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Aims and Scope

Asia-Pacific Journal of Rural Development is a peer-reviewed journal that provides a platform for publication of articles in all areas of rural development. The aim of this journal is to provide a platform for policy makers and academicians to promote, share and discuss various new issues and developments in different areas of rural development. The journal publishes conceptual, empirical and review papers in the form of research articles, reports of ongoing research, analyses of current and topical practice, policy issues relating to rural development field notes and book reviews. The journal is peer-reviewed and adheres to a rigorous double-blind reviewing policy in which the identity of both the reviewer and author are always concealed from both parties.

Subject areas include any thematic areas related to sustainable integrated rural development aligned with Sustainable Development Goals (SDGs). The thematic areas are including but not limited to the following:

- Sustainable use of natural resources
- Management of rural areas in transition
- Land and water resources management
- Agro processing and rural market
- Rural livelihoods and poverty reduction
- Education and skill development
- Entrepreneurship and financial inclusion
- Climate change
- Local governance
- Food and nutrition
- Health and hygiene
- ICT and geospatial technology for rural development
- Renewable energy for rural consumption
- Rural transportation
- Sustainable rural tourism

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Reduction in Lifetime Fertility Through MNCS in Rural Bangladesh

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Abstract

This study assesses the effect of a customised Maternal Neonatal and Child Survival (MNCS) intervention in the rural areas of Bangladesh. This study attempts to estimate the lifetime fertility rate and the proportion of live births ≥3, and the age-specific lifetime fertility patterns among the women of reproductive age. This quasi-experimental study used impact evaluation data from the MNCS intervention in 2013 and compared these with the baseline data collected in 2008. We used a multi-stage, cluster random sampling technique to include 6,000 and 4,800 women in 2008 and 2013, respectively. The respondents were either mothers who had alive/deceased infants or the mothers whose pregnancy was terminated or who had living children of 12–59 months without pregnancy outcomes in the preceding year of the surveys. Based on the mean difference of live births from baseline to endline year for each intervention union, and then we compared these two areas (intervention and control unions). Overall lifetime fertility rate declined significantly in high-performing intervention unions (from 2.6 to 2.2/woman, $p < .001$) or in control unions (from 2.4 to 2.2/woman; $p < .001$). The degree of reduction of fertility increased significantly with age, and such a change was most prominent in the case of women ≥35 years old. Multivariate analyses suggest that the likelihood of having live births ≥3 reduced significantly in high-performed intervention compared to control unions. In conclusion, the probability of reducing lifetime fertility over time increases with a higher level of access, degree and duration of the customised intervention.

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Lifetime fertility, IMNCS intervention, BRAC, rural Bangladesh

Introduction

Worldwide, the maternal deaths reduced satisfactorily over a period of time: 1990–2010 (WHO, 2019), and women have lower fertility rates, though the adolescent fertility remains relatively high across the developing world (PMNCH, 2015; Reher & Requena 2020). For decades, both the government and non-governmental organisations (NGOs) in Bangladesh have worked to improve the situation and fairly meet Millennium Development Goals (MDGs) 4 and 5 (The Dhaka Tribune, 2014; WHO, 2013, 2015a; WHO & UNICEF, 2012). However, the Independent Evaluation Group (IEG) of the World Bank (IEG, 2013a, 2013b) identified the limited success of MDGs. Of course, there have been claims that the MDGs cannot be fully achieved due to the way the goals were designed (Clemens et al., 2007). Additionally, there was a lack of focus and accountability, as well as a lack of interest in sustainable development' (UN, 2010). Thus set out as the target for Sustainable Development Goals 3 in improving maternal and child health in developing countries including Bangladesh (Fehling et al., 2013; IEG, 2013b; WHO, 2015b).

This study carries significance primarily because Bangladesh till continues to face significant challenges due to high maternal and neonatal death rates. Despite significant reductions over the last two decades, the maternal mortality ratio and neonatal mortality rate remain high, at 194 deaths per 100,000 live births and 37 deaths per 1,000 live births, respectively (Khatun et al., 2021; NIPORT, 2009). Bangladesh, with a high poverty rate in the world, is committed to achieve the MDGs by 2015. The promise of MDG 5 (improving maternal health) has influenced national policy and programme implementation. Beginning in 1994, the emergency obstetric care (EmOC) strategy dominated, with collaboration from many UN entities.

The approach was broadened in 2001 with the development of the National Maternal Health Strategy, which built on the rights-based approach to safer motherhood (Khatun et al., 2012). It was incorporated into the ongoing Health and Population Sector Programme and, later, the Health, Nutrition, and Population Sector Programme, which define government policies and programmes. At the primary healthcare level, interventions were delivered through a one-stop essential services package (ESP), with health and family planning cadres managed under a single management structure. While the ESP had five components, maternal health was prioritised, with an emphasis on EmOC to minimise maternal mortality and basic obstetric care to encourage best practices, early detection of issues and appropriate referral (Koblinsky et al., 2008).

The average fertility in Bangladesh declined remarkably in the past four decades. From over six children per woman in the 1970s to over three children per woman in the 1990s, and it further declined by one child to 2.3 children per woman in 2011, and currently, however, the average fertility has remained

stable (NIPORT et al., 2016, 2019). The fundamental reason for the high population density in Bangladesh has been the widespread unawareness of maternal and child healthcare and their consequences (PRB, 2014; World Bank, 2018). In response to this situation, the health programme of BRAC, the largest national NGO in the world, introduced a project called Improving Maternal Neonatal and Child Survival (IMNCS) with aims to improve maternal and child health in rural areas of a few selected Northern districts of Bangladesh. The project ensured the curative and preventive services at the community level for the last six years and beyond.

Women and child health outcomes are determined by factors such as high education, low fertility rates, improved nutritional status and a low frequency of illness (Cleland et al., 2019; IEG, 2013b). It is well established that fertility and death rates are the summary outcomes for all health indicators, and that the lifetime fertility rate is determined by the total number of live births ever delivered by a woman of reproductive age (Ullah, 2000, 2004). Hence, the main indicator was considered to be lifetime fertility. The primary objective of this study was to statistically quantify the precise change that occurred between 2008 and 2013. This will, in the long run, generate evidence-based policymaking in operational planning. And in fact, there is no study done on a large sample to address the gaps of a health-related project implemented in South Asia, including Bangladesh (IEG, 2013b).

Under this backdrop, this study prioritises measuring the effectiveness of maternal, neonatal, and child health (MNCH) intervention of BRAC in the six Northern districts of Bangladesh. Therefore, this study attempts to estimate the lifetime fertility rate and the proportion of live births ≥ 3 and the age-specific lifetime fertility patterns among the women of reproductive age. Finally, it aims to determine the most effective factors responsible for variations in lifetime fertility rates amongst women of reproductive age living in intervention areas.

Background of BRAC-IMNCS Intervention in Bangladesh

With over four decades of experience implementing community-based health interventions through health programmes in rural and urban Bangladesh, BRAC's Health Nutrition and Population Program (HNPP) launched MNCH services in urban slums in 2007 under the banner of 'MANOSHI' (acronym for mother, neonate and child in Bangla) (Ahmed et al., 2010; Choudhury et al., 2012). BRAC-HNPP initiated its five-year MNCH services in rural areas of Nilphamari, Rangpur, Gaibandha and Mymensingh districts in 2008 to help meet the MDGs 4 and 5.

In raising awareness of core MNCH issues and ensuring the service provisions of essential medications are the key components of the IMNCS project. This project is also well-designed to address demand and supply side obstacles associated with establishing a continuum of care from home to hospital for MNCH separately, through the use of a group of trained community health workers (CHWs). They provide their phone numbers to pregnant mothers while visiting

their households. Mothers usually inform them as they face any complications (BRAC, 2006) and go to the patient's house immediately and try to contact or go with the patients the nearby community-based clinic (CBC). If they are refused from the CBC, they usually go to the upazila (sub-district) and district hospital for EmOC services. It depends on patient's physical condition.

Each emergency patient has access to a complete referral system, which provides cooperation between BRAC personnel and hospital doctors, as well as community engagement in decision-making and fund management issues. Additionally, the IMNCS project provides additional services to infants and children in mitigating acute pneumonia and diarrhoea and managing them through an extensive network of local women, known as Shasthya Sebikas, trained in maternal and child primary healthcare, amongst others, known as newborn health workers, involved in delivery care throughout the villages. The project includes secondary target population such as CHWs, BRAC staff, public and private health care providers, local government bodies, village elites, school teachers and other community influencers, the local NGOs and national and/or international agencies concerned with the improvement of MNCH. The project's impact evaluation is supported and arranged by a systematic planning process.

Data and Methodology

Data

This study mainly used the MNCH impact evaluation data sets of 2008 and 2013 surveys on married women of age 15–49, which aims to measure the impact of IMNCS intervention of BRAC on a summary level outcome focusing the maternal and child health. Thus, it measures the level of change from 2008 to 2013 surveys across the MNCH services. The leading outcome indicators are the lifetime fertility, that is, mean number of live births ever born per woman and the occurrence of live births ≥ 3.

A baseline survey of this impact study was conducted in the six districts, four are intervention districts and two are control districts. Intervention districts are Nilphamari, Rangpur, Gaibandha, Mymensingh and the control districts are Naogaon and Netrokona. In 2013, the follow-up survey to select the same intervention and control districts was conducted. Nilphamari, Rangpur, Gaibandha, Mymensingh were called old intervention districts and Naogaon and Netrokona were called old control districts. Faridpur, Madaripur, Rajbari, Magura, Kurigram and Lalmonirhat were new intervention districts and Jhenaidah was the new control district (Figure 1). The respondents of this study were the women who were in their reproductive age (15–49 years). Inclusion of the women was conditional upon ever married and as being or having been a mother (in the case of a child death). The total number of respondents was 7,200 in 2008 and 3,600 in 2013 (Table 1 and Figure 2). The grand total of respondents was 10,800. Two groups of mothers were selected for the survey based on some criteria. Between

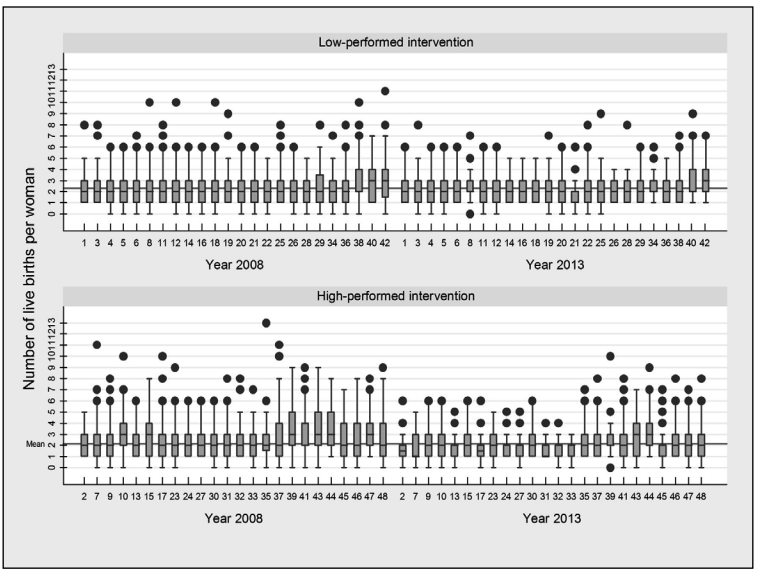

Figure 1. Variation in Number of Live Births by Union and IMNCS Area.

Source: The authors.

Note: Each box represents the variation in live births by IMNCS area and year at each union. The 75th, 50th (median) and 25th percentiles are presented within the box; outlier values are presented outside the box. The thick line at 2.3 represents the mean value for low-performed and 2.2 for high-performed IMNCS *unions* (n = 48). The numbers on X-axis refer to union codes.

Table 1. Number of Respondents by Study Area and Surveyed Year, 2008–2013.

	Baseline: 2008		Follow Up: 2013	
Respondent Characteristics	Intervention	Control	Intervention	Control
Group-1: Mothers who had any pregnancy outcome in the past year	2400	400	1,200	600
Mothers of infant living currently	1,995	984	974	485
Mothers of infant died in the past year	97	42	49	19
Mothers whose pregnancy was terminated by abortion/ menstrual regulation (MR)/ intrauterine device (IUD)/stillbirth	308	174	177	96
Group-2: Mothers of children 12–59 months	2,400	1,200	1,200	600
Total (Group-1 + Group-2)	4,800	2,400	2,400	1,200

Source: The authors.

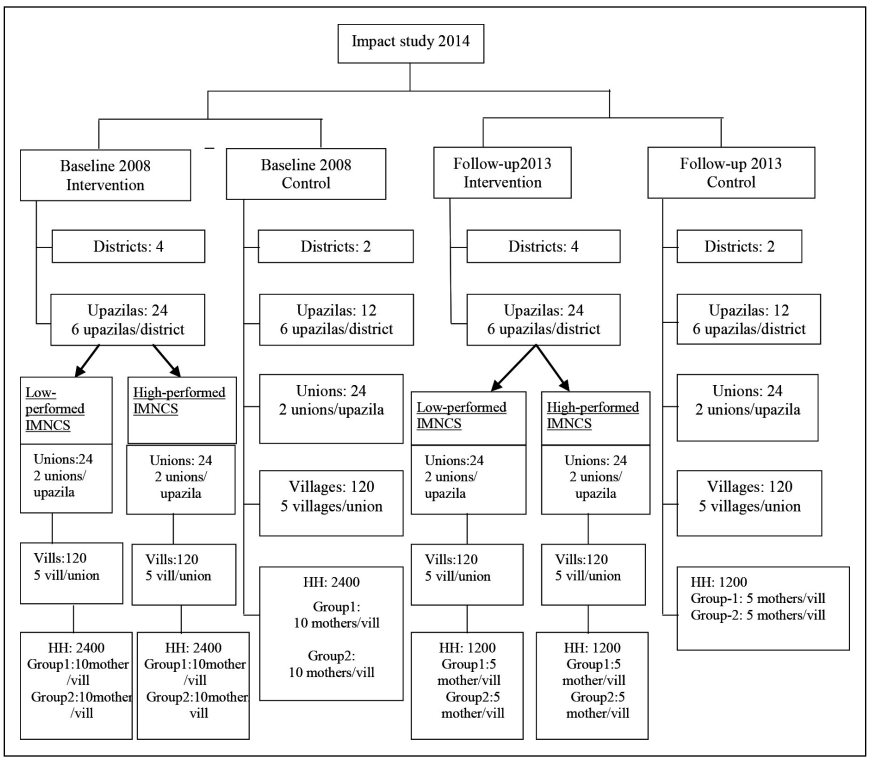

Figure 2. A Sampling Frame of the Study 2008–2013.

Source: The authors.

2008 and 2013, respondents were selected using a multistage cluster random sampling approach. The selection of intervention and control districts was made by a purposive sampling strategy. Geographically and culturally, the intervention and control districts were similar, as were the responder selection criteria (see BRAC, 2006, 2000a, 2008b for detail).

The sampling strategy for the endline survey was a multistage random sampling procedure consisting of districts, upazilas, unions, villages and households as the population strata. The selection of intervention districts was based on the presence of intervention. The control districts were selected on the basis of absence of intervention and considering the geographical and cultural similarities with the intervention districts. Simple random sampling was then performed for site selection at each successive stratum. If any mother was eligible for both the groups, she was preferred for the most recent pregnancy outcome; if more than one mother from a household were eligible for selection, the mother with the most recent pregnancy outcome was preferred. The listing of households was done clockwise and stopped as soon as they had 10 eligible mothers from Group-1 and 10 eligible mothers from Group-2. Finally, five mothers from Group-1 and five mothers from Group-2 were randomly selected from the

available eligible mothers. The sample sizes for the districts, which had less than six upazilas, were adjusted by increasing the number of respondents per village (Table 1 and Figure 2).

The Research and Evaluation Division of BRAC conducted a comprehensive quantitative baseline survey in 2008, and the follow-up in 2013, covered the issues of IMNCS intervention by choosing a suitable cut-off level, December 2012–January 2013, for ongoing intervention (see Figure 3 for sampling frame). A total of 10,800 mothers of reproductive age (15–49 years) were respondents. Ultimately two groups of mothers experienced a pregnancy outcome, and the mothers who had living children of 12–59 months without having any pregnancy outcome in the preceding year of the survey were interviewed (Salam et al., 2009; Ullah, 2010).

During the implementation of the baseline survey, 4,800 intervention households were visited from 240 villages, on the basis of five villages per union (an administrative boundary usually consists of 4–5 villages) and two unions per upazila, following a similar procedure for selecting 2,400 control households from 120 villages. The endline survey in 2013 followed the same rules of the baseline survey for selecting the respondents, 2,400 intervention households from 240 villages and 1,200 control households from 120 villages were visited. Therefore, 4,800 women from the intervention unions and 2,400 women from the control unions were interviewed during the baseline and 2,400 women from the intervention unions and 1,200 women from the control unions were interviewed during the endline survey.

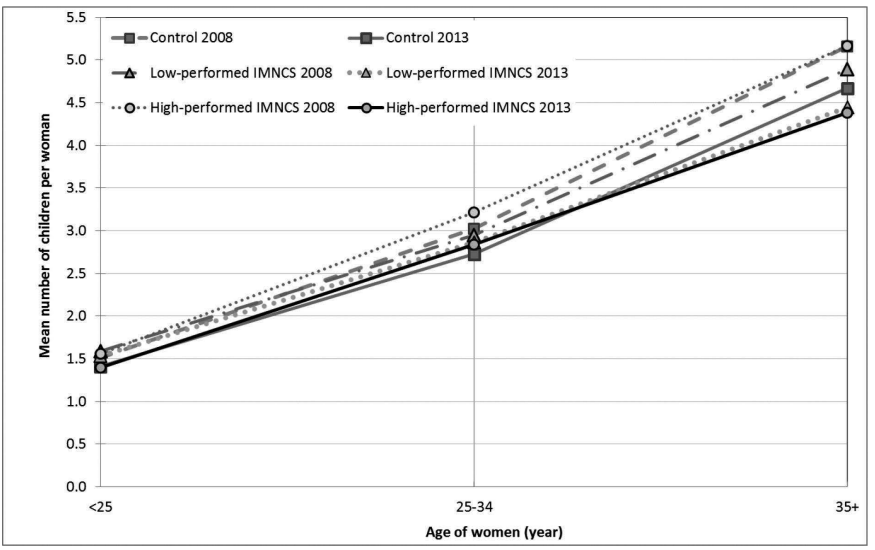

Figure 3. Age-specific Lifetime Fertility Rates by Study Area and Survey Year 2008–2013.

Source: The authors.

Two questionnaires were developed, one for the household and one for the individual. The household questionnaire contained information on household characteristics, household possessions and amenities, disability and death. The individual questionnaire contained information on adolescents' characteristics and their health, education and livelihood issues. The household wealth index was calculated according to Filmer and Pritchett (2000). Principal components analysis was used to produce a new set of linearly combined measurements for the household wealth scores, which were classified into quintile, such as poorest, second, third, fourth and richest. Also constructed variables such as lifetime fertility (mean number of live births ever born per woman by the childbearing age; Kpedekpo, 1982) and live births ≥3 (number of live births ever born per woman of the childbearing age and dichotomised as live births ≥3 and live births ≤ 2).

Estimation Method

The preliminary analysis indicates while selecting the intervention and control areas during surveys, socio-economic characteristics of the two areas were not completely matched. This has caused the problem in the final analysis (Gani, 2014). Besides, there may be an underestimate of the true effect of the intervention which may occur due to the closeness of the controls to intervention areas. In order to overcome this problem and unveil the effects of an intervention clearly, we applied the stratification theory of epidemiology in our analysis in controlling the potential confounders' effect (Rothman, 2002). Therefore, we ranked (low- and high-performed unions) based on the mean difference of live births from baseline to endline year for each intervention union, and then we compared the intervention and control unions. This is explained in Figure 3.

To compare the main outcome indicators (the lifetime fertility rate and the occurrence of live births ≥3) between high- or low-performed interventions and control areas, the mean and the odds ratio (OR) and their corresponding 95% confidence interval (CI) were calculated. Chi-square tests were conducted to analyse the differences in proportions between two groups from the baseline as well as the endline status over the period of intervention and the independent sample *t*-tests for mean differences were also performed to understand whether the interventions are actually effective. Net-effects of high-performed intervention for key indicators were calculated based on relative changes between the baseline and endline survey results for high-performed intervention or control unions (IEG, 2013b; Karim et al., 2001; Kpedekpo, 1982).

