposes only - The study is conducted by the Czech University of Life Sciences Prague	

Demographic Questions	Gender:	M	F
1. How old are you?			

Activity Chart (*all interviewees*)
1. Describe the activity being performed. (*record type of activity, e.g. land preparation, planting, irrigation, fertilizer/pesticide application, weeding, harvesting, transportation, threshing, drying, milling, storing, and type of plant, e.g. rice, wheat, sugarcane*)
2. Record start time. (*e.g. 10:25 am*)
3. Indicate with an X minutes during which work is not performed (*e.g. respondent takes a break, talks to the interviewer, switches to another task*)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

4. Record initial number of steps. (*e.g. 142*)
5. Record final number of steps. (*e.g. 255*)