Bivariate logistic regression analysis was performed to calculate the odds ratios of the regression coefficients in exploring the relative decrease of the live births ≥3 per woman from the baseline year 2008 to the endline year 2013 by controlling all background variables in the model. Variables significant in the univariate analysis were included in the multivariate analysis to estimate the relative impact of the BRAC's IMNCS project on the number of live births ≥3 per woman of reproductive age.

In multivariate analysis, the outcome variables are the number of live births ever born per woman of childbearing age and the live births ≥3, as they are not continuous in measure and thus did not clearly meet the normal distribution criteria. Therefore, the logistic regression model (Menard, 1995) was suitably fitted with these data sets and used to explore the decrease in live births ≥3 per woman, controlling for survey years, demographic variables (age of women, age at marriage and first pregnancy, the experience of child deaths and the contraceptive uses), socioeconomic variables (women education, husbands occupation, women earning, wealth index, sale of labours and the households sanitation facilities) and cultural variables (family type and sex of household head). A total of 57 logistic regression analyses were conducted: 19 for low- and high-performed IMNCS intervention unions separately and 19 for control unions. In Table 6, for each area (i.e., low-performed, high-performed and control), at first three ORs show the overall change of lifetime fertility against the year 2013 compared to 2008 considering all explanatory variables in the models. Secondly, three ORs show the change among the women of age <25 years keeping all explanatory variables as usual. In this way in three areas, a total of 57 ORs were shown from 57 logistic regression equations. In Table 7, for each area, only three logistic regression equations were shown considering all explanatory variables in the models.

Results

Table 2 presents the demographic and socio-cultural characteristics of the women respondents. The mean age of women was around 25 years, and the mean age of their husbands was remarkably higher in all intervention or control unions. It is notable that the proportion of younger women (<25 years) in the high-performed IMNCS unions significantly increased in the year 2013 compared to 2008 (53.4% vs. 47.2%, $p < .001$). Mean age at marriage increased significantly, but their mean age at first pregnancy remained nearly the same in high-performed IMNCS or control unions; however, these characteristics decreased significantly in low-performed IMNCS unions. The proportion of women experienced with child deaths decreased significantly in all areas; on the other hand, use of contraceptives increased considerably only in IMNCS unions and stayed constant in control unions.

The mean year of schooling among women and their husbands improved significantly in three areas. Husbands' occupation of service status, wage earner including unemployed/disabled/beggar somehow increased and the agriculture or business occupation decreased remarkably. The proportions of the poorest households decreased significantly, and the richest increased. The proportion of improved sanitation coverage increased substantially, and the landowning trends declined gradually in all study unions. However, all of these background characteristics of women respondents varied during the period 2008–2013.

Table 3 presents the lifetime fertility rates among the women by study areas and year 2008 and 2013. Overall lifetime fertility rates, that is, mean number of

Table 2. Background Characteristics in Low and High IMNCS and Control Areas in 2008 and 2013.

Background Characteristics	Low-performed IMNCS		High-performed IMNCS		Control	
Demographic Status	2008	2013	2008	2013	2008	2013
Age (in year) (%)						
<25	53.8	53.5	47.2	53.8$^{\psi}$	51.8	53.5
25+	46.2	46.5	52.8	46.2	48.3	46.5
Mean age of women	25.1	24.9	25.7	24.6$^{\psi}$	25.2	25.1
Mean age of husbands	32.7	32.3	33.4	31.7$^{\psi}$	33.3	32.9
Marriage age ≤17 years (%)	77.6	83.4$^{\psi}$	81.1	80.6	77.0	74.0
Mean age of marriage	15.6	15.4$^{\psi}$	15.3	15.6$^{\psi}$	15.8	16.0*
First pregnancy age ≤19 years (%)	81.1	85.3‡	82.1	82.8	81.1	79.8
Mean age at first pregnancy	17.6	17.1$^{\psi}$	17.4	17.4	17.5	17.6
Use any contraceptives (%)	64.0	69.5‡	62.5	67.4‡	65.6	65.5
Experience of child deaths (%)	17.8	14.8*	18.6	14.3‡	14.8	12.3*
Mean household size	5.0	5.0	5.1	4.9*	5.1	5.0
Cultural Status						
Muslim religion (%)	86.6	85.8	94.0	91.6*	88.9	88.6
Joint family (%)	30.7	35.3‡	28.0	36.3$^{\psi}$	35.9	40.3*
Female headed household (%)	2.2	1.5	2.9	1.8	2.5	1.4*
Socioeconomic Status						
No schooling of women (%)	33.3	19.7$^{\psi}$	36.0	18.8$^{\psi}$	33.7	22.9$^{\psi}$
Mean year of school (women)	4.3	5.0$^{\psi}$	3.9	5.3$^{\psi}$	4.0	4.9$^{\psi}$
No schooling of husbands (%)	45.4	34.3$^{\psi}$	47.9	33.9$^{\psi}$	46.3	36.5$^{\psi}$
Occupation of husbands (%)						
Service	9.5	12.5‡	11.0	16.3$^{\psi}$	7.9	9.5
Agriculture	46.8	35.0$^{\psi}$	44.0	30.7$^{\psi}$	53.5	49.9*
Business	16.6	15.6	16.9	19.8*	15.8	18.9*
Wage earner	25.6	34.3$^{\psi}$	27.0	31.6‡	22.0	20.3
Others$^{¥}$	1.5	2.6*	1.2	1.7	0.8	1.4
Wealth index (quintile) (%)						
Poorest	32.2	11.2$^{\psi}$	31.5	11.2$^{\psi}$	34.2	18.5$^{\psi}$
Richest	11.2	19.3	13.6	26.3	14.4	24.8
Improved sanitation (%)§	63.8	73.3$^{\psi}$	63.2	79.7$^{\psi}$	54.4	64.8$^{\psi}$
Number of respondents (*n*)	2,400	1,200	2,400	1,200	2,400	1,200

Source: The authors.

Notes: $^{¥}$others-unemployed, beggar, disabled, student, non-response (NR), etc.
§ring slab with or without water seal and sanitary latrine.
χ^2 for test of heterogeneity, student's *t* for mean test and the significant differences between 2008 and 2013 are $^{*}p < .05$; $^{\ddagger}p < .01$; $^{\psi}p < .001$.

live births ever born per woman reduced significantly from the year 2008 to 2013 in high-performed IMNCS and control unions (absolute change: −0.48, $p < .001$ vs. −0.24, $p < .001$), but the degree of reduction had yielded the highest precision in high-performed IMNCS unions (relative change: −18.4%, $t = 8.58$) compared to control (relative change: −10.1%, $t = 4.29$). Therefore, high-performed intervention had a net effect in reducing lifetime fertility rate by 8.3%.

Figure 3 and Table 4 depict the age-specific lifetime fertility pattern, that is, the distribution of fertility rates at childbearing ages tends to increase steadily with age. The data revealed a general downward trend in the relative percentage change of lifetime fertility rates from 2008 to 2013 in all areas. Specifically, the degree of declining effects in age-specific fertility rates increased gradually with age, and that was much higher for high-performed intervention unions, in contrast to control or low-performed intervention unions (low IMNCS: −9.1%, $p < .05$; high IMNCS: −15.1%, $p < .01$; and control: −10.6%, ns). The 35-years or above ages had appeared as a significantly most effective cohort of the IMNCS intervention in reducing lifetime fertility from the base-year to endline comparing to other age groups, followed by the 25–34 years age group (low IMNCS: −2.8%; high IMNCS: −11.7%, $p < .001$; and control: −11.0%, $p < .001$) and the below 25 years age group (low IMNCS: −3.2%; high IMNCS: −10.4%, $p < .001$; and control: −7.2%, $p < .01$). In all age groups, the 35-years or above in the high-performed intervention unions had revealed as the most influencing ages in changing the lifetime fertility rate among the women respondents (Figure 3).

As with the lifetime fertility rate, the frequency of live births ≥3 demonstrated the similar patterns of effectiveness of the intervention union (Table 4). The results indicated that the occurrence of live births ≥3 reduced significantly with the greatest precision in high performed IMNCS unions (relative change: −29.0%, $\chi^2 = 52.0$, $p < .001$) from 42.8% in 2008 to 30.4% in 2013 compared to control unions (relative change: −18.5%, $\chi^2 = 15.2$, $p < .001$) or low-performed IMNCS unions (relative change: −4.8%, $\chi^2 = 1.5$, $p < .001$). Thus, the high-performed IMNCS over control unions had a net effect in reducing the occurrence of live births ≥3 by 11.7%.

Table 4 also showed the odds ratio estimates (including the 95% CI) by study areas and survey year. The likelihood of occurring live births ≥3 among the mothers in high-performed IMNCS unions decreased by 42% during 2008–2013 (OR 0.58, 95% CI 0.50–0.68). While in control unions the likelihood of occurring live births ≥3 among the mothers decreased by 26% from 2008 to 2013 (OR 0.74, 95% CI 0.64–0.86). Therefore, it is easy to conclude from the above results that the high-performed IMNCS intervention is more protective for having higher fertility compared to control.

Furthermore, an inference can also be drawn from the estimates of odds ratio by stratifying the mothers age groups into younger (<25 years) and adult (≥25 years), and therefore, the high-performed IMNCS intervention unions' adult mothers (≥25 years) (high-performed IMNCS: OR 0.54, 95% CI 0.44–0.67 vs. control: OR 0.72, 95% CI 0.58–0.89) are less likely to have live births ≥3 than that of younger mothers <25 years (high-performed IMNCS: OR 0.64, 95% CI

Table 3. Lifetime Fertility Rate, Relative Percentage Change, 95% CI by Area and Year 2008–2013.

	Survey Year		Difference		Statistical Test			
Lifetime Fertility Rate	2008	2013	Absolute Change	Relative Percentage Change	*t*-Statistic	*p*	95% CI	*N*
Low-performed intervention, *L*	2.35	2.27	−0.09	−3.61	1.31	ns	(−0.01 0.18)	3,600
High-performed intervention, *H*	2.63	2.15	−0.48	−18.36	8.58	ψ	(0.37 0.59)	3,600
Control, *C*	2.42	2.18	−0.24	−10.06	4.29	ψ	(0.13 0.35)	3,600
Total (*n*)	7,200	3,600						10,800

Source: The authors.

Notes: Minus (−) and plus (+) signs indicate the decrease and increase respectively.
Significant differences between the 2008 and 2013 are; ψ$p < .001$.
ns = Not significant at 10% level.

Table 4. Occurrence of Live Births ≥3 by Study Area and Survey Year 2008–2013.

	Survey Year		Difference		Statistical Test			
Number of Live Births ≥3 (%)	2008	2013	Absolute Change	Relative Change in Percentage	Statistic (χ^2)	*p*	OR (95% CI)	*n*
Low-performed IMNCS	36.67	34.92	−1.75	−4.77	1.52	ns	0.93 (0.80 1.07)	3,600
High-performed IMNCS	42.83	30.42	−12.41	−28.98	51.99	ψ	0.58 (0.50 0.68)	3,600
Control	34.88	28.42	−6.46	−18.52	15.16	ψ	0.74 (0.64 0.86)	3,600
Total (*n*)	7,200	3,600						10,800

Source: The authors.

Notes: Minus (−) and plus (+) signs indicate decrease and increase respectively.
Significant differences between the year 2008 and 2013 are; ψ$p < .001$.
ns = Not significant at 10% level.
$\chi^2 = 27.563$, $p < .001$ vs. $\chi^2 = 10.169$, $p < .001$.

0.44–0.92 vs. control: OR 0.65, 95% CI 0.44–0.94). In other words, the control unions' adult mothers are more likely to have live births ≥3 than younger mothers.

Table 5 shows the change in the occurrence of live births ≥3 by key demographic, socioeconomic and cultural variables from baseline 2008 to endline status of 2013. The occurrence of live births ≥3 in high-performed IMNCS is strongly associated with women's first pregnancy age ≤19 years ($p < .01$), no child deaths ($p < .001$), Muslim religion ($p < .001$), family types ($p < .001$), education of women or husbands ($p < .001$) and service occupations of husbands ($p < .001$). Moreover, both the high-performed intervention and control were significantly associated with the women age ($p < .001$ vs. $p < .01$), using any contraceptives ($\chi 2 = 22.79$, $p < .001$ vs. $\chi^2 = 13.737$, $p < .001$), households sanitation facilities ($p < .001$ vs. $p < .01$), agriculture occupation ($p < .01$ vs. $p < .05$), wage earners occupation ($p < .001$ vs. $p < .05$), landowner of 50 decimal or more.

Table 5. Occurrence of Livebirths ≥3 by Socio-demographic and Cultural Factors by Area and Year.

	Low-performed IMNCS		High-performed IMNCS		Control	
Characteristics	2008	2013	2008	2013	2008	2013
Age of women (year) (%)						
<25 years	11.2	9.3	11.0	7.3‡	10.2	6.9*
25+ years	66.3	64.3	71.3	57.4ψ	61.3	53.2‡
Marriage age ≤17 years (%)	40.6	38.6	47.0	33.2	38.4	31.3
First pregnancy age ≤19 years (%)	38.7	36.6	45.5	32.6‡	37.5	30.3
Use any contraceptives (%)	37.5	36.1	43.7	33.5ψ	34.1	26.6ψ
No child deaths (%)	28.5	27.8	33.4	23.1ψ	27.8	22.4‡
Muslim religion (%)	37.7	36.8	43.8	31.1ψ	36.0	29.5
Joint family (%)	26.4	20.3*	30.5	17.7ψ	23.4	21.7
Female household head (%)	38.5	44.4	37.1	27.3	36.1	29.4
Improved sanitation (%)	34.4	33.9	39.7	29.5ψ	31.2	24.7‡
Education of women: primary + (%)	24.2	27.6	30.1	23.7ψ	22.2	21.2
Education of husbands: primary + (%)	27.6	28.7	32.8	22.8ψ	23.8	20.9
Women earning (%)	13.9	8.6‡	26.6	6.6	14.6	10.0
Occupation of husbands (%)						
Service	21.5	18.0	28.5	14.9ψ	23.7	22.8
Agriculture	37.3	36.2	45.0	37.2‡	36.6	31.9*
Business	37.4	37.4	43.7	34.0*	31.9	22.0‡

(Table 5 continued)

(Table 5 continued)

	Low-performed IMNCS		High-performed IMNCS		Control	
Characteristics	2008	2013	2008	2013	2008	2013
Wage earner	40.0	38.6	44.1	29.0$^{\psi}$	36.3	27.2*
Others$^{¥}$	48.6	35.5	53.6	40.0	47.4	47.1
Land 50 + decimal (%)	33.9	29.5	42.0	25.0$^{\psi}$	31.7	23.1$^{\psi}$
Wealth index (%)						
Poorest	40.1	47.8	50.5	44.8	47.0	36.5‡
Richest	27.5	31.6	28.1	22.5	18.2	16.4
Overall	36.7	34.9	42.8	30.4$^{\psi}$	34.9	28.4$^{\psi}$
Total (*n*)	2,400	2,400	2,400	1,200	1,200	1,200

Source: The authors.

Notes: Significant differences between the year 2008 and 2013 are *$p < .05$; $^{\ddagger}p < .01$; $^{\psi}p < .001$; $^{¥}$unemployed, beggar, disabled, student, non-response, etc. ns = Not significant at 10% level.

These findings revealed that the magnitude of association is strongly effective for high-performed IMNCS intervention compared to control unions. However, only the control unions were significantly associated with the bottom quintile households ($p < .01$). All of the above findings in Table 6 indicate that the live births (3) patterns effectively dropped from 2008 to 2013 in the IMNCS intervention's high-performed unions.

Regression Estimates (Factors Predicting Three or More Live Births)

The model's pseudo-R^2 indicates all independent variables explained separately 43.2% for low-performed IMNCS, 45.3% for high-performed IMNCS and 38.0% for the control (Tables 6 and 7). Multi-collinearity arose among few explanatory variables for the model because of high correlation coefficients (r) of women age with husbands age, marriage age with first pregnancy age, women education with husbands' education, land ≥50 decimal with the richest quintile and the sanitation facilities with the poorest quintile, $r = 0.63$, $r = 0.49$, $r = 0.394$, $r = 0.35$, $r = -0.34$, respectively. At the second step, after excluding husbands age, marriage age, husbands' education, land ≥50 decimal, poorest quintile, the logistic regression model was run with 14 explanatory variables following the forward Wald method. The model screened out insignificant variables such as using contraceptives, women earning, agriculture work, religion, and sale of labour, and finally, the model considered 10 explanatory variables in predicting the live births ≥3. The results indicate an overall likelihood of increasing more children per woman was about 35% lower in the year 2013 compared to reference year 2008 in high-performed IMNCS unions, and the change is significantly highest in high-performed IMNCS (OR 0.66, 95% CI 0.535-0.818) compared to control (OR 0.86, 95% CI 0.706-1.052) and low-performed IMNCS unions (OR 1.03, 95% CI 0.841–1.274).

The estimates of odds ratios, except the overall results, were calculated by controlling for each category of background variables separately. Logistic regression analysis found that among area-specific outcome factors, live births ≥3 in high-performed IMNCS areas declined significantly in 2013 compared to 2008. However, when data for low-performed IMNCS or control unions were analysed independently, no significant difference in reducing the prevalence of live births ≥3 was observed in the survey year 2013.

Table 6. Multiple Logistic Regression Coefficients, ORs Against Year 2013 (2008 as Reference Year) in Predicting the Risk for Live Births ≥3 by Each Factors and Areas (n = 10,800).[å]

Factors	Model-I[ø] (n = 3,600)	Model-II[¢] (n = 3,600)	Model-III[§] (n = 3,600)
All	1.03	0.66[ψ]	0.86
Women age			
<25 years	1.03	0.74	0.70
25+ years	1.05	0.63[ψ]	0.94
First pregnancy age			
≤19 years	1.07	0.67[‡]	0.83
20+ years	0.92	0.66	1.01
Experience of child deaths			
No	1.20	0.66	1.45
Yes	1.01	0.66[ψ]	0.81
Education of women			
None	1.13	0.66*	0.75
Primary+	0.99	0.67[‡]	0.92
Occupation of husband			
Non-service	1.07	0.67[ψ]	0.85
Service	0.67	0.67	1.02
Wealth index			
Poorest/middle	0.997	0.66[‡]	0.84
Richest	1.35	0.68	0.90
Family type			
Nuclear	1.21	0.69[‡]	0.76*
Joint	0.66	0.60*	1.16
Sex of household head			
Male	1.04	0.66[ψ]	0.86
Female	2.08	0.69	0.34
Sanitation status			
Not improved	0.93	0.66*	0.87
Improved	1.09	0.66[‡]	0.85

Source: The authors.

Notes: Significant differences between the year 2008 and 2013 are *p < .05; [‡]p < .01; [ψ]p < .001.
[ø]Results for low-performed IMNCS area.
[¢]Results for high-performed IMNCS area.
[§]Results for control area.
[å]Number of live births ≥3 ever born per woman of the childbearing age and dichotomised as live births ≥3 (code 1) and live births ≤ 2 (code 0).

In comparison to the control, the high-performed intervention demonstrated a significantly declining trend for a variety of factors—particularly for adult women respondents, women with a first pregnancy age of 19 years or less, women with primary/higher education, husbands engaged in non-service occupations (i.e., agriculture, wage employment—agri or non-agri, large or small business), households with the poorest or moderate poor or middle-class socio-economic status (SES), and households with adequate sanitation. However, a substantial number of young mothers from control unions, who are from nuclear family demonstrated an impressive reduction in their risk of having the live births ≥3, but the magnitude of reduction is more precise in high-performed IMNCS unions (OR 0.69, 95% CI 0.54–0.88 vs. OR 0.76, 95% CI 0.60–0.97).

Table 7. Multiple Logistic Regression: Predictors of Risk for Live Births ≥3 Among 15–49-Years-old Women (*n* = 10,800).[å]

Factors	Model-I[¤] (*n* = 3,600)	Model-II[¢] (*n* = 3,600)	Model-III[§] (*n* = 3,600)
Survey year			
2008	1	1	1
2013	1.03 (0.841 1.274)	0.66 (0.535 0.818)[ψ]	0.862 (0.706 1.052)
Women age			
<25 years	1	1	1
25+ years	26.47 (21.074 33.245)[ψ]	29.26 (23.151 36.982)[ψ]	16.97 (13.684 21.055)[ψ]
First pregnancy age			
≤19 years	1	1	1
20+ years	0.18 (0.139 0.234)[ψ]	0.21 (0.163 0.270)[ψ]	0.25 (0.198 0.325)[ψ]
Experience of child deaths			
Yes	1	1	1
No	0.09 (0.071 0.121)[ψ]	0.08 (0.063 0.114)[ψ]	0.14 (0.109 0.190)[ψ]
Women education			
None	1	1	1
Primary+	0.34 (0.277 0.428)[ψ]	0.44 (0.352 0.543)[ψ]	0.35 (0.284 0.425)[ψ]
Occupation of husband			
Non-service	1	1	1
Service	0.55 (0.386 0.787)[‡]	0.63 (0.459 0.877)[‡]	1.01 (0.705 1.436)
Wealth index			
Poorest/middle	1	1	1
Richest	1.04 (0.770 1.410)	0.77 (0.584 1.021)	0.53 (0.400 0.705)[ψ]
Family type			
Nuclear	1	1	1
Joint	0.67 (0.536 0.833)[ψ]	0.59 (0.469 0.738)[ψ]	0.84 (0.682 1.023)

(Table 7 continued)

(Table 7 continued)

Factors	Model-I[¤] (*n* = 3,600)	Model-II[¢] (*n* = 3,600)	Model-III[§] (*n* = 3,600)
Sex of household head			
Male	1	1	1
Female	0.61 (0.303 1.210)	0.64 (0.343 1.179)	1.38 (0.717 2.667)
Sanitation status			
Not improved	1	1	1
Improved	0.93 (0.751 1.150)	0.99 (0.796 1.233)	0.96 (0.792 1.171)
Constant	0.807	0.790	0.410
−2 Log likelihood	2671.696	2634.028	2828.721
Pseudo R^2 (Cox and Snell R^2)	0.432	0.453	0.380
Nagelkerke R^2	0.592	0.615	0.530

Source: The authors.

Notes: Significant differences between the year 2008 and 2013; ‡$p < .01$; ᴪ$p < .001$.
[¤]Results for low-performed IMNCS.
[¢]Results for high-performed IMNCS.
[§]Results for control.
[â] Number of live births ≥3 ever born per woman of the childbearing age and dichotomised as live births ≥3 (code 1) and live births ≤ 2 (code 0).

Discussion of Findings

The BRAC's IMNCS intervention covers four Northern rural districts of Bangladesh with a certain implementation procedure. However, regardless of the implementation strategy, the IMNCS intervention had a diverse impact after five years. This study has been a testament for an evaluation of health interventions and BRAC's response to the IEG of the World Bank (2013) in improving a high-quality impact evaluation with the focus on demographic indicators (IEG, 2013a). The lifetime fertility rate was used in estimating the effectiveness of IMNCS intervention over the said period in contrast to control areas (Barclay, 1958; Kpedekpo, 1982).

However, socioeconomic characteristics of female respondents living in intervention or control areas were not completely controlled during the control area selection process. The final results revealed this fact. Due to the close proximity of the controls to intervention unions, it is likely that an underestimate of the true effect of intervention unions occurred. With an aim to surmount this issue, we applied the stratification theory of epidemiology in our analysis in controlling the potential confounders' effect, which is associated with outcome and exposure variables (Rothman, 2002). Macinko et al. (2007) conducted an impact study assuming the quasi-experimental design and rated the healthcare programme with scoring, and we pursued a similar approach in stratifying the IMNCS intervention unions. We though ranked the high- or low-performed intervention unions in such a way that each union-specific mean difference of live

births ever born per woman during 2008–2013 could be compared between the intervention and control unions. Even though the overall effects of IMNCS in declining lifetime fertility rates were higher, but variations in lifetime fertility rates within IMNCS unions were remarkable. However, the stratification analysis indicated that the process of care should be prioritised, indicating the possibility of quality improvement initiatives to ascertain how the best performed IMNCS unions achieved a greater reduction in lifetime fertility and to communicate lessons learned to low-performed IMNCS unions (Macinko et al., 2007).

Areas were classified as low- and high-performers based on high intensity and low intensity. We understand the fact it may not be reasonable to predict that high-performed areas would have a greater impact. If, on the other hand, high-performers are chosen based on their performance in family planning indicators prior to the baseline, then their strong impact in that area may even be more promising (assuming that cutting fertility is a desirable thing—which may not be the case though).

Our analyses suggested that the overall lifetime fertility rate was about 2.2 per woman. This, in fact, reflected the results of the Bangladesh Health and Demographic Survey (NIPORT et al., 2016). The lifetime fertility rates were 2.5 in 1999–2000, 2.3 in 2007 and 2.2 in 2011 (NIPORT et al., 2009, 2013). The basic analysis confirmed that overall lifetime fertility rates declined most effectively in high-performed IMNCS unions in contrast to control unions. Therefore, the high-performed IMNCS had a net effect in declining lifetime fertility rate by 8.3%.

In general, the age-specific lifetime fertility patterns assess the shape, structure and age patterns of fertility by areas (Barclay, 1958). As expected, the area-specific curves tend to increase steadily and gradually spread with respect to mean ages at childbearing. Thus, low age-specific lifetime fertility rates are frequently associated with high levels of intervention, and it is easy to deduce that fertility declines as the degree of intervention increases (Barclay, 1958; Kpedekpo, 1982). Our findings indicate that lifetime fertility rates declined significantly in the age group of 35 years or older women living in high-performed IMNCS unions between 2008 and 2013, and as a result, this age group was recognised as the most influential factor in reducing fertility. Abbasi-Shavazi et al. (2013) and Jones and Gubhaju's (2009) study endorse the findings. More than half of the selected respondents were younger and they represent the high-performed IMNCS unions. This implies that the improvements in maternal and neonatal health services, particularly those directed at young women (25 years), have the potential to reverse this trend. Jones and Gubhaju (2009) argued that this pattern is obviously related to the delay in age at marriage, and consequently a higher proportion of women remain single in Eastern Asia (Jones & Gubhaju, 2009).

During 2008–2013, the occurrence of live births ≥3 was analysed, and high-performed IMNCS intervention appeared as the most effective in declining the occurrence of live births (OR 0.58, 95% CI 0.50–0.68 vs. OR 0.74, 95% CI 0.64–0.86). Odds ratio analyses suggest the probability of lowering the live births ≥3 among mothers in high-performed IMNCS unions than that of the control unions, to be highest. In other words, the above data indicate that the

high-performed IMNCS intervention is more protective against having a high fertility rate than the control unions.

Overall, the findings confirmed that between 2008 and 2013, the occurrence of live births decreased dramatically across a range of socio-demographic factors such as first pregnancy age of 19 years, child deaths, women or husbands education, employment and a few cultural factors such as religion and joint family formation—but the degree of decline is much greater for high-performed IMNCS intervention compared to control. Numerous studies had already highlighted our study findings with the exception of contraceptive uses (Aarssen, 2005; Abbasi-Shavazi & Gubhaju, 2014; El-Ghannam, 2005; Khan & Raeside, 1997; Sobotka & Beaujoun 2014; Weeks, 1994). Several other studies confirmed the fact that usually increasing contraceptive uses is attributed to declining of fertility (Casterline & Sinding 2000; Cleland et al., 2006), but surprisingly our study is inconclusive about this issue. Because this was only supported by cross-tabulation analyses, not revealed through multivariate analyses. This study flagged the similar question, can fertility preferences be influenced on contraceptive use, if so how, as for some other studies (Bongaarts, 2011; Robinson & Cleland, 1992) including a few studies conducted at Matlab of Bangladesh (Freedman, 1997). Unlikely that the IMNCS intervention had no significant effect on the poorest or richest households, but a significant reduction of more live births is evident only in control area for the poorest households ($p < .01$). However, the multicollinearity problem precludes drawing causal conclusions about some of these findings, which are frequently observed in other studies as well (Bongaarts, 2011).

After area stratification, we employed regression modelling to thoroughly control the impacts of confounders in order to illustrate the intervention's effects (Rothman, 2002). The logistic regression analyses suggested the risk of occurring live births ≥3 in high-performed IMNCS unions declined significantly in the year of 2013 as compared to 2008. While data were analysed specifically for low-performed IMNCS and control unions, no significant reduction in the chance of having live births ≥3 was observed in 2013.

In contrast to the control area, the high-performed IMNCS intervention demonstrated a significant decline in number of factors, including adult mothers, first pregnancy at the age of 19 years or younger without child death, women with primary or higher education, husbands engaged in non-service occupations, such as agriculture, wage employment—agri or non-agri, large or small business, socioeconomic status, sanitation facilities and household head. However, a substantial number of younger mothers of control unions living with a nuclear family had shown an impressive nature in reducing the risk for having live births ≥3, but the strength of reduction is more precise for the high-performed IMNCS unions' mother.

Finally, the overall effectiveness of high-performed IMNCS intervention had the highest magnitude in reducing lifetime fertility rate as compared to control and/or low-performed IMNCS. The IMNCS intervention, including control is strongly correlated with the lifetime fertility rates, and the low levels of fertility rates, are found to be mostly associated with high-performed IMNCS intervention. Thus, the reasoning is straightforward lifetime fertility becomes lower as the degree of IMNCS intervention becomes higher.

Conclusion

In general, high-performed IMNCS interventions were more effective at lowering lifetime fertility rates than controls or low-performed IMNCS interventions. The IMNCS intervention, including control, has a strong correlation with lifetime fertility rates, and low fertility levels are generally connected with high-performed IMNCS interventions. Thus, the reasoning is straightforward: as the degree of intervention increases, lifetime fertility decreases.

In Bangladesh, socio-demographic and cultural differentials do explain a little about fertility reduction in recent decades—but not all of it. A substantial residual exists, which is most likely explained by the existence of an effective family planning programme. Given that the drop in fertility has slowed, it is reasonable to wonder how the pace can be sustained. Women with higher fertility are less likely to utilise the health services so that the case for home visits should be reconsidered as a part of the wider strategy for fertility reduction. To reduce total fertility, it is necessary to target younger women, including spouses, by encouraging the use of contraceptives, increasing community understanding about the optimal maternal age for conception and increasing knowledge about pregnancy-related issues through health education.

The policy implication is that a target-oriented quality programme on MNCH has been a significant contributor to improving the fertility rates in Bangladesh, as it remains unchanged. Hence, this is relevant to the current context in Bangladesh. Finally, multilevel modelling can be applied suitably on the same topic and could be replicated and justified for other demographic parameters like neonatal or infant mortality coupled with epidemiologic concepts, in determining the impact of IMNCS intervention more precisely to inform the health, population and development practitioners, stakeholders and the policymakers.

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Article

Assessment of Local Adaptive Capacity of Mountain Farmers: A Way Forward for Sustainable Livelihood Development

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Abstract

This study aims to understand the perception of mountain farmers towards the local adaptive capacity at a household level in an agro-ecological landscape. An indicator-based assessment is conducted to examine the 6 determinants and 27 indicators to give a local adaptive capacity index of the villages around Govind Wildlife Sanctuary and National Park, located in the Indian Himalayan region. The findings indicate that, though the connected and isolated villages have a low and very low adaptive capacity, respectively, the effect of various determinants on the local people varies among the village settlements, based on their socio-economic capacity. Despite the government endeavours to build the livelihood of mountain farmers through different programmes and policies, it still lacks proactive decision-making. The study suggests for an integrated assessment and sustainable enhancement of the landscape as a whole, with a focus on community-level adaptation strategies. It draws attention to the need for enhanced collaboration between research institutions, government and private sectors with the mountain community in the centre.

Keywords

Local adaptive capacity, indicator-based assessment, mountain farmers, sustainable livelihood development

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Introduction

According to Mountain Partnership (ICIMOD, 2018), the mountains cover more than 22% of the earth's land area and are home to 915 million people or about 12% of the world's population. The mountain ecosystems are famous for their scenic beauty and aesthetic value, providing many important natural resources and ecosystem services to meet the human needs. According to the Food and Agriculture Organization (2019), the world currently faces a multitude of global challenges, such as, hunger and malnutrition, climate change, environmental degradation, water scarcity and desertification, loss of biodiversity, population growth, migration, etc. These challenges affect mountain regions and their inhabitants disproportionally and more severely, particularly in developing countries (FAO, 2011). Many studies highlight the fact that mountain people and communities are more susceptible to the effects of socio-economic and climatic pressures than the lowland communities (Foggin, 2016). Mountain societies in developing and low-income countries are particularly vulnerable to constraints imposed by their natural environments and geographic location (Manandhar et al., 2018). They are particularly threatened by the ongoing processes of global environmental change, population dynamics and economic globalisation, and resultant exploitation of mountain resources (Borsdorf et al., 2010).

Mountain agriculture faces a number of well-known inherent constraints, which include inaccessibility, ecological fragility and marginality (Pratap, 2011). Susceptibility to multiple natural hazards (von Dach et al., 2017) and high sensitivity to climate change (Mountain Research Initiative EDW Working Group et al., 2015), further, influence its socio-economic development. Factors such as region's infrastructure and services, institutions and governance, diversity of actors and their capacities, and its endowment with natural resources (von Dach & Ruiz Peyré, 2020) shape the mountain economies. A holistic approach is needed to achieve a sustainable mountain development, overcoming the environmental, economic, social, cultural and political challenges faced by the mountain areas (FAO, 2011). Sustainable and inclusive economies and supportive policies are crucial for enabling the mountain people to be relieved from multidimensional poverty and to live a good life, so that no one is left behind (United Nations, 2015). As rightly stated by Scoones (2009), livelihood perspectives start with how different people in different regions live. Thus, it is important to identify and understand the mountain farmers' perception about changing socio-economic and environmental scenario that impact the rural ecosystem as well as their livelihood.

Throughout the world, people compose complex and dynamic livelihood portfolios that are attenuated by climatic, political and economic variabilities and uncertainties (Ellis, 2000). In order to move forward with development, Scoones' (2009) conviction that a 'central future challenge must be integrating livelihoods thinking and understandings of local context and responses with concerns for global environmental change' should be made the centre of global growth and development. Thus, sustainable development for humanity needs to be guided by

approaches based on epistemologies and ontologies of development that appreciate the human–biosphere relationship (Folke, 2016). The overall goal of regional development in mountains is to reduce disparities, while enhancing mountain people's well-being and strengthening their resilience (von Dach & Ruiz Peyré, 2020). Resilience reflects the ability of people, communities, societies and cultures to live and develop with change, with ever-changing environments (Folke, 2016). It is a dynamic concept concerned with navigating through complexity, uncertainty and change across levels and scales (Cumming et al., 2013). The concept of adaptation is closely associated with the concepts of vulnerability and adaptive capacity (Simane et al., 2014). Adaptation refers to the process, action or outcome in a system that helps to better cope with, manage or adjust to some changing conditions, stress or opportunity (Smit & Wandel, 2006). Adaptation is a manifestation of adaptive capacity that is inherent in a system and represents the ways of reducing vulnerability (Engle, 2011). Adaptive capacity denotes the ability to prepare for a response to stresses as well as the effects of those stresses (Engle, 2011).

Recent studies have highlighted how adaptive capacity is composed of both specific and generic components (Lemos et al., 2016). Thus, the success or failure of adaptation is determined by the system's adaptive capacity, which describes the ability of a system to mobilise resources to prepare for and respond to current or perceived stresses (Mesfin et al., 2020). Adaptive capacity is a latent property of an individual, community or social–ecological system and is activated in response to a crisis or opportunity (Engle, 2011). Clay (2017) suggests a more common interpretation of adaptive capacity as a static entity that households have or lack to varying degrees. But as observed by Magnan (2010), there is a little understanding of adaptive capacity at the household level. There is a research gap at this juncture. Vincent (2007) demonstrates that the indicators of adaptive capacity cannot be generalised across scales. Thus, national-level indicators generally fail to capture many of the processes and contextual factors that influence adaptive capacity at the local level (Eriksen & Kelly, 2006). Similarly, there are only a few frameworks available for studying the processes and determinants of adaptive capacity in detail at the local level (Jones et al., 2010).

In this backdrop of the literature, this study assesses the adaptive capacity of mountain farmers at the household level. The study targets the different likely factors that affect adaptive capacity of mountain households, and, then, it quantifies their relative contributions to that adaptive capacity and the development of sustainable livelihood. The study specifically aims to answer the following:

1. How strong is the adaptive capacity of the mountain farmers?
2. What are the drivers that affect their adaptive capacity?
3. What interventions can the mountain community develop?

The findings of the study partially answer these questions and thus provide government institutions and policymakers with some relevant information about the region prior to the implementation of any developmental policy or programme.

Methods and Materials

Conceptual Framework of the Study

According to the Intergovernmental Panel on Climate Change (IPCC, 2014), adaptive capacity is 'the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences'. However, the IPCC report failed to make a distinction between determinants at the national and local levels (Mesfin et al., 2020). Adaptive capacity studies concentrate on adaptation processes to identify what challenges are faced by whom and why (Adger et al., 2009). Adaptive capacity appears to be unevenly distributed across households, communities, regions and other analytical levels (Goldman & Riosmena, 2013). Generic adaptive capacity of a system is determined by factors that influence the functioning of the system. Some studies have identified economic development, education, technology, knowledge, infrastructure, institutions, equity and social capital as generic determinants of adaptive capacity (Kruse et al., 2013). Appropriate determinants and indicators must be tailored to each case (Brooks & Adger, 2005), and hence, it is not desirable to apply a national-level index into a smaller scale of analysis (Vincent, 2007). Smit and Wandel (2006) reported that the conditions that interact to shape adaptive capacities are community-specific. Thus, it is important to pay attention to how local actors and institutions shape the opportunities and face the challenges for sustainable livelihood development. It is important for the mountain farmers to adapt, explore and transform, for their livelihood diversification, based on the locally available assets and their capabilities.

Generally, the indicator-based study focuses on assets and resources, and the approaches that enable local actors at the local scale to self-assess their capacity to respond to the socio-ecological changes. According to Defiesta and Rapera (2014), indicators used in recent times are largely based on the sustainable livelihood framework, comprising five assets categories—human, social, natural, physical and financial capital—from which livelihoods of people are built (Serrat, 2010). The asset-based approaches are useful in helping us to understand the resources at the disposal of a system to cope with and adapt to changing environments; they typically mask the role of processes and functions in supporting adaptive capacity (Elrick-Barr et al., 2014; Mortreux & Barnett, 2017). This further helps in identifying the various income-generation windows, as per the region, for maintaining and enhancing the lives of the mountain community, irrespective of the changing global regime. Recent assessments also argue that the underlying social and institutional factors like social capital and governance that create capacity have been underplayed in earlier studies (Parry et al., 2007). Thus, an indicator-based conceptual framework was adapted, which was proposed by Abdul-Razak and Kruse (2017), who developed the smallholder farmers' adaptive capacity index (SFCAI) to better understand the local adaptive capacity of farmers.

Study Area

The study was conducted in Govind Wildlife Sanctuary and National Park, located between 35°55′N–31°17′N latitude and 77°47′E–78°37′E longitude, in Uttarkashi district of Uttarakhand (India). It is spread over an area of 957.969 km^2. The entire area lies in the middle and greater Himalayas with a varying altitude of 1,300–6,323 m. The landscape is an important catchment for the Tons River and its two major tributaries Rupin and Supin. The protected area constitutes a rich floral and faunal diversity. Few of the floral species include, oak, deodar, chir pine, juniper, rhododendron and kale, among others. About 32 species of mammals, 115 species of birds, six species of reptiles and four species of amphibians have been recorded, such as, snow leopard, Asiatic black bear, Himalayan brown bear, musk deer, Himalayan tahr, etc.

The climate of the protected area is generally temperate with well-marked seasonal variations. Owing to a large variation in altitude, the lower valleys of the rivers Rupin–Supin have a subtropical climate, while the highest parts remain perpetually under snow. The spring season (mid-March to mid-June) is characterised by occasional showers of rain, which is sometimes accompanied with thunderstorms and hail. The lower valleys are uncomfortably hot during June before the rain occurs. The average rainfall in the area is 1,500 mm, which mostly occurs in the monsoon season, generally beginning by the middle of June and continues till the second week of September. The autumn (mid-September to mid-December) is pleasant with a clear weather. The landscape experiences an extreme cold weather during the winter season (mid-December to mid-March) with a heavy snowfall and a permanent snow line in the higher reaches.

The region has a fairly dense human population, with 42 villages inside and 15 villages outside the protected area. The agro-ecosystem in the area is complex, as it is composed of crop husbandry, livestock rearing and forests, forming an interlinked production system. Some of the traditional crops cultivated in the area are; kuttu/buckwheat (*Fagopyrum esculentum* and *Fagopyrum tataricum*), jau/barley (*Hordeum himalayense*), ragi/finger millet (*Eleusine coracana*), bhangjeera (*Perilla frutescens*), kulthi/horse gram (*Macrotyloma uniflorum*), chaulai (*Amaranthus spp*.) and local varieties of rice (*Oryza sativa*) locally famous as red rice and wheat (*Triticum aestivum*). A change from traditional subsistence agriculture to cash-crop-based farming (potato and kidney bean) has been observed in the area. In the past few years, the terraced farms have largely been converted into apple orchards.

Analytical Framework of the Study

Sampling Technique

The study covered various issues from socio-economic to biophysical aspects of livelihood, which required both quantitative and qualitative data. During the assessment of adaptive capacity, the perceptions of the population sampled and

the local community, as well as that of associated experts, were kept in mind. Two assumptions were taken into consideration: (a) the adaptive capacity perception will vary among the individuals/community and experts, and (b) accessibility of the village (location) will impact the agricultural-based livelihood constraints as well as the local adaptive capacity for socio-economic development.

The study employed a multi-stage sampling technique to select the villages as well as the respondents. In the first stage, the study site was purposively selected, based on its remoteness, inaccessibility and fragility. In the second stage, all the villages in the study area were enlisted, and a stratified random sampling technique was employed for the selection of villages (Figure 1). All villages were divided into two strata based on their accessibility via motorable roads. Two villages from each strata were randomly selected for data collection (Table 1). In the third stage, the sample size was determined, and households were randomly selected from each target village for data collection. The primary data were collected through various participatory rural appraisal (PRA) tools, such as key informant interview

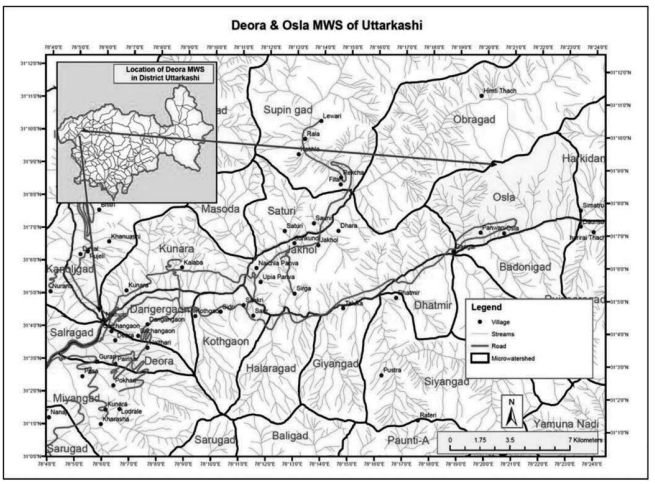

Figure 1. Micro-Watershed Map of the Target Villages in the Study Area.

Source: Watershed Management Directorate, Uttarakhand.

Table 1. Baseline Data for the Selected Four Villages.

Sl. No.	Name of the Village	Area of the Villages (ha)	Total No. of house-holds	Total Population	Accessibility	Sampled No. of Households
1.	Gainchwan Gaon	137.76	192	783	Connected	129
2.	Deora	44.18	99	99	Connected	79
3.	Dhatmeer	269.16	192	192	Isolated	129
4.	Osla	378.56	151	151	Isolated	109

Source: Census 2011, Uttarakhand.

(KII), focus group discussion (FGD), household survey (HHS) and field observations. This allowed us to get an in-depth understanding of the challenges and constraints faced by the local communities while practising agriculture.

Estimation Method

An indicator-based assessment for a sector-specific (mountain farming) and region-specific (mountainous area) adaptive capacity was made. An adaptive capacity index (ACI) approach was used, where the indicators were based on five livelihood assets: human, social, physical, financial and natural capital. It is important to recognise that these capitals have varying values and importance among different communities, depending on their regional backgrounds. After a thorough study of the literature, the determinants of farmers' adaptive capacity were first categorised into economic, social, technology, infrastructure, institution, and awareness and training. After reviewing and discussing with the experts, a final set of indicators were finalised for the main determinants (Figure 2). Relevant indicators were included to assess each dimension, in order to provide a complete picture of adaptive capacity at a local level. The indicators were not necessarily related to climate change or natural hazards, but were relevant in assessing the socio-economic standing of the local people.

In the first phase of analysis, the finalised six determinants of adaptive capacity and their respective indicators were presented, discussed and ranked by the experts. The ranking technique of Fabbris (2013) was applied in the case of conducting KII and FGDs. Then, the ranking scores were relatively proportioned to an assumed maximum (total) adaptive capacity score of 100. The ranking (R) score for each determinant is the average of all the ranking scores assigned to it by all the experts. In the second phase, a weighted average index (WAI) analysis was applied, to assess the satisfaction level of the local community, corresponding to the determinants of adaptive capacity. This helped in the validation of the developed framework for assessing the local adaptive capacity, as the determinants and indicators were broadly characterised, supported and calculated, incorporating the expert's knowledge, experience and ranking scores. For WAI, the individual respondent was asked to score the determinant for their satisfaction level based on a 0–2 Likert scale (where, 0 = low, 1 = moderate and 2 = high). WAI was estimated, using the following formula:

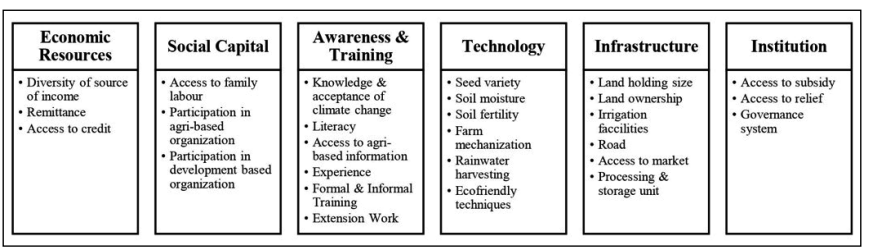

Figure 2. Determinants of Indicators for the Assessment of Local Adaptive Capacity.

Source: The authors.

Table 2. Categorisation of Adaptive Capacity.

Level of Adaptive Capacity (AC)	ACI Score Range
Very high AC	4.01–5.00
High AC	3.01–4.00
Moderate AC	2.50–3.00
Low AC	1.51–2.49
Very low AC	0.0–1.50

Source: Egyir et al. (2015).

$$\text{WAI} = \frac{F2W2 + F1W1 + F0W0}{F2 + F1 + F0} = \frac{\sum FiWi}{\sum Fi}$$

where, F = frequency, W = weight of each scale and i = weight (2 = high satisfaction, 1 = moderate satisfaction and 0 = low satisfaction).

In the third phase, surveyed questionnaires were assessed and a composite index approach was used to identify the local ACI (LACI) score for each respondent (based on Abdul-Razak & Kruse, 2017). The indicators were assessed by the interviewees, using a Likert scale of 0–5 (0 being the minimum and 5 being the maximum on the scale of satisfaction), based on the farmers' perception regarding its utility in mountain farming and livelihood. The LACI score was calculated in the following three stages:

1. Calculation of the score for each indicator—The indicator score for each of the indicators was separately determined by aggregating the respondent scores relative to a Likert scale of 0–5.
   I = (Cumulative response score/maximum response score) × 5 (1)
2. Calculation of the capacity score for each determinant—It involved the summation of the indicator scores (in the previous step) for each determinant relative to their respective ranking score.
   Capacity Score D_x = ($\Sigma I(D_x)$/the maximum $\Sigma I(D_x)$) × ranking score for D_x
   Where, $\Sigma I(D_x)$ = the cumulative I scores for D_x
3. Calculation of the LACI—It involved the summation of capacity scores of all the determinants and converting it to an ACI between 0 and 5.
   ACI = (ΣD/100) × 5
   where ΣD = the summation of the capacity scores of all the determinants.

The levels of adaptive capacity were categorised as follows (Table 2):

Results and Discussion

For the calculation of the LACI, the expert's weightage scoring (out of 100) and ranking of the six determinants were the decisive factors. The results from the experts' interview and ranking score show that infrastructure, technology and

institution were the most relevant factors, determining the adaptive capacity of mountain farmers, based on the local conditions of the study area (Table 3). According to the experts, awareness and training were moderately important as it could help the farmers increase their production and diversify their livelihood opportunities. The least important of all were economic resources and social capital. As the area recorded negligible outmigration, households had ample availability of family labour. The area also recorded a diversity of income sources, which not only included agriculture, horticulture or livestock but there was also a huge revenue generation from the construction labour work and tourism activities such as trekking, hiking, camping and tour guide.

The result of WAI, based on local community, further validates the assessment framework used for calculating the adaptive capacity. As per the local community, they were highly dissatisfied with the infrastructural development and technological advancement in the area, as it had affected their daily lives (Table 4). The people were well aware of their social capital and income potential but demanded institutional support and guidance.

The cumulative response score for all the indicators as given by the local farmers were collected through a survey questionnaire (Table 5). These responses were based on their preference and satisfaction level, evaluated on the Likert scale ranging from 0 to 5.

Table 3. The Ranking Scores of the Determinants on the Basis of Experts' Judgement.

Determinant	Average Ranking Score
Economic resources	15
Social capital	8
Awareness and training	12
Technology	22
Infrastructure	25
Institution	18
Total	100

Source: The authors.

Table 4. Determinant of Ranking Based on the Satisfaction Level of Local Community.

Determinant	WAI	Rank (from least satisfied)
Economic resources	0.72	V
Social capital	0.80	VI
Awareness and training	0.50	IV
Technology	0.30	II
Infrastructure	0.20	I
Institution	0.40	III

Source: The authors.

Table 5. Cumulative Response Score for the Indicators.

Indicator	Cumulative Response Score	
	Connected Villages	Isolated Villages
Diversity of source of income	840	475
Remittance	120	20
Access to credit	45	30
Access to family labour	640	850
Participation farmer-based organisations	165	415
Participation in other organisations	35	85
Knowledge and acceptance of climate change	655	465
Level of literacy	625	275
Access to climate, agriculture, livestock and other livelihood related information	100	285
Farming experience	330	80
Formal and informal training	60	140
Access to extension work	70	645
Knowledge of seed varieties	665	310
Knowledge of soil moisture retention technique	635	350
Knowledge of soil fertility and management	410	345
Knowledge of farm mechanisation	225	15
Rainwater harvesting	655	560
Adaptation of eco-friendly farming practices	235	175
Land holding size	670	480
Land holding ownership	820	970
Irrigation infrastructure	0	0
Access to roads	730	0
Access to markets	700	0
Processing and storage unit	0	0
Government subsidy	20	15
Disaster relief assistance	30	10
Governance system	220	70

Source: The authors.

Based on the level of adaptive capacity (Egyir et al., 2015), a low adaptive capacity of 1.75 was recorded for connected villages, and a very low adaptive capacity of 1.15 was observed in isolated villages (Table 6). It was suggestive of the inherent constraints and widespread challenges that are being faced by the farmers within the mountain communities.

Table 6. Capacity Score (CS) of Determinants and Adaptive Capacity Index.

Determinant	Connected Villages	Isolated Villages
Economic resources	5.02	2.62
Social capital	2.24	3.60
Awareness and training	3.68	3.78
Technology	10.36	6.43
Infrastructure	12.17	6.04
Institution	1.62	0.57
Aggregate CS	35.09	25.05
Adaptive Capacity Index	1.75	1.15

Source: The authors.

Based on the determinant's capacity score, there were some recorded location- and accessibility-related differences in adaptive capacity levels of the determinants between the connected and isolated villages. Figure 3 presents the differences in the perceptions of the mountain community, and it actually defines the local adaptive capacity related to the different spheres of sustainability, which impacts the livelihood development and diversification. The individual respondents are extremely dissatisfied with the institutional support and governance set-up in the area. Among the overall poor adaptive capacity of the region, the isolated villages are better off, in the social as well as awareness and training aspects of livelihood development, in comparison to their counterparts. However, the connected villages are more equipped in the infrastructural set-up, technological advancement and economic development than the isolated villages.

The comparison, between the LACI of connected and isolated villages, clearly highlights the differences between the conditions of mountain farmers, based on the accessibility and social disparity. The low adaptive capacity is attributed to the fragile ecological conditions in the mountains coupled with the social marginality. The sustainable development of mountain farmers is driven by factors such as inadequate awareness and vocational training, lack of infrastructural facilities, unavailability of financial support and credit, and absence of local institutional governance and network, among others. Though the LACI for connected and isolated villages was low and very low, respectively, assets' availability and local challenges clearly varied among them.

Livelihood Resources and Diversification

Originally, the local community followed a barter system of the agricultural produce among the nearby villages. There was no system of market selling, and agriculture was just a means of subsistence living. With the commercialisation of the agricultural sector, the farming system in the study area had drastically shifted towards cash crops. Two types of farming systems were identified during the FGDs, namely subsistence farm and conventional farm. The staple crops were

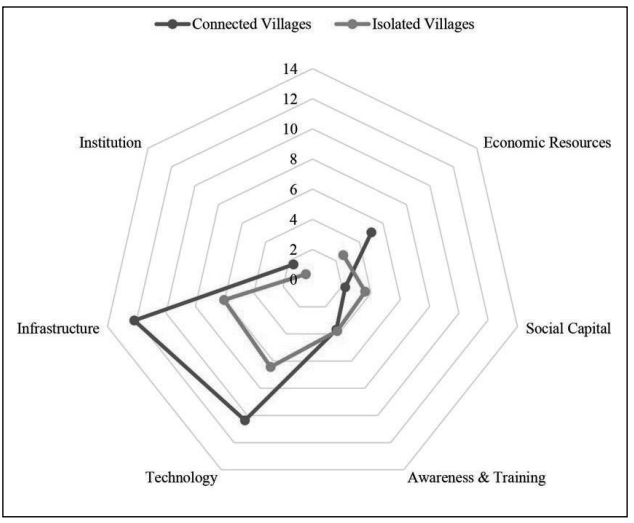

Figure 3. Comparison of Determinants Capacity Score Based on Individual Respondents' Perception.

Source: The authors.

similar across the landscape, but the dependency of isolated villages was high on amaranthus for its easy adaptability, low water requirement and high productivity (food and fodder). The apple orchards have flourished in the connected villages (Gainchwan Gaon = 5,674.95 kg/ha and Deora = 5,811.97 kg/ha), due to climatic conditions, easy availability of inputs, connectivity and market access. The apple orchards in isolated villages are young; hence, the yield is comparatively low at 1,175 kg/ha in Dhatmeer and only 13.71 kg/ha in Osla. Even though the farmers used the same varieties, the isolated villages recorded low production due to the sub-alpine climatic conditions and negligible use of synthetic inputs. The isolated villages have, at present, earned through superior quality production of potato and kidney bean, with a productivity of 608.95 kg/ha and 694.43 kg/ha, respectively. Of late, their focus of isolated villages has shifted towards walnut production (Dhatmeer = 100.05 kg/ha and Osla = 33.23 kg/ha), for its high medicinal use, demand and value (Figure 4).

The subsistence farms as well as the conventional farms in connected villages grew a larger number of crops (ANOVA, $p < 0.0001$) in comparison to the isolated villages, implementing a greater agricultural biodiversity. The major reasons given by the farmers were geo-climatic conditions, water availability, labour force, fragmented landholding and soil conditions. Due to the easy availability of farm inputs, market access and participation in agricultural policies and programmes, farmers in the connected villages maintained their agro-biodiversity for income generation. The proportion of farmer households that were beneficiaries to agricultural policies and programmes was significantly different in the village settlements (Pearson's chi-squared test, $p < 0.01$). This may be due to the easy

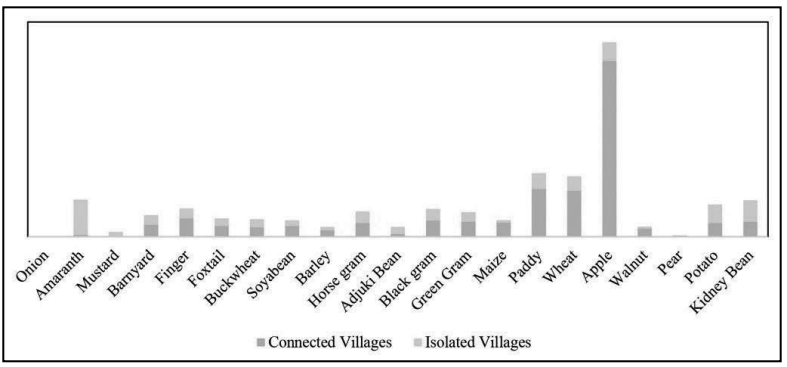

Figure 4. Comparison of Crop Productivity (kg/ha) in Connected and Isolated Villages.

Source: The authors.

accessibility and connectivity of farmers as well as the policy- and fieldworkers for the implementation of the same. Approximately 43% of households in connected villages were beneficiaries to at least one policy, while it was just 20% in isolated villages.

The qualitative data obtained during FGDs and field observations revealed the potential areas in other on-farm and off-farm activities such as animal husbandry, medicinal plants farming, construction labour work, wool production and tourism. As the area had recorded very low outmigration, the income through remittances was limited to only 6% of the households. The national agricultural policies and programmes were not effectively transformed into an action mode strategy for rural mountain communities. According to HHS and FGD, 36% of the households were acquainted with the agricultural credit facilities. But, merely, 3% of the educated farmers with large landholdings and flourishing apple orchards, had access to microfinance facilities and were based in connected villages on the roadhead and near to the market centre. The diversified nature of livelihood was attributed to the availability of natural resources in a mountain ecosystem, but they were often unsustainably utilised due to high illiteracy, limited awareness and absence of agricultural extension work.

Infrastructural Setback

Land is one of the most important assets and a source of livelihood in the rural area, but its fragmentation and sloped landscape, often, makes it difficult to cultivate. In the study area, the mean landholding size is 0.4 ha. The per capita agricultural land availability is the highest in Osla (0.13%), followed by Gainchwan Gaon (0.11%), Dhatmeer (0.07%) and Deora (0.06%). The major problem faced by the farmers is that of connectivity. Even though connected villages are on the roadhead, they face difficulty in commuting during monsoon and winters. Accessibility becomes an issue, especially, for isolated villages, such

as Dhatmeer and Osla, which are at a trekking distance of 8 km and 25 km, respectively, from the Taluka village (the last village a vehicle can reach). According to the farmers, they have a huge agricultural production potential, but the lack of post-harvest processing, storage and transportation facilities hinders their progress. This also leads to an increase in production cost, which the marginal mountain farmers are unable to face. Even though the apple quality and quantity are massive in the regional belt, they face difficulty with competing in the national market for apples in comparison to their neighbouring state—Himachal Pradesh. The local market is not enough for selling the produce as the market prices are generally low.

Innovation and Technology

Innovation and Technology enabled the rural communities to improve their livelihood, natural resource utilisation habits, and existing adaptive behaviour and practices. About 98% of households in both connected and isolated villages were using improved and high-yielding variety of seeds, seedlings and cuttings for the apple orchards. About 92% of households in the connected villages were using inorganic fertilisers and pesticidal chemicals in apple orchards, as their access to farm inputs was easier. This percentage use decreased to 0% in isolated villages because of their personal affordability and lack of accessibility to market on a regular basis, making the fields organic in nature. The study area lacked irrigation facilities, and the farmers depended on rainfall or natural *nalas* (small stream or spring) opening in their fields. Soil and water conservation practices were weak and exploitative in the connected areas, and as far as the isolated villages were concerned, they followed organic farming and water harvesting.

Knowledge and Information

The ability of the local community to access, generate, receive, utilise and disseminate knowledge and information across their region directly enhances the adaptive capacity of the socio-ecological system they live in. Literacy plays a key role in the understanding and usage of the relevant information needed for sustainable livelihood development. Most of the farmers have studied up to primary school level and have good knowledge about their farming system (Figure 5). The farmers have an understanding about climate change but only the educated youth are aware of its circumstantial consequences. Their only experience with a climatic extreme has been that of a disastrous hailstorm, which destroyed their apple orchards 5 years ago. According to the local community, they have experienced temperature fluctuations, like summers becoming hotter than usual from the past 2 years. The main challenge has been the access to latest information regarding weather forecast, market or new technologies in agriculture, as the study area has a poor telecom connectivity. In the age of 5G communication, the telecom signals in the villages fluctuate every day and, at times, disappear for weeks. Social

networks among the villagers and local market gatherings are the only ways for information dissemination. Thus, the limited access to the outside world, isolates the entire region by slowing down the growth of agribusiness for the mountain farmers.

Forward-Looking Governance System

The study area lacks in the participatory consideration of the traditional knowledge and experience of the mountain farmers within the institutional set-up of the region. Immediate reactive responses are generally short-term coping strategies, which further degrades the asset base of the farmers without actually giving a sustainable solution. The implementation of agriculture-based programmes is more in few selected villages, one of which is Osla. Though the connected villages have an advantage of being near the block office, giving them a better access to government aid, the agricultural extension work and training is minimum in these villages. Osla has the maximum adaptive capacity in institutional system as various research work and extension demonstrations are being implemented in the area, with tremendous support in organic farming. The selective bias treatment of local farmers by the government's administrative system at the village level is a serious matter of concern. The agricultural subsidy aid has not been accessed by all, even though the farmers have the knowledge about it, but the lack of guidance in order to approach it is considered the biggest hindrance. Few of the farmers enjoy the personal preference, which disturbed the equal allocation of governmental benefits.

According to the local farmers, government national programmes like the public distribution system (PDS) and Mahatma Gandhi Employment Guarantee Act (MGNREGA) have both positive and negative impacts on the local mindset. On the one hand, they have helped ensure food and economic security, but, on the other, people have started abandoning traditional crop farming. The availability of staple food grains at a price lower than the cost of production, which they might incur on their own lands, along with an increase in outmigration, has led to traditional crop abandonment. Many of the educated youth of the region casually rely on the money under MGNREGA, which is regularly transferred to their bank accounts. There are many agricultural policy measures, such as the National Mission for Sustainable Development, National Food Security Mission, Rashtriya

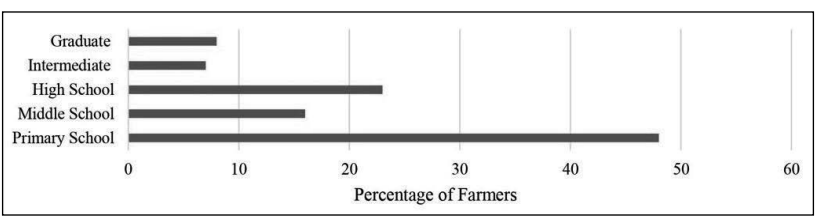

Figure 5. Level of Education.

Source: The authors.

Table 7. Measurement of Village-Level Parameters for Sustainable Development [Satisfied/yes (a), Neutral/Don't Know (b) and Dissatisfied/No (c)].

	Categorical Measure	
Parameter	Connected Villages	Isolated Villages
Access to water	a	c
Access to electricity	b	c
Road connectivity	a	c
Telecom connectivity	c	c
Access to market	a	c
Access to health facilities	b	c
Access to new and improved farming technologies	c	c
Access to information and knowledge on climate change	c	c
Access to disaster/natural hazard relief	c	c
Support system within the community	b	a
Cooperation in farming activities	b	a
Knowledge about ecosystem services	b	c
Community efforts to protect natural resources	c	c
Restraining local rules and norms	c	c
Equitable access to the support provided by local institution	c	c
Participation in agricultural/developmental policies and programmes	b	c
Trust in local government	c	c
Trust in forest department	a	a
Satisfaction with local governance	c	c
Community participation in decision-making	c	c

Source: The authors.

Krishi Vikas Yojana, Paramparagat Krishi Vikas Yojana, Pradhan Mantri Krishi Sinchai Yojana, along with continuous initiatives for subsidies, land development, technological integration, industrial investment, etc. Unfortunately, nobody knows up to what extent are these being administered, implemented, monitored and evaluated.

Integrating the Culture and Livelihood Needs

A bottom-up approach is best suited to identify local needs and assist local actions to build adaptive capacity for a sustainable livelihood. It is of utmost importance to

understand and utilise the local experience and perception for a long-term sustainable transformation. At times, the locally derived measures can be accounted as faulty, as it may be difficult to replicate it in some other community and region. But to apply one solution to all is not feasible, as the constraints and challenges may vary. The adaptation option and pathway tend to be shaped by the community's participation to combat the uncertainty. The adaptation and development planning process should make efforts to account for these differences by addressing the specific dimensions (Table 7). For the generation of equitable benefits in the mountain areas, it is necessary to involve the local stakeholders who are able to effectively represent the voice of rural community, thus making the entire process a bit more participative in nature. It is important that the local community and the local government are capable to anticipate and respond to different economic and environmental changes the society might face. The incorporation of proactive decision-making and governance system can improve the adaptive capacity for sustainable development. Decentralising policy formulation and implementation process with a focus on community-level adaptation programme can increase the efficacy of developmental policies in assisting sustainable livelihood opportunities, without further widening the socio-economic gap.

- Site-specific approaches for livelihood opportunities.

Livelihood Diversification	Explanation
Future smart crops	In today's society, people are becoming more health conscious, and a nutrition transition is clearly evident. In an ongoing effort to diversify the diet, there has been an increasing interest in the traditional crops and food culture. In the global scenario of malnutrition and over-nutrition (obesity issues), the traditional foods are now influencing the contemporary food habits. Uttarakhand is already famous for future smart crops like millets and pulses. It is important to evaluate how education, awareness and scientific research can increase the popularity of traditional crops in the global market, which are already dominated by a number of niche crops and pulses
Medicinal and aromatic Plants (MAPs)	With the escalating demand for herbal supplements, medications and cosmetics in global and international markets, cultivation of MAPs is a remunerative option in ecological and economic terms for the mountain farmers. The area harbours a rich biodiversity of 55 MAPs. A total of 4% of the farmers in the isolated villages have ventured into medicinal plant farming by establishing nurseries. Development of a comprehensive scientific database on MAPs farming requirements, agronomic practices, post-harvest management under different biophysical conditions can be helpful for income generation

Animal husbandry	The area has a potential for livestock rearing, with a cattle population of 2,122 in connected villages and 8,418 in the isolated villages. The farmers generally trade in sheep and goat with the neighbouring state of Himachal Pradesh. There is lack of veterinary aid and market chain for animal by-products. Resource centres and collection banks can be established for scientific and technical guidance
Contract farming and Public procurement system	A public–private partnership mode can be developed, where the state government can coordinate with the food and manufacturing companies, so as to link the rural areas directly with the urban centres, minimising the exploitation by middlemen
Certification and labelling scheme	As the isolated villages do not use synthetic chemicals, their produce can be tested and certified as organic. Through certification and label, the mountain farmers can gain an access to the organic market, where the profits are manifold
Rural tourism	The area has positive attributes like natural beauty, climate, wildlife, adventure and various trekking routes. Among the high mountain peaks, lush red-green apple orchards and fresh air, the area can be considered for agritourism, home-stay, healthy food and yoga. Figure 6 clearly highlights the shifting trend from religious tourism to adventure tourism, as an increase in tourist inflow can be observed.

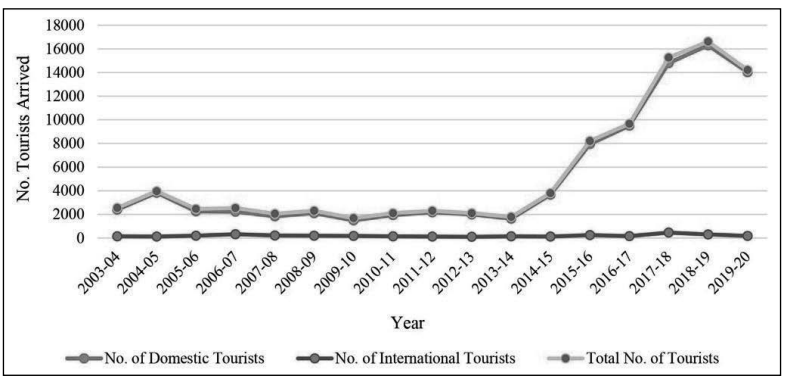

Figure 6. Comparison of Tourist Inflow in the Study Area.

Source: Uttarakhand Forest Department.

- **Recognition:** The diverse traditional knowledge of the local community should be recognised and appreciated, making it inclusive in the discussions and management practices, so as to mobilise the local support.
- **Governance, participation and decentralisation:** Often the village panchayat and/or gram sabha lacks the true representation of the local people, particularly the underprivileged and women. To some extent, their

functioning has been mostly advisory in nature, with a limited part in decision-making and negligible role in authoritative management of their region. Provisions should be made for a more meaningful involvement of the local community, under the legal jurisdiction for an open, transparent and accountable decision-making to encourage a fair system.

Limitation of the Study

The quantification of adaptive capacity by using mathematical techniques has been a problematic and contested approach because of the processes involved and intention behind the measurement (Jones et al., 2017). It is important to pave a way for a wider and more comprehensive analysis that stretches far beyond analysing adaptive capacity based only on the livelihood assets (Mesfin et al., 2020). As reported by Vincent (2007), including dimensions other than the commonly used asset base sounds more logical as adaptive capacity is multidimensional and determined by complex interrelationships of many factors at different scales. However, assets cannot be underestimated, as adaptive capacity is dependent on access to resources (Adger et al., 2004), and their availability forms a fundamental platform on which to pursue further understanding of the process of adaptation (Abdul-Razak & Kruse, 2017; Piya et al., 2012; Nelson et al., 2010; Deressa et al., 2008). Solely analysing the asset base gives an incomplete picture of the adaptive capacity, as the system requiring assets must also be able to mobilise them effectively in the pursuit of adaptation (Wall & Marzall, 2006; Brooks & Adger, 2005). The study highlights the importance of multiple perspectives (experts, local community, government officials) in assessing the adaptive capacity of local people, and thus, it would be difficult to compare the results of this study with the components of other studies.

Conclusion

Over the past few years, there are a growing number of studies on resilience and vulnerability against climate change. But there are only a few studies on the adaptive capacity of smallholder farmers in the Himalayan region that focuses not only on climatic variability but also the changing socio-economic scenario. Thus, this study brought out the basic information about the region-specific adaptive capacity of the mountain farmers for the development of adaptation policies and sustainable livelihood opportunities. The study delivered an insight of the social and ecological determinants, which contribute in the strengths and weaknesses of the mountain farming, so as to further assess the local conditions for a region- and community-based agricultural policy development and intervention. The adaptive capacity in the mountain villages was recorded to be low, which reflected that agricultural communities in the study area were prone to be adversely impacted

by external changes due to their lack of capacity and assets to cope and manage with the impacts. Combining the perceptions of the local community with the assessed adaptive capacity levels, an imbalance of rural developmental policies catering to the mountainous region was observed. These policies lacked the potential to aid the adaptation processes as they did not involve the local needs, their traditional knowledge and understanding, and community participation.

Why the government policies still fail to increase the adaptive capacity and livelihood of mountain farmers who are most vulnerable to the socio-economic crisis, is definitely a matter of concern. For years, collective action was employed to use and conserve the environment, natural resources, addressing the economic situation for growth and development. But to what extent did these national laws and policies target the specific situation of mountain regions? To achieve sustainable mountain development, it was essential that all the concerned stakeholders of the mountain-based livelihood activities were involved and that awareness was raised about the mountain ecosystem and the prevalent challenges faced by the local communities. It was also important to take into account the knowledge and experiences of indigenous mountain communities as well as the traditional farming practices and land-use systems.

The new technologies and approaches need to complement and be integrated into local practices, in order for the isolated mountain community to have a good life by attaining economic security (SDG-1—no poverty), food security (SDG-2—zero hunger) and ecological security (SDG-15—life on land). For an overall mountain development, it is important to reduce the region-specific, socio-economic and cultural disparities, while strengthening their resilience and enhancing their well-being. The specific objectives of sustainable development need to be based on people's aspirations and needs, making the developmental strategies inclusive, people-centred and place-based.

Declaration of Conflicting Interests

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Article

Determinants of Crop Diversification in Bangladesh: An Econometric Analysis

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Abstract

This study aims to investigate the factors that influence household behaviour in cultivating the diversified crops on their cultivable land in Bangladesh. Cragg's alternative tobit model has been applied to a unique rural household level dataset to find the catalysts of crop diversification. The results obtained portrayed a mixed impression of crop diversification in the country. The estimated results have revealed that the male head of household, the accessibility of information, a greater number of farming parcels and the availability of hired labour seem to govern the decision of a farming household to participate in non-rice crop production, while factors such as the total amount of land, agricultural extension service and irrigation facilities influence rice cultivation. Moreover, the findings obtained from the same Cragg's alternative tobit model estimation for the *Aman, Boro* and *Aus* seasons have also revealed a similar depiction of crop diversification in Bangladesh.

Keywords

Crop diversification, crop diversification index, Cragg's alternative tobit model, Bangladesh agriculture

Introduction

Agriculture is the dominant sector in Bangladesh in terms of its contribution to rural livelihoods and national food and nutrition security. Almost half of the total active labour force and about 70% of the rural population are directly or indirectly dependent on agriculture (Ministry of Finance, 2019). Agricultural growth was

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around 3% on average, along with the sustained growth in staple crops (Ministry of Finance, 2019). But the steady growth of agriculture is dominated by staple crop production, which is reflected in Bangladesh's primary dependence on rice cultivation and consumption (Tisdell et al., 2019). Intense dependence on rice consumption has led the agricultural cropping system to have long experience of 'subsistence basis' and 'mono-cropping (rice)' cultivation systems (Hossain et al., 2017). However, the sustained growth per capita in Bangladesh is shifting the consumption pattern toward non-rice crops like protein-enriched items, such as fish, meats, fruits and vegetables. These non-rice foods and crops are highly valued and more profitable (Helal et al., 2021; Hossain et al., 2017; Mahmud et al., 1994, Shahabuddin & Dorosh, 2002). Therefore, the higher demand and greater profitability of non-rice crops are expected to offer adequate incentives to farmers to diversify their portfolios of crop production at the farm level. In addition to the market forces, the Government of Bangladesh (GoB) is also continuously trying to promote agricultural diversification. Keeping an eye on these incentives, the GoB has formulated and implemented various policies and projects, for instance, the National Agricultural Policy, National Agricultural Mechanisation Policy, the Northwest Crop Diversification Project (NCDP), etc., to accelerate the diversification of farms away from rice production. The NCDP project was implemented during 2001−2009 in 61 sub-districts of the 16 districts of northwest Bangladesh to accelerate economic growth through high-valued crops and non-crops like fruits and spices (Ministry of Finance, 2010).

The climate and soil conditions in Bangladesh are auspicious for diversified crops throughout the year. Despite the favourable weather conditions, crop diversification[1] started in the late 1990s (Hoque, 2001) and experienced a plodding expansion pace (Islam & Hossain, 2016; Quasem & Rahman, 1993). Using time-series data in Bangladesh, Tisdell et al. (2019) found very low diversification. The study also revealed a low land-use diversity index within crop agriculture in Bangladesh. More specifically, the existing diversification in Bangladesh can be better explained through a shift from traditional rice to High Yielding Variety (HYV) rice (Hossain et al., 2017). Thus, the staple crop rice still plays a dominant role in the cropping system, accounting for approximately 70% of total farm revenue in the country (Rahman & Talukdar, 2001).

Even though the profitability (measured by a benefit−cost ratio that exceeds a value of one) of non-rice crops was quite attractive, it failed to attract the farmers to diversify their crops on the farms (Helal et al., 2021). Therefore, despite the profitability and government efforts, low crop diversity necessitates an in-depth study in this field. Although many studies in the field of cropping intensity and patterns are found worldwide, only a few studies with nationally representative household-level data and cutting-edge methodology are available in crop diversification in Bangladesh (for instance, Islam & Hossain, 2016; Mahmud et al., 1994; Metzel & Ateng, 1993; Rahman, 2008; Zohir, 1993, etc.). Most of them either used earlier data or failed to explain the causality of different economic factors and crop diversity. Additionally, applying appropriate econometric specifications to find causal relationships is highly required for academic

endeavours and policy recommendations. Therefore, the findings from these studies might shed light on formulating pragmatic policies for the country.

In order to fill the knowledge gap for the analysis of the causal relationship centring on diversification, the study tried to explore the reasons behind such a low level of crop diversification in the country using recent data and appropriate methods. This study, by investigating the causes, may provide valuable insights to the academics in this field as well as concrete policy recommendations to the policymakers concerned.

Literature Review

Crop diversification has been practised in agriculture for a long time to increase income from farming along with a lower level of fluctuation due to price and production uncertainty (Helal et al., 2021; Mahmud et al., 1994). Mango et al. (2018) found that diversification of cropping patterns can increase farm revenue and income. They showed that high-value minor crops had increased the farm revenue by more than 35%, which has increased the per-capita food consumption of their households. Diversification can generate employment opportunities, paired with increasing income and revenue (Pacheco et al., 2018). Besides, Johnston et al. (1995) showed that agricultural workers had secured their employment year-round due to the cultivation of minor crops throughout the year. Therefore, workers were found to increase their overall standard of living by providing better food to their families and better schooling for their children. Banerjee and Banerjee (2015) also found that crop diversification can increase farm revenue and food security in India. Therefore, it can reduce the incidence of poverty in the country. A similar result has also been found in a study conducted in Nepal (Thapa et al., 2018). They found evidence of better welfare outcomes among households in Nepal that cultivated high-value crops. Therefore, deviating from 'mono-cropping' cultivation has been observed as common practice among farmers.

Searching for the factors of this tendency in different studies has found that household income, trade experience, household membership in a farmers' association, household size, farmer's education, farming experience, number of livestock and land ownership are widely identified as the major catalysts of crop diversification (Ashfaq et al., 2008; Benin et al., 2003; Birthal et al., 2007; Dube & Guveya, 2016; Mahmud et al., 1994; Metzel & Ateng, 1993; Mussema et al., 2013; Rahman, 2009a; Rehan, 2020; Sichoongwe et al., 2014). Although the availability of irrigation can be anticipated as one of the crucial factors to diversifying the portfolio, Rahman (2008) has found that irrigation encourages the farms in Bangladesh to cultivate mostly HYV rice crops instead of non-rice crops. Rahman (2008) further showed that tenant farmers are more likely to adopt HYV technology than farmers operating on their own lands. On the other hand, Ahmed et al. (2017) found that irrigation access has decreased the extent of diversification in India.

Farming experience and farm size also play a critical role in cultivating different types of crops. Ashfaq et al. (2008) have found that a greater level of farming experience has reduced the likelihood of diversification in Pakistan. Though farm size may be expected to enhance crop diversification (Ashfaq et al., 2008; Sichoongwe et al., 2014),[2] Metzel and Ateng (1993) and Islam and Hossain (2016) have pointed out that farm size might inversely affect diversification in Bangladesh, unlike the findings of Rehan et al. (2017). Metzel and Ateng (1993) also found evidence favouring concentration on fewer crops, especially rice-related crop production in Bangladesh. Rahman and Kazal (2015) also found that less diversified farms are more energy efficient in Bangladesh. Moreover, a cheap and adequate supply of labour, credit facilities, availability of seeds and fertilisers are also crucial for cultivating non-rice crops (Rahman, 2009a; Ahmed et al., 2017). Ahmed et al. (2017) showed that a comparatively high endowment of labour in the households of small farms is indispensable to the diversification of a farm's portfolio. Birthal et al. (2007) found that higher per-capita income had influenced farmers to grow various non-rice crops in India. However, some constraints, such as the cost of inputs and the associated risk of producing non-rice crops, are sometimes mentioned as a hindrance to diversification in different studies (Metzel & Atneg, 1993; Zohir, 1993). Nevertheless, the scanty flourish of diversification toward non-rice crops needs to be further investigated with recent data.

Crop Diversification and Its Pattern in Bangladesh

Studies show that both horizontal and vertical crop diversification are in practice in the agriculture of Bangladesh, albeit on a limited scale (Biswas & Mandal, 1993; Hossain et al., 2017; Islam & Hossain, 2016; Mahmud et al., 1994). However, this study has tried to focus on horizontal diversification. The cropping pattern of Bangladesh has been depicted through trend lines in Figure 1. The figure shows the trends of the cultivated area of major crops in the country for about 50 years. *Part a* of Figure 1 shows the total cultivated area of rice and non-rice crops, while *Part b* presents the cultivated area of the major nine non-rice crops in the same period.

All data is measured in thousands of acres. The left- and right-sided vertical axes of the former graph demonstrate the total cultivated area of rice and non-rice crop production in Bangladesh, respectively. Data pictured in *Part a* shows that Bangladesh has experienced sustained growth in rice cultivated areas. However, non-rice cultivated areas mostly remained unchanged, though a bit of an increase has been observed in the 2000s. *Part b* may perhaps offer some explanation for that increase. It can be realised from *Part b* that the increase in non-rice crop cultivated area has come from only some limited crops, such as wheat, mustard and pulses. On the other hand, tobacco, sugar cane, tea, cotton and moong have remained stable.

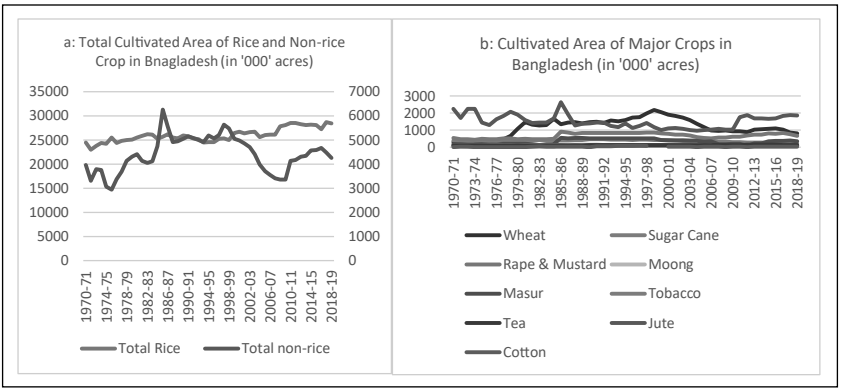

Figure 1. Trends in major crop cultivated area in Bangladesh from 1970−1971 to 2018−2019.

Source: Monthly Economic Trends, Statistical Department, Bangladesh Bank.

This cropping pattern may be further inferred from the total production of different types of crops presented in Figure A1. *Part a* of Figure A1 presents the combined rice and non-rice production in a thousand metric tonnes (MT), while *Part b* depicts the production of the major nine crops of the country in the same unit. It can be readily observed from Figure A1 that although rice production has increased substantially, the production of major non-rice crops has remained stable or even declined. Therefore, graphs 1 and A1 may suggest that crop diversification has not flourished well in Bangladesh; instead, it concentrates on rice, especially HYV rice varieties.

Data and Methodology

Description of Data

The study is primarily based on nationally representative and unique rural household data, supplemented by some secondary data from Bangladesh Bank. The data used in this study was collected from 62 villages across the country in 2014. The data is, in fact, a part of a repeat survey that has five rounds in total. The data for each round has been collected by tracking the same households in the same villages over three decades. Each round of this dataset has been conducted and supervised by Dr. Mahabub Hossain, and it is therefore commonly known as the Mahabub Hossain Panel Data (MHPD). The first round of this longitudinal study was conducted in 1987−1988, followed by the surveys conducted in 1999−2000, 2003−2004, 2007−2008 and 2014.

Sample households and villages were selected using a multistage random sample technique for the baseline survey conducted in 1987−1988. At the first

stage, all unions—the lowest administrative unit—of the country were considered based on the population census conducted in 1981. From the list of all unions, 62 unions from the country's 57 (out of 64) districts were chosen using a random number table at the first stage (Hossain & Bayes, 2018).[3] At the second step, two villages from each sample union were purposively selected based on: (a) number of households, (b) rate of literacy and (c) the ratio of land to people, yielding a total of 124 villages. Based on focus group interviews, 62 villages were selected from 124 villages for conducting an in-depth household survey. By taking 20 households on average from each village, a total of 1,245 sample households were finalised for administering the baseline survey. A second round held in 1999−2000 followed the same households and their offshoots by taking 30 households from each village on average. Besides the old sample households and their offshoots, some new households were added using the Participatory Rural Appraisal (PRA) method. A similar technique was applied in the third, fourth and final rounds.[4] Ensuring all the households were conducted in the earlier four rounds, 40 households, on average, were selected, resulting in a total of 2,846 sample households in the final round (Hossain & Bayes, 2018). However, this study has utilised the final round held in 2014 for empirical investigation.

Description of Variables

As dependent variables, participation status in crop diversification (CDP) and crop diversification index (CDI) have been used. The CDP is a dummy variable having 1 when a farm cultivates non-rice crops and 0 for only rice cultivation, while the CDI is a continuous index variable ranging from 0 to 1. To develop a crop diversification index, the share of land under *i*th crop, S_i, can first be defined as follows:

$$S_i = \frac{L_i}{\sum_i^n L_i}$$

where, S_i indicates the proportion of land under *i*th crop, L_i indicates cultivated land under *i*th crop and $\Sigma_i^n L_i$ is, therefore, the total cropped area where $i = 1, 2, \ldots, n$. Thus, CDI can be developed as follows:

$$\text{CDI} = 1 - \sum_i^n S_i^2$$

where, $\Sigma_i^n S_i^2$ is the Herfindahl index (HI).[5] The zero value of CDI implies complete specialisation (to rice), while an absolute one value of CDI indicates complete diversification. Therefore, the higher the value of the CDI index, the greater the diversification of the farm toward non-rice crop production.

Socio-economic variables that are likely to affect crop diversification have been used as explanatory variables. The detailed definition of each variable is delineated in Table A1. The age of the household head has been used as a proxy

for farming experience. Age^2 is the squared age variable and is employed to capture the non-linear effect of age. Household size, income, total land and the total number of livestock function as household factors. However, income has been dropped from the study due to its reverse causality. The availability of information can play an essential role in the decision-making process. Getting the correct information at the right time may help farmers cultivate the appropriate crops, which may, in turn, minimise the associated risk and uncertainty in cultivation. Therefore, agricultural extension services, information from NGO workers, TV, newspapers, FM radio or the internet are considered for taking care of the availability of information. Finally, farm-related information of a household like farm size, total usage of fertilisers, accessibility of irrigation, use of hired labour and number of plots is also controlled. In addition, farms and households are treated identically in this study.

Estimation Method

The study has wielded Cragg's alternative tobit model to investigate the factors of crop diversification in Bangladesh. Cragg's tobit model is an alternative to the standard tobit model. The standard tobit model is generally used when the data is truncated or censored. Truncation and censoring problems are observed in the traditional linear regression model when only positive outcomes are observed (Tobin, 1958). The general censored data regression model can be represented as an additive error that follows a normal distribution and constant variance (Cameron & Trivedi, 2005). Mathematically, a censored or corner-solution model is as follows:

$$y_i = y_i^* \quad \text{if } y_i^* > 0$$
$$y_i = 0 \quad \text{if } y_i^* \leq 0$$

and

$$y^* = Z'\beta + \varepsilon$$

where, Z is a vector of explanatory variables and ε refers to the stochastic disturbance term that follows the distribution.

$$\varepsilon \sim N\left[0, \sigma^2\right]$$

The disturbance term has a variance constant across the observations resulting from the distribution of the latent variable $y^* \sim N\left[Z'\beta, \sigma^2\right]$. The censored density function can be modelled after (Tobin, 1958). Following the representation of Cameron & Trivedi (2005)

$$f(y \mid z) = \left[\frac{1}{\sqrt{2\pi\sigma^2}} \exp\left\{\frac{1}{2\sigma^2}\left(\left(y - Z'\beta\right)^2\right)\right\}\right]^d \left[1 - \Phi\left(\frac{Z'\beta}{\sigma}\right)\right]^{1-d}$$

where, d is defined as a binary indicator and it takes 1 if $y_i^* > 0$ and 0 if $y_i^* \leq 0$ and Φ represents the standard normal cumulative distribution function. The

standard tobit model maximises the log-likelihood function in order to obtain (β, σ^2). The log-likelihood function (Cameron & Trivedi, 2005) is

$$\ln L_N\left(\beta,\sigma^2\right)=\sum_{i=1}^{n}\left\{d_i\left(-\frac{1}{2}\ln 2\pi-\frac{1}{2}\ln\sigma^2-\frac{1}{2\sigma^2}\left(\left(y_i-Z'\beta\right)^2\right)+\left(1-d_i\right)\ln\left(1-\Phi\left(\frac{Z_i'\beta}{\sigma}\right)\right)\right)\right\}$$

From the above log-likelihood function, we can estimate the parameters. However, one of the apparent limitations of the tobit model is that the probability of taking a decision of positive y value and the actual value of$y$ provided that $y > 0$ are assumed to be identical and determined by the same process. More precisely, $P(y>0\mid z)$ and $E(y\mid z, y>0)$ are assumed to have the same sign and be identical. To avoid the problem of the same probability and expected value of y, Cragg (1971) proposed an alternative model that integrates two steps, including the probit model and a truncated typical regression model for some given positive values of y. It implies that the two-tiered model allows the choice of $y > 0$ versus $y = 0$ to be distinctive from the selection of actual y provided that $y > 0$ (Woolridge, 2010). Since Cragg (1971) integrates two stages, including a probit model and a truncated standard regression model, it is commonly known as the two-tiered or double-hurdle model.

Since some farmers do not diversify, we will get some zeros for the dependent variable, CDI, for these farmers. Therefore, ordinary least square (OLS) does not satisfy the BLUE (Best Linear and Unbiased Estimators) properties of the classical linear regression model (Wan & Hu, 2012). At the same time, the standard tobit model does not fit as well due to its equal treatment of the coefficients of probability and magnitude (Lin & Schmidt, 1984). On the other hand, the first stage of Cragg's alternative tobit model includes a probit model that estimates the probability of participation, while the second stage investigates the extent of crop diversification. According to Cragg (1971),

$$f(w,y\mid z)=\left[\frac{\Phi\left(z_1\delta\right)(2\pi)^{-\frac{1}{2}}\sigma^{-1}\exp\left\{\frac{\left(y-z_2\beta\right)^2}{2\sigma^2}\right\}}{\Phi\left(\frac{z_2\beta}{\sigma}\right)}\right]^d\left\{1-\Phi\left(z_1\delta\right)\right\}^{1-d}$$

In the case of $z_1 = z_2$ and $\delta=\frac{\beta}{\sigma}$, the tobit model is, however, nested within the above model (Burke, 2009). Since the above model includes both probit and truncated standard models, it incorporates CDP in probit and CDI in the truncated regression model as the dependent variable. Therefore, one can easily estimate the likelihood of participation and magnitude of crop diversification from the above Cragg (1971) model.

Results and Discussion

Descriptive Statistics

Table 1 presents the summary information of the relevant variables used in this study. The average age of the household head in the sample is marked as 47.31 years, which is approximately identical to the average age (47.65 years) of the head of a household involved in fishing and aquaculture activities (Azad & Wadood, 2017). More than four-fifths (84%) of the aggregate number of household heads are male, indicating the portrait of patriarchal society in Bangladesh.

Table 1. Summary Statistics of Sample Households.

	Variables	Observations	Mean	SD	Minimum	Maximum
Individual factors	Age (years)	2,846	47.31	14.27	16	110
	Sex	2,846	0.84	0.36	0	1
	Education (years)	2,846	4.47	4.34	0	16
Household factors	HH size	2,846	4.39	1.96	1	17
	HH income (000 BDT)	2,846	179.28	201.64	0	2,716.28
	HH total land (decimals)	2,769	98.32	176.19	0	3,000
	Total livestock	1,640	2.80	2.15	0	18
Source of information	Agri extension services (dummy)	2,846	0.58	0.49	0	1
	Visits extension workers	2,846	6.02	19.39	0	354
	Access to news media (dummy)	2,846	0.74	0.44	0	1
	NGO membership (dummy)	2,846	0.46	0.50	0	1
Farm characteristics	Total used fertilisers (KG)	1,616	306.23	422.02	0	4,728
	Number of hired labour	1,616	42.08	220.95	0	8,573
	Access to irrigation (dummy)	1,547	0.84	0.37	0	1
	Farm size (dummy)	2,846	0.22	0.42	0	1
	Total number of plots	1,547	4.16	3.76	1	58
	CDP (dummy)	1,547	0.48	0.50	0	1
	CDI	1,132	0.47	0.40	0	1
	CDI in *Aman* (dummy)	908	0.15	0.34	0	1
	CDI in *Boro* (dummy)	1,036	0.56	0.45	0	1
	CDI in *Aus* (dummy)	466	0.84	0.35	0	1
	CDP in *Aman* (dummy)	1,547	0.11	0.31	0	1
	CDP in *Boro* (dummy)	1,547	0.44	0.50	0	1
	CDP in *Aus* (dummy)	1,547	0.26	0.44	0	1

Source: The author.

The average level of education found is almost 5 years (4.47 years), which is nearly enough to complete primary education. Since the survey has been conducted in the rural areas of Bangladesh, this lower level of average education is expected. Regarding the household factors, the average size of a household in the study is 4.39, which is slightly higher than the national average (4.06) (Bangladesh Bureau of Statistics [BBS], 2019). This marginally higher average than the national average may have happened because the survey was conducted approximately 2 years ago in rural areas.[6]

The average household income is also approximately equal to that of the national average. Data used in this study shows that an average family's income is approximately Bangladesh Taka (BDT) 180,000, implying that monthly per-capita household income is approximately BDT 15,000. This per-capita income is close to the national average of BDT 16,000 (BBS, 2019). Land is historically considered one of the sources of power in the rural area. However, farm size is facing increased pressure to decline due to the gradual increase in the population and the demand for urbanisation. The data summarised in Table 1 shows that the average landholding of a household is about 98 decimals. An average household has almost three livestock, despite the rapid advancement of technology and automation. The holding of livestock may innuendo that rural households cannot be considered without livestock.

Although access to information is crucial, every household does not have access to information, as shown in Table 1. Table 1 shows that almost 60% of the surveyed farms seem to collect useful data from the modern agricultural extension workers by visiting them on an average six times a year, while approximately 75% of them have access to TV, news or internet facility. Table 1 also shows that almost half of the sample households (46%) are involved with NGOs. Therefore, it can be inferred that NGOs seem to play a significant role in rural people's livelihoods in Bangladesh. On the other hand, Table 1 also delineates that 84% of households are currently enjoying access to irrigation facilities. In terms of farm size as defined, only 22% of the households in the country can be identified as large farms. Each farm has used an average of 306 kg of fertiliser and 42 paid days of hired labour, with approximately four plots of land.

Data also shows that the mean value of CDP is 0.48, meaning that less than half of the rural farms are involved in non-rice production. On the other hand, the mean value of CDI is 0.47, implying that farms are perhaps moderately diversified. Nasim et al. (2017) supported this monotonous tendency of rice cultivation. They showed that five key rice varieties are cultivated on more than 51% of the total net cropped area in Bangladesh. Rahman (2009b) also found a similar mean value of the HI, 0.6, by investigating three districts in Bangladesh. Moreover, Table A2 also shows that the greater diversification has been observed during the *Aus* season while the greater concentration of rice is noticed during the *Aman* season. This is expected so far, as multiple varieties of crops are usually cultivated in *Aus* season in the country.

Table 2 provides descriptive statistics based on the CDP status. The simple *t*-test has been carried out to determine whether statistical differences exist between the two groups of the farms for the variables. Table 2 presents that more

Table 2. Summary Statistics Based on Diversification.

	Variables	Farms Participated in Diversification (mean)	Farms didn't Participate in Diversification (mean)	*p*-Value Diff = Mean (1) − Mean(0) H_o: diff = 0
Individual factors	Age (years)	49.46	51.03	0.03
	Sex	0.95	0.79	0.00
	Education (years)	5.20	5.50	0.19
Household factors	HH size	4.75	4.35	0.00
	HH income (in thousand BDT)	203.16	232.59	0.02
	HH total land (decimals)	178.79	157.91	0.05
	Total livestock	2.79	3.19	0.01
Access to information	Agri extension services	11.36	5.50	0.00
	Access to news media (dummy)	0.81	0.74	0.00
	NGO membership (dummy)	0.44	0.33	0.00
Farm characteristics	Total used fertiliser (KG)	383.79	275.75	0.00
	Number of hired labour	49.98	30.45	0.00
	Access to irrigation (dummy)	0.83	0.84	0.85
	Farm size (dummy)	0.39	0.33	0.00
	Total number of plots	4.83	3.54	0.00

Source: The author.

experienced and educated household heads with larger household size, income and a greater number of livestock on average participated less in crop diversification. In contrast, the farms that participated in crop diversification used more inputs and had better access to information than those that did not. The rice cultivating farms also enjoy a higher income on average than the diversified farms, around 30,000 BDT annually.

Data presented in Table 2 exhibits that most of the indicators are statistically significant across the status of crop diversification. Only two of the aforementioned variables-education level and access to irrigation- are found statistically insignificant on the crop diversification status. This implies that socio-economic indicators are pretty distinctive between the two groups.

Regression Results

Table 3 presents the pooled regression results of Cragg's (1971) alternative tobit model. The probability of taking a decision in favour of non-rice crop production

is reported in the first tier, while the magnitude of crop diversification is presented in the second tier. The findings presented in Table 3 sketch the regression results from pooled observations by combining all three seasons. The identical econometric specification has been employed for the three main agricultural seasons—*Aman, Boro* and *Aus* separately, and their results are reported in Table A2.[7]

Table 3. Regression Results of Cragg's Alternative Tobit Model.

	Variables	Probability of Participation in Crop Diversification	Extent and Magnitude of Crop Diversification
Individual factors	Age (years)	−0.030 (0.022)	0.002 (0.004)
	Age2	0.000 (0.000)	−0.000 (0.000)
	Sex	0.553 (0.205)***	−0.024 (0.052)
	Education (years)	−0.012 (0.011)	−0.001 (0.002)
Household factors	HH size	−0.036 (0.023)	−0.005 (0.005)
	HH total land (decimals)	−0.001 (0.000)***	0.000 (0.000)**
	Number of livestock	0.005 (0.022)	0.007 (0.005)
Access to information	Agri extension services	−0.001 (0.002)	−0.002 (0.000)***
	Access to news media (dummy)	0.116 (0-.115)	0.043 (0.025)*
	NGO membership (dummy)	0.392 (0.096)***	0.033 (0.019)*
Farm characteristics	Total used fertiliser (KG)	0.000 (0.000)	−0.000 (0.000)***
	Number of hired labour	0.004 (0.001)***	0.001 (0.000)***
	Access to irrigation (dummy)	−0.544 (0.142)***	−0.025 (0.028)
	Total number of plots	0.127 (0.020)***	−0.024 (0.004)***
	Constant	0.878 (0.617)	0.752 (0.120)***
Fitness of model	Number of observations	886	
	Wald χ^2 (*p*-value)	92.8 (0.000)***	
	Sigma	0.228(0.007)***	

Source: The author.

Note: ***, ** and * Indicate statistical significance at the 1%, 5% and 10% level respectively. SEs are shown in parentheses.

Individual Specific Factors

Among the individual factors used in the study, only the gender variable was found to be statistically significant in the first tier with a positive sign. The positive and statistically significant coefficient implies that male-headed households or farms are more likely to participate in non-rice crop production. This finding is consistent with Sichoongwe et al. (2014) and Dube & Guveya (2016). Although gender identity can significantly increase the likelihood of diversification, it cannot enhance the extent of diversification as the coefficient of gender identity of the household head is negative and insignificant. The remaining explanatory variables—age, and education—of individual factors are found to be statistically insignificant at both tiers, implying that these variables do not play much contribution in the probability and extent of diversification.

The reported findings of individual factors in Table A2 also show a similar trend of diversification. However, one deviation can be mentioned that, unlike the pooled regression, the obtained results for *Aman* indicate that the coefficients of age and age^2 are significant with positive and negative signs, respectively, in the second tier. It implies that farming experience positively governs diversification at a diminishing rate for the season. Since almost all variables of individual characteristics for pooled and separate seasons are found statistically insignificant, factors under the individual category cannot provide strong evidence regarding crop diversification.

Household Specific Factors

Among the household factors, total owned land, the number of livestock and household size are considered in the study. However, the total land is the only factor found as statistically significant among them under the pooled regression at the both stages. According to the obtained results, a farmer with an additional decimal of owned land has a 0.10% lower probability of participating in diversification. A similar finding was also found in Metzel and Atneg (1993) and Birthal et al. (2007). Nonetheless, the coefficient of the total land in the second tier cannot provide much evidence about diversification because of its tiny magnitude. Household size is found to inversely affect the probability and magnitude of diversification. However, the insignificant coefficient at both tiers cannot produce much evidence about diversification. Although signs of livestock coefficients are found positive at both stages, these coefficients are also statistically insignificant, like the household size. Perhaps technology and automation are gradually occupying the tasks of the agricultural sector that were previously done by livestock.

Nearly similar findings are observed for all three seasons except the *Aus* season, when household size significantly reduces the probability and magnitude of diversification (Table A2). Therefore, it can be argued that factors of household characteristics like individual factors do not play a significant role in the overall decision of participation and the extent of diversification.

Information Availability

The availability of information at the right time is crucial for making a good decision. Therefore, having access to media (television, radio, newspaper or internet), involvement in NGO and number of visits to agricultural extension workers are kept under access to information factors. All variables are statistically significant in the second tier, while NGO membership is the only significant variable in the first tier. Although the coefficient of access to media is not statistically significant, it is significant in the second stage. Table 3 shows that this access increases the magnitude of diversification by 0.043 units. Since the index is measured on a scale of 0 to 1, it implies that this facility vastly increases the diversification magnitude.

Moreover, among the information factors, NGOs play the most vital role in crop diversification for both the probability and magnitude of diversification. If an individual of a household is associated with NGOs, it raises the chances of diversification about 40% higher than its counterpart. Paired with the increase in probability, the magnitude of CDI is also increased by about 0.033 units. Since NGOs function on a community basis, it might help the farms cultivate high valued crops besides rice. Perhaps getting information about better quality seeds, marketing strategy for their produced crops, etc., from NGOs makes the farm owners more confident in cultivating non-rice crops. Although involvement with NGOs and access to the media motivates a farmer toward the cultivation of diversified crops, the greater number of visits to agricultural extension workers is found to discourage crop diversification. Besides, getting information from NGOs is perhaps easier and less costly than getting it from the agricultural extension workers in the country. The reported results shown in the Table A2 also display a similar portrait (with some minor variations in significance level) for three seasons. Thus, the factors of information play a significant role in crop diversification.

Farm-specific Characteristics

Farm-specific factors primarily influence the farm's behaviour regarding farm-related activities. Use of fertilisers, hired labour, access to irrigation and the total number of plots are considered under farm characteristics. Table 3 shows that most of the variables of farm characteristics are found to be highly statistically significant. Despite being highly significant, the coefficients of fertiliser are very tiny at both stages. Therefore, it cannot explain the nature and extent of crop diversification. The availability of hired labour can significantly increase the probability and magnitude of crop diversification. Obtained findings show that if hired labour is increased by an additional unit, it elevates the probability by 0.4% and the CDI index by 0.001 units. It implies that the availability of a greater number of hired labour during the cultivation of non-rice crops helps to increase both the likelihood and extent of diversification. Birthal et al. (2007) also found compatible findings. Cultivation of high valued crops may probably require more use of labour than staple crop rice.

On the other hand, access to irrigation also encourages the farms to concentrate themselves on traditional rice cultivation instead of diversification. Table 3 shows

that access to irrigation reduces the likelihood of diversification by about 55%, and this facility also shrinks the magnitude of diversification by a considerable amount of 0.025 units. However, the latter one is not significant. Farmers having access to irrigation perhaps have switched toward HYV rice varieties instead of non-rice crops. This finding is largely commensurate with that of Mahmud et al. (1994) and Rahman (2008). In the case of the number of plots, one can assume that a farmer with a greater number of plots may intend to cultivate various crops. The results presented in Table 3 seem very consistent with this prior assumption. Table 3 also shows that an additional plot significantly increases the likelihood of diversification by 13%. However, it significantly decreases the extent of diversification by about 0.024 units. Therefore, although a greater number of plots initially increases the probability of diversification, it eventually reduces crop diversification.

Moreover, the factors of farm characteristics in three seasons also affect the farm's decision and responses to cultivating non-rice crops in line with pooled regression. However, some modicum variations are found in the results reported in Table A2. A deviation can be mentioned in the case of the *Aus* season, where the irrigation coefficient is found to be statistically significant only in the first stage. In this season, access to irrigation increases the probability in favour of non-rice crop production by about 80%, unlike Table 3. This finding is quite expected as farmers generally prefer to cultivate high yielding (HYV) varieties in the *Boro* season and high-valued crops, mostly during the *Aus* season. Overall, the findings obtained from the farm characteristics have revealed that farm-related factors like access to irrigation play a central role in crop diversification.The obtained regression results also show that all specifications of econometric models (pooled and individual specifications for three separate seasons (*Aman, Boro* and *Aus*) are found to be statistically significant. Therefore, it implies that the chosen models exactly fit the data.

Conclusion

The cultivation of varieties of crops is expected to enhance the profitability of farms and the sustainability of land productivity. Considering the prospects and potentiality of the cultivation of non-rice crops, they might have flourished substantially in the country. However, the findings do not offer a satisfactory picture of crop diversification. Only the availability of hired labour, the number of plots and NGO membership are found to positively affect diversification. In contrast, most farm-related factors like irrigation, fertiliser, total land owned, agricultural extension services and the number of plots under cultivation are found to reduce the probability and extent of diversification. Farm-specific factors primarily advocate in favour of concentration on the cultivation of rice. Besides, the average income of the households who have diversified their portfolios is significantly lower than the farms that have concentrated on rice production. This can also be inferred from the trends of major crop-producing areas and their

production. Thus, this clearly suggests that a significant lack of incentives exists to influence farmers' decisions to go for crop diversification.

The question is whether this portrait of diversification may be a matter of concern. Not really, as long as they are driven by the underlying incentives at the household level. If the constraints for diversification, like the existing irrigation system, inadequate supply of inputs, poor market structure and price variation, etc., are changed over time, then the underlying incentive structure may induce a higher level of diversification. The consumption pattern of Bangladesh, which is overdependent on rice, is still the main contributing factor to the concentration of rice production even though there are policies in place to bring a shift in there. Paired with consumption pattern, a huge population further intensifies the needs of rice production in the country, even forcing to import of food grains, especially rice, almost every year. Another interesting fact is that it is tough for the farmers to deviate from rice production substantially as they do not have the luxury of facing a substantial variation in income from adventuring into new non-rice crops as they perceive. Any mistakes in choosing the right set of crops may lead to losses at best and starvation at worst.

Therefore, the study has two recommendations: (a) ensure the adequate amount of inputs like year-round irrigation, fertilisers and availability of information that will induce rice and non-rice production evenly and (b) ensure adequate incentives through subsidies in input and purchases directly from the farmers to ensure the profitability of non-rice crops. Incentives can be channelised for diversification at the aggregate level through promoting value-added crops in agro-ecological zones where particular crops have some comparative advantages. Helal et al. (2021) argued for policies that promote diversification at the aggregate level, but specialisation at both households and agro-ecological zones.

Appendix A

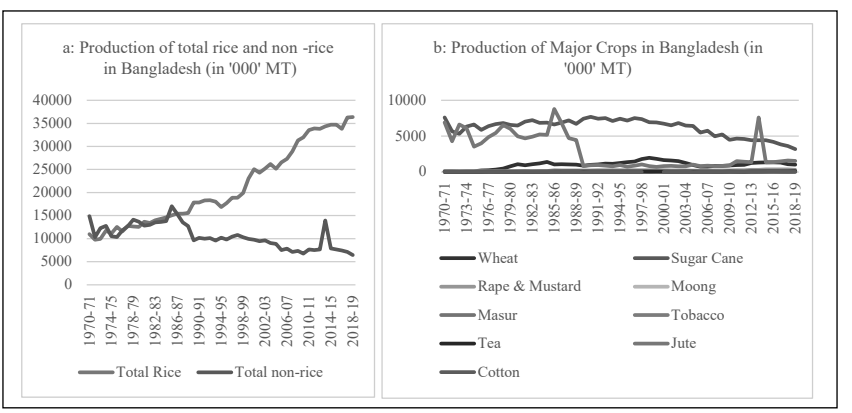

Figure A1. Trends of Major Crops Production in Bangladesh from 1970–1971 to 2018–2019.

Source: Monthly Economic Trends, Statistical Department, Bangladesh Bank.

Table A1. Definition of the Relevant Variables.

	Variables	Definition of the Variables
Individual factors	Age	Age of household head in years
	Age squared	Squared of age
	Sex	Dummy variable (=1 if sex is male otherwise 0)
	Education	Education of household head in years
Household factors	HH size	Total number of household
	HH income	Yearly total household income (000 BDT)
	HH total land	Total amount of land a household owns in decimals
	Total livestock	Total number of livestock in a household including cow, buffalo, horse, goat and lamb
Access to information	Agri extension services	Dummy variable (=1 if a farm takes agricultural extension services and otherwise 0)
	Visits extension workers	Total number of visits to agricultural extension workers
	Access to news media	Dummy variable (=1 if a household has access to Radio, TV, News Papers, FM Radio and internet and otherwise 0)
	NGO membership	Dummy variable (=1 if any member of a household is associated with NGO, otherwise 0)
Farm characteristics	Total used fertilisers	Total amount of used fertilisers by a farm in a given year (KG)
	Number of hired labour	Total number of hired labours a given years in days
	Access to irrigation	Dummy variable (=1 if a household has access to irrigation by any means and otherwise 0)
	Farm size	Dummy variable (=1 if a household's total land exceeds 149 decimals)
	Total number of plots	Total number of plots a household
	CDP	Dummy variables (= 1 if a farm practices crop diversification and otherwise 0)
	CDI	Crop diversification index
	CDI in *Aman*	CDI in *Aman* season
	CDI in *Boro*	CDI in *Boro* season
	CDI in *Aus*	CDI in *Aus* season
	CDP in *Aman*	Dummy variable (=1 if a farmer participates in crop in *Aman* season and otherwise 0)
	CDP in *Boro*	Dummy variable (=1 if a farmer participates in crop in *Boro* season and otherwise 0)
	CDP in *Aus*	Dummy variable (=1 if a farmer participates in crop in *Aus* season and otherwise 0)

Source: The author.

Table A2. Regression Results of Cragg's Alternative Tobit Model.

Variables		*Aman*		*Boro*		*Aus*	
		Probability of Participation in Crop Diversificatio-n	Extent and Magnitude of Crop Diversificatio-n	Probability of Participation in Crop Diversificatio-n	Extent and Magnitude of Crop Diversificatio-n	Probability of Participation in Crop Diversificatio-n	Extent and Magnitude of Crop Diversificatio-n
Individual factors	Age (years)	−0.016 (0.024)	0.022 (0.010)**	−0.025 (0.022)	0.002(0.004)	0.022(0.039)	−0.002(0.003)
	Age2	0.000 (0.000)	−0.000 (0.000)**	0.000 (0.000)	−0.000(0.000)	−0.000(0.000)	0.000(0.000)
	Sex	0.138 (0.286)	−0.020 (0.133)	0.481 (0.234)**	−0.032(0.051)	0.092(0.480)	0.044(0.036)
	Education (years)	0.002 (0.015)	0.003 (0.007)	−0.008 (0.012)	0.003(0.002)	−0.029(0.023)	0.001(0.002)
Household factors	HH size	−0.004 (0.031)	0.014 (0.013)	−0.047 (0.025)**	−0.004(0.005)	−0.135(0.046)*	−0.006(0.003)**
	HH total land	−0.000 (0.000)	0.000 (0.000)	−0.001 (0.000)***	0.000(0.000)	0.001(0.001)	0.000(0.000)***
	livestock Number	0.010 (0.027)	0.004 (0.011)	0.001 (0.022)	0.004(0.004)	0.041(0.052)	−0.001(0.003)
Access to information	Agri Ex-tensio	−0.004 (0.003)	−0.000 (0.002)	−0.001 (0.002)	−0.001(0.000)**	−0.002(0.006)	−0.000(0.000)
	Access to news	0.296 (0.167)*	0.012 (0.086)	0.181 (0.126)	0.028(0.024)	0.549(0.219)***	−0.023(0.017)
	NGO membership	0.160 (0.121)	0.010 (0.050)	0.386 (0.102)***	0.028(0.019)	0.543(0.194)***	0.036(0.012)***

(Table A2 continued)

(Table A2 continued)

Variables		*Aman*		*Boro*		*Aus*	
		Probability of Participation in Crop Diversificatio-n	Extent and Magnitude of Crop Diversificatio-n	Probability of Participation in Crop Diversificatio-n	Extent and Magnitude of Crop Diversificatio-n	Probability of Participation in Crop Diversificatio-n	Extent and Magnitude of Crop Diversificatio-n
Farm characteristics	Total use fertiliser	−0.001 (0.000)***	−0.000 (0.000)	0.000 (0.000)	−0.000(0.000)**	0.000(0.000)	0.000(0.000)
	Hired labour	0.007 (0.001)***	0.001 (0.000)**	0.004 (0.001)***	0.001(0.000)***	0.001(0.002)	−0.000(0.000)
	Access to irrigation	0.177 (0.184)	−0.009 (0.084)	−1.936 (0.325)***	−0.139(0.027)***	0.810(0.214)***	0.011(0.018)
	Number of plots	0.051 (0.023)**	−0.032 (0.009)***	0.114 (0.021)***	−0.020(0.003)***	0.012(0.040)	−0.005(0.002)**
	Constant	−1.341 (0.719)	0.172 (0.302)	2.138 (0.696)***	0.959(0.114)***	−0.127(1.135)	1.030(0.079)***
Fitness of model	No. of observations	719		820		376	
	Wald χ^2 (p-value)	59.02 (0.000)***		99.55 (0.000)***		48.33 (0.000)***	
	Sigma	0.261 (0.017)***		0.210 (0.006)***		0.105 (0.004)***	

Source: The author.

Note: ***, ** and * Indicate statistical significance at the 1%, 5% and 10% level respectively. SEs are shown in parentheses.

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Notes

1. Crop diversification is generally a way of transforming conventional mono-cropping cultivation to the cultivation of multiple varieties of crops. Diversification can be defined as cultivating a number of crops instead of a single crop or shifting from farm to non-farm cultivation diversification (Haque et al., 2010; Mango et al., 2018; Nayak & Kumar, 2018). The former diversification is broadly identified as horizontal crop diversification, whereas the latter one is vertical diversification. More specifically, farmers shift their cultivation from a single crop or a group of similar crops to diversified crops in the case of horizontal diversification, while they shift their pattern of cultivation in vertical diversification (Haque et al., 2010; Mango et al., 2018; Nayak & Kumar, 2018).
2. Ashfaq et al. (2008) conducted a study based in Pakistan, while Sichoongwe et al. (2014) conducted their study in Zambia.
3. Seven districts were excluded from the survey due to the difficulty of administering the survey.
4. See (Hossain & Bayes, 2018) for detailed sample size and sampling design.
5. The HI measures the sum of the square of share of *i*th crop in a portfolio. The magnitude of crop diversification is generally calculated through the Herfindahl Index (Sichoongwe et al., 2014; Dube & Guveya, 2016), although the Ogive Index (OI) has also been used to calculate the magnitude of crop diversification in some existing literature (see Benin et al., 2012; Islam & Hossain, 2016; Kumar et al., 2012).
6. The national average rural household size was 4.11 in 2016, while the national average household size was 4.50 in 2010.
7. Rice varieties of the *Aman* season are planted in July and harvested in November−December; rice varieties of *Boro* are planted in November−December and harvested in March−April; and rice varieties of *Aus* are planted in March−April and harvested in June−July.

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Article

Farmland Lease Options in the Rural China: Key Determinants and Policy Implications

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Abstract

The study looks at the factors that influence farmland transfer option in Yunnan province, China. To help achieve this objective, 6,007 households were randomly selected from rural communities. The sample includes households who are engaged in lease-out, lease-in, and those who engage in neither lease-out nor lease-in. The data was analysed using multinomial probit model. The results show that farmland certification and knowledge of land tenure policy have positive impact on both lease-in and lease-out decisions relative to the reference category. Farmland size and years of schooling show negative and positive impact on lease-in and lease-out decisions, respectively, relative to the reference category. The net income of the household and crop insurance have positive and negative effect on lease-in and lease-out decisions, respectively, relative to the base category. The results suggest that price per mu has a positive effect on the lease-out decision relative to the base category. The study broadens the scope of analysis on farmland transfer by considering all the options available to a household in farmland transfer decision taking.

Keywords

Farmland transfer, lease-out, lease-in, crop insurance, Yunnan Province of China

Introduction

Land plays an essential role in food supply especially in the time when global food supply is under threat; food security and stability have a very substantial

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significance on individual level as well as national level (Wang et al., 2015). As the global population continue to increase substantially and China as the most populated country in the world, it is of a great importance that its food supply receives a specific attention (Veeck, 2013). It is estimated that from 2002 to 2015 China's grain supply increased and the total supply after 2015 remained constant and stable where in 2019 the combined output reached 66.384 million tons. This monumental achievement is attributed to a host of policies and measures that were put in place. Some of the policies included farm land protection, land transfer, the subsidisation of agricultural and land consolidation policy (Yu et al., 2015). Farmlands-transfer has also played a big role in the developing countries where there is high climate risk. The stability of land tenure is very much important for food security especially when farmland resources are scarce (Holden & Otsuka, 2014). It is with this reason that the land decentralisation of tenure that is very weak can cause extensive land use and this leads to extensive land degradation and productivity decline (Holden & Ghebru, 2016).

Farmland is one of the challenges confronting China's agriculture prospects. It is estimated that China has a total of 960 million hectares of arable land. With this figure, it is one third estimated at 14.8 per cent that is available for food crop production and horticultural products (Qiang et al., 2013). Under China's household responsibility system (HRS), each household has 0.50 ha of farmland (Ni, 2015). To ensure maximum returns from the limited farmlands, improve households' income and preserve nature, the central government has instituted farmland transfer policy. Farmland transfer is seen as the best approach to tackling agricultural productivity challenges and food security challenges in the process of alleviating the poverty in rural areas (Li et al., 2018b). The essence of the policy is to inject efficiency into farmland use through the transfer from less efficient users to more efficient users. The policy is to ensure an increase in the scale operation and to modernised agricultural operations as opposed to subsistence farming and to avoid the situation of idle farmlands as a result of rural–urban migration.

Land transfer is beneficial to achieving a great scale operation of land; it plays an important role in optimising resource allocation, increasing households' income, improving land use efficiency therefore improving agricultural land production (Udimal et al., 2020; Yan et al., 2016). Land transfer involves many sectors, which include economics, land science agriculture, law and administration (Yuan et al., 2018). The deviations between willingness to transfer and the decision itself is an explanation to the fact that the factors that influence farmers to transfer are not quite the same.

China has lost close to about 280 million rural farmers to urban migration in the last 40 years (Cheng et al., 2019; Liu et al., 2014; Wang et al., 2016). This has led to farmland abandonment in some places attributable rural labour migration (Liu, 2018; Liu et al., 2014). This development has created a mismatch in farmland demand from farming households and solid farmland supply patterns in rural areas due to the Household Contract Responsibility System (HCRS) (Su et al.,

2020). HCRS a special land property rights used throughout China (HCRS), hindered the use of farmlands left behind by migrants since those who stayed in the village and wanted to expand their farmland could not easily have unfazed access to its use (Gao et al., 2018). Under HCRS, the farmland historical number of farmland owners are registered on the land are put into consideration rather than its current occupants and the land within the area is collectively owned by the residents (Xiao & Zhao, 2018). Nevertheless, the land can be used but not owned for decades, the land contract relationship is valid at least for 30 years.

Under the HCRS, farmland owners have no right to sell their registered land in the land market even if they are leaving the village to settle in the city permanently. With an increase in rural–urban migration, it therefore, implies that farmlands abandonment would be a common phenomenon. This development led to rural farmland becoming a topical issue within the research community and finally gained the attention of central government in 2014. To help deal with rural farmland abandonment issues the central government introduced the 'separating three property rights' (Li et al., 2018a; Long, 2014; Su et al., 2020). Under the 'separating three property rights' the land ownership is not changed but the rural land property rights system engages in dividing farm household's contractual and usage rights into non-tradable contractual rights and tradable land usage rights. With this new system, farmers who no longer want to engage in agriculture activities are able to trade their rural usage rights that makes it easy for farmers who want to expand the farmland operations (Li et al., 2018b), the process that is often referred 'rural land transfer' (RLT). The central government has since formulated policies to encourage RLT. Data from the Ministry of Agriculture and Rural Affairs indicate farmlands transfer has reached 67.8 million thus 29.5 per cent of total household farmers. In terms of land area, the data shows that 470 million mu (Chinese unit for measurement of land) have been transferred representing 35.15 per cent of contracted land in China. Despite the central government's commitment to the promotion of RLT, reports show that the percentage of rural farmland transfer as against total land area has not seen an increase.

It against this backdrop that the study seeks to look at factors that influence farmland transfer by considering all the dimensions of farmland transfer options available to household decision maker thus, lease-out, lease-in and no lease (those who neither engages in lease-out nor lease-in i.e autarky). This study presents a more holistic approach by considering all dimensions of farmland transfer decisions opened to a household and their influencing factors. Several studies have looked at farmland transfer in China but the approaches adopted are not holistic enough for proper understanding of factors that influence farmlands transfer, as they only considered either lease-out or lease-in. Several Studies including those by Udimal et al. (2020) and Yan et al. (2016) looked at factors that influence lease-out behaviour without considering of various dimensions of farmland transfer.

While land transfer is usually put in the context of leasing-out, there are those households who engage lease-in and those who neither engages in lease-in nor in

lease-out (autarky). It is argued in this study that lease-in, lease-out and no lease decisions by households are influenced by different factors. This study focuses on the factors that lead a typical household to opt for either option. Many studies have been conducted and have looked at the factors that lead to land transfer in different provinces of China (Yan et al., 2016). While many researches have been done on this issue, no study has looked at the three options available to a household in farmlands' transfers; lease-in, lease-out and neither lease-out nor lease-in (autarky) a single study.

Data and Methodology

Data

The data were collected through a field survey using questionnaires in selected rural areas across Yunnan province, China. Yunnan province is one of the lagging provinces in China, especially in rural areas where there are little opportunities for active population. Based on peculiar nature of the province, it is therefore assumed households would react differently to farmland's transfer policy; thus, to engage-in, rent-out, rent-in or neither rent-out nor rent-in (autarky) based on their prevailing circumstances. The rural communities were purposively selected for their inclusion in the study based on the availability of agricultural land after which random sampling technique was used to select households for interview. In total, 55 enumerators were engaged in the data collection. In total, 6,007 households were randomly selected for the study. Three types of households were interviewed. They include those who engage lease-out, lease-in or no lease (autarky). Each group was randomly selected with the help of land transfer secretariat in the respective communities. Data collection took place between July and September 2020. The questionnaire was originally designed in English and translated into Chinese to facilitate data gathering, and later translated back into English after data collection was completed.

Estimation Method

Conceptual Framework

This study models farmland transfer options based on the theory of expected utility (Coble et al., 2000; Ke & Wang, 2002; Sherrick et al., 2004). The expected utility theory is based on the assumption that economic agents take into consideration the risk associated with various options available to them and their specific environment risk. That is, the decision to opt for lease-in, lease-out or no lease (autarky) is based on the expected utility of each option.

The three modes of farmland transfers are set of options that are available to each economic agent (household). Each option has a possibility of been adopted

by the economic agents. However, an economic agent would opt for an option that gives maximum expected utility. The economic agent takes a decision of whether to or not to opt for any and some are not mutually exclusive all of the farmland transfer options, *j*, available (j = 0,1, … , s). A household assesses each *j* farmland transfer option by looking at the return distribution of each option. Expected utility conditional of the adoption of a particular farmland transfer option is denoted by $U(T_i, Z)$ where T_i ; represents i^{th} farmland transfer option and z is a vector of individual and economic conditions surrounding the household. Implicit attributes of profit, cost and risk are in the function $U(T_i, Z)$. An individual household problem concerning farmland transfer is then stated as follows:

Choose $T_i : T_i = \arg\max[U(T, z)]$,

$$i = 0,1,\ldots,s. \tag{1}$$

Modelling farmland transfer decisions would offer a better understanding of the interdependencies among various options. A number of models are available for studying decision-making such as this but in this study multinomial probit model, which is an extension of the standard probit model will be adopted. Multinomial probit regression model is one of the appropriate models for dealing with multivariate decision making (Dorfman, 1996; Feder et al., 1985).

The standard probit model takes a single decision-making option with a response variable, which is binary and assumes only two possible outcomes thus 1 and 0. The model takes two equations representation, first, a latent variable (which is unobserved) and described by a set of independent variables and a distributed stochastic error term:

$$U = z\beta + \varepsilon \tag{2}$$

Where U denotes the latent variable, z is a vector of the independent variables, which influences the latent variable through the vector of the coefficient β and ε is the stochastic error term. The second equation deals with the observable choice of the decision maker,

$$y = 1, \text{ if } U > 0; y = 0, \text{ for otherwise, } U \text{ is the expected utility.} \tag{3}$$

The multinomial probit model generalises probit model. The stochastic error term is assumed to follow a multivariate normal distribution and correlated across choices. The model extends Eq. (1) into a system of equations and with a latent dependent variable. Consider a set of J unoredered alternatives available to the decision makers that are modeled by regression case specific and alternative specific covariates. The underlying model is the J latent variables as stated by Powers and Xie (2000):

$$U_{ij} = \beta x_{ij} + \alpha_j x_i + \varepsilon_{ij}, \tag{4}$$

where *i* denotes (*i*th household member) and *j* denotes various options of farmland transfer options opened to the household. In addition, x_{ij} is a $1 \times p$ vector of alternative-specific variables, β is a $ap \times 1$ vector of the parameters, z_i denotes a 1

× q vector of case-specific variables, a_j denotes a $q \times 1$ vector of parameters for jth option/alternative and $\varepsilon_i = (\varepsilon_{i1}, \ldots, \varepsilon_{ij})$ is the distributed multivariate normal with a mean of zero and covariance matrix Ω. Jointly distributed multivariate normal random variables is the assumption made concerning the stochastic error term. The unknown parameters captured in the Eq. (4) are estimated through maximum likelihood procedure. An economic agent selects an alternative or option, which he/she derives maximum expected utility:

$$y_i = 1, \text{ if } U_i = \max\left[U_j, j = 0,1,\ldots,s\right]; y_i = 0, \text{ otherwise} \tag{5}$$

The general expression for the probability of choosing an alternative 'i' (i = 1, 2, .., J) from a set of J alternatives is:

$$P_{ij} = prob\left[U_{ij} > U_{ik} \text{ for all } j \neq k\right] \tag{6}$$

The multinomial probit model allows the analysis of decision making across alternatives of more than two, and the determination of the probability of selecting each available alternative (Greene, 2003; Wooldridge, 2002). The multinomial probit model relaxes the assumption of the independence of irrelevant alternative imposed in the multinomial logit model and conditional logistic models as it allows for the general covariance structure of the stochastic error terms (Dow & Endersby, 2004). The multinomial probit model allows the probability of selecting one option/alternative over other alternative to depend on the remaining alternatives/options. The multinomial probit model has been applied extensively in the studies involving choices (Abay et al., 2016; Dorfman, 1996; Tsinigo & Behrman, 2017; Velandia et al., 2009).

The current study seeks to understand factors that influence household's decision to opt for any of the available options; lease-out, lease-in or no lease (autarky) by applying multinomial probit model.

Specification of the MNL Model

In the MNL model, the decision to lease-in, lease-out or no lease is treated as a discrete choice with the decision in qualitative form. It is assumed that the decision to opt for either option is influenced by many factors, which range from economic to non-economic.

The MNL model is therefore specified as follows:

$$\begin{aligned} Y_{ij} = {} & \beta_0 + \beta_1 \text{ Age}_1 + \beta_2 \text{ Age2}_2 + \beta_3 \text{ Edu}_3 + \beta_4 \text{ Income}_4 + \beta_5 \text{ Health}_5 + \\ & \beta_6 \text{ Price}_6 + \beta_7 \text{ Landsize}_7 + \beta_8 \text{ Comp}_8 + \beta_9 \text{ Cert}_9 + \beta_{10} \text{ Exper}_{10} + \\ & \beta_{11} \text{ Kpolicy}_{11} + \beta_{12} \text{ Spolicy}_{12} + \beta_{13} \text{ Satisfaction}_{13} + \beta_{14} \text{ Insurance}_{14} + \varepsilon_i. \end{aligned} \tag{7}$$

The choice of the explanatory variables was purely based on prior empirical studies, economic theories and factors related to land certification policy roll out by the central government (Udimal et al., 2020; Yan et al., 2016). Table 1 presents variables description and their respective modes of measurement.

Table 1. Variable Description and Mode of Measurement

Variables	
Transfer	0 for Lease-out; 1 for lease-in; 2 for neither lease-in nor lease-out
Age	Number of years
Gender	1 for male, 0 for otherwise
Education	Years of schooling
Health status	1 for being in good health; 0 for otherwise
Income	Net household annual income (RMB)
Price	Price of farmland per mu
Land size	Number of mu
Compensation	Amount received in compensation for insurance cover (RMB)
Certification	1 if household has received farmland certification; 0 for otherwise
Experience	Number of years being engaged in farming
K-land policy	1 if household head has knowledge of land tenure policy; 0 for otherwise
S-land policy	1 if household head supports land tenure policy; 0 for otherwise
Satisfaction	1 if household is satisfied with land tenure policy; 0 for otherwise
Crop insurance	1 if production is covered by insurance in case of disaster; 0 for otherwise

Note: 1USD = 6.425CNY, 1mu = 0.066 hectare.

Results and Discussion

Table 2 presents the results on the descriptive statistics. The results show that 4,532 of the respondents representing 75.5 per cent of the study sample have no crop insurance, while 1,474 represent 24.5 per cent indicated that they have crop insurance. On the farmland transfer, the result shows that 943 of the respondents are engaged in lease-out, 1,576 engaged in lease-in and 3,486 engaged in neither lease-our nor lease-in (autarky), representing 15.7 per cent, 26.2 per cent and 58.1 per cent, respectively. The results further show that 4,008 of the respondents representing 66.7 per cent had received farmland certification while 1,998 of the respondents representing 33.3 per cent indicated otherwise.

Table 3 shows the descriptive statistics on age, household net income, rent per mu, crop insurance compensation and educational level. The mean age for the sample is 50 years. The average household annual income is about 15,302 RMB. The results show that the average cost of farmland per mu is about 582 RMB. Compensation for crop insurance in case of disaster averaged about 993 RMB. The average years of schooling is about two years.

Table 4 above provides estimates on the MNL model. Households who have neither engaged in lease-out nor lease-in (autarky) are treated as reference category (base group). The Wald chi^2 of 60.91 with a p-value of .0007 tells us that our model as a whole fit significantly than an empty model (i.e., a model with no predictors). The results show that crop insurance has a positive significant effect on lease-in behaviour relative to the reference group. This is statistically different from zero at ($p < .0000$). This means having a crop insurance boost household's

Table 2. Descriptive Statistics of Variables

Variables	Frequency	Percentage
Crop insurance	4,532 (no)	75.5%
	1,474 (yes)	24.5%
Transfer	943 lease-out	15.7%
	1,576 lease-in	26.2%
	3,486 no lease	58.1%
Certification	4,008 received certification	66.7%
	1,998 otherwise	33.3%
Gender	4,739 male	78.9%
	1,267 otherwise	21.1%
K-land policy	444 have adequate knowledge	7.4%
	5,562 otherwise	92.6%
S-land policy	2,970 supports land tenure policy	49.5%
	3,036 otherwise	50.5%
Health status	3,805 in good health	63.4%
	2,201 otherwise	36.6%
Satisfied with land tenure policy	2,085 satisfied	34.7%
	3,921 otherwise	65.3%

Source: Authors' own calculations.

Table 3. Descriptive Statistics of Other Variables

	Age (Years)	HH-Income (RMB)	Rent Per Mu (RMB)	Compensation (RMB)	Education Level
Mean	50.8828	15302.5458	582.8837	993.36	2.1304
Std Deviation	9.04447	11039.57054	222.78786	18716.983	1.13288
Minimum	31.00	1000.10	50.00	0	1.00
Maximum	99.00	87210.00	990.00	1,000,000	4.00

Source: The authors.

Table 4. Estimates of MNL Model

	Coef.	Std Error	Z-Stats	Coef.	Std Error	Z-Stats
Land Transfer Choice	Lease-In			Lease-Out		
Age	–0.004	0.011	–0.38	0.008	0.010	0.83
Age^2	–0.002	0.001	–1.37	–0.076***	0.026	–2.91
Gender	0.034	0.077	0.44	0.036	0.069	0.52
Education	–0.076**	0.035	–2.19	0.045**	0.022	2.05
Health	0.120***	0.043	2.79	0.041	0.056	0.74
Income	0.056**	0.024	–2.35	–0.026***	0.009	–2.91
Price	–0.064	0.054	–1.17	0.008**	0.004	2.32

(Table 4 continued)

(Table 4 continued)

	Coef.	Std Error	Z-Stats	Coef.	Std Error	Z-Stats
Land Transfer Choice		Lease-In			Lease-Out	
Land size	–0.003***	0.001	–3.02	0.005**	0.002	2.30
Compensation	0.016***	0.005	2.98	0.077	0.054	1.43
Certification	0.064***	0.024	2.62	0.073**	0.036	2.02
Experience	–0.011	0.021	–0.50	0.007	0.019	0.37
K-land policy	0.408***	0.106	3.85	0.369***	0.101	3.65
S-land policy	0.097	0.066	1.47	–0.054	0.059	–0.91
Satisfaction	–0.062	0.070	–0.89	0.087	0.063	1.38
Insurance	0.114***	0.036	3.18	–0.027***	0.011	–2.52
Constant	–0.840***	0.305	–2.75	–0.865***	0.278	–3.11
Log likelihood: –5467.1654						
Number of obs.: 5,750						
Wald chi^2 (30): 60.91						
Prob > chi^2 : 0.0007						

Source: Authors' own calculation.

Note: Base category is the group that has neither engaged farmland lease-in nor lease-out. 1%, 5% are at ***, **, respectively.

interest in acquiring more lands to increase production or households with better access to crop insurance are generally interested in land lease-in, so they can reverse causality. The results, however, show that crop insurance has a negative association with the lease-out behaviour in relative to the reference category. Households who have crop insurance covering their production are less likely to lease-out their farmlands. This is statistically different from zero at ($p < .0000$). The findings support the studies by (Boyd et al., 2011; Fahad et al., 2018; Falco et al., 2014; Goodwin & Smith, 2003), which concluded that crop insurance is an adaptation tool for dealing with the economic losses in the agricultural sector and therefore guarantees farmers of their investment and therefore motivates them to invest. The study further corroborates the research by (Fu et al., 2016), which concluded that crop insurance increases the demand farmlands rentals.

On farmland certification, the results show that land titling (certification) has a positive association with the lease-in. This implies that prospective investors are more likely to engage in lease-in behaviour when they know that lands titling (certification) has been acquired by a household. Prospective investors are likely to lease-in more farmlands in addition to what they may already have when the household receives titling rights. This is statistically different from zero at ($p < .0000$). Land titling (certification) guarantees investors in the commitment of their resources as there is legal prove of the ownership. The results further show that land certification (titling) has a positive significant impact on household's lease-out behaviour. Households who have received farmland certification are more likely to engage in lease-out relative to farming on their own. This finding refutes researches by Besley (1995), Besley & Ghatak (2010), De Soto (2000), Goldstein

& Udry (2008) and Joireman (2008), which indicated that farmlands certification has positive impact on investment by households through easy access to credit as the lands can serve as collateral. The results corroborate the research by Holden et al. (2009), McArthur (2016) and Qin et al. (2020), which suggested that farmlands certification increases rental scale of farmlands.

Concerning the understanding of land tenure policy, the results show that individuals who have proper understanding are most likely to engage in lease-in behaviour relative to the base category. This is statistically different from zero at ($p < .0000$). The understanding prospective investors have in the country's land tenure policy has positive influence on the decision to engage in lease-in behaviour.

The results show that land size has a negative significant influence on the lease-in behaviour. As land size increases, the person is less likely to acquire additional plots of farmland relative to the base category. This is statistically different from zero at ($p < .000$). Land size, however, has a positive significant association with lease-out (rent-out) behaviour relative to the base category. Individuals who own more farmlands are most likely to engage in lease-out instead of keeping it. This implies that farmland transfer-out behaviour is a function of land size. The results corroborate the study by Zou et al. (2018), which indicated that households who own more lands are more likely to engage in lease-out. The results further show that price of farmland per mu have a positive association with the lease-out behaviour. As farmland price increases, households would be willing to lease-out relative to the base category. This is statistically significant at 5 per cent.

On household annual net income, the results show that income increase has a positive association with lease-in behaviour compared to the base category. As household's income increases, they turn to acquire more farmlands for investment. This is statistically significant at 5 per cent. The results, however, show that households' income increase has a negative association with the lease-out behaviour relative to the base category and it is significant at 5 per cent. This finding corroborates the study by Qin et al. (2020), which found a positive relationship between income and farmland investment. As households' income increase, they turn to invest more by acquiring more farmlands instead of just holding on to household's farmlands. The study further supports the finding by Zou et al. (2018), which revealed that rich rural households have higher propensity of acquiring more farmlands for investment and do not leave farmlands idle.

For the education, the results show a negative significant association with the lease-in behaviour relative to the base category. This implies that people who are more educated have a high tendency of migrating to the cities to seek for jobs hence less desire to acquire farmlands. The result, however, shows that households who are more educated are most likely to engage in lease-out behaviour relative to the base category. This can also be attributed to secure job opportunities (off-farm), which people who are more educated turn to get hence the tendency to lease-out their farmlands. This finding refutes earlier findings by (Udimal et al., 2020; Zou et al., 2018), which indicated that education has a negative association with the farmland transfer-out decision. This finding can partly be attributed to the high chances of people who are educated to engage in off-farm activities and

also migrate to the urban cities to seek employment compared to those who are least educated.

The results further show that age has a non-linear relationship with farmland transfer behaviour. The results show that age-square has a negative association with the lease-out behaviour in relative to the base category. This is statistically significant at 1 per cent. Households who have advanced in age turn to keep their farmlands against lease-out. This can be attributed to their desire to protect family assets and to pass it peacefully to the next of kin. This results support a study by Udimal et al. (2020), which found that a non-linear relationship between farmland transfer and age. The results, however, refute the study by Zou et al. (2018), which found that households heads who have advanced in age decreases the likelihood to engage in farmland lease-out.

Table 5 provides estimates on the marginal effects of MNL model. The result shows that crop insurance increases lease-in and decreases lease-out behaviour by 5 per cent and 2 per cent, respectively. Households who have crop insurance against disasters turn to acquire more farmlands to boost their production. For lease-out, having crop insurance discourages lease-out behaviour. These are statistically significant at 1 per cent and 5 per cent for lease-in and lease-out, respectively. The results show that having knowledge about land tenure policy increases the likelihood of engaging in lease-in and lease-out behaviours by 6 per

Table 5. Marginal Effects of MNL Model

Land Transfer Choice	dy/dx	Std Error	Z-Stats	dy/dx	Std Error	Z-Stats
	Lease-In			Lease-Out		
Age	0.002	0.002	1.01	0.001	0.002	0.70
Age^2	–0.010	0.011	–0.88	–0.016***	0.006	–2.63
Gender	0.007	0.016	0.42	0.034	0.013	0.29
Education	–0.062***	0.023	–2.70	0.048**	0.020	–2.42
Health	0.065***	0.023	2.80	0.019	0.011	1.80
Income	0.060**	0.024	–2.49	–0.007***	0.002	2.92
Price per mu	–0.082	0.073	–1.12	0.083***	0.030	–2.77
Land size	–0.053**	0.024	–2.19	0.064**	0.032	–2.00
Compensation	0.012***	0.005	2.71	0.006	0.007	0.90
Certification	0.064***	0.022	2.94	0.069**	0.034	2.00
Experience	–0.002	0.004	–0.53	0.002	0.004	0.66
K-land policy	0.061***	0.024	2.60	0.071**	0.022	3.23
S-land policy	–0.020	0.014	–1.44	0.021	0.011	1.90
Satisfaction	0.026	0.015	1.76	–0.017	0.012	–1.44
Insurance	0.054***	0.014	3.96	–0.023**	0.012	–2.00

Source: Authors' own calculation.

Note: 1%, 5% are at ***, **, respectively.

cent and 7 per cent, respectively. These are statistically significant at 1 per cent and 5 per cent, respectively.

The result further reveals that farmland certification (land titling) has positive impact on both lease-in and lease-out behaviour. Farmland certification increases lease-in and lease-out behaviour by 6 per cent and 7 per cent, respectively. These are statistically significant at 1 per cent and 5 per cent respectively. On the compensation, the results show that an increase in amount received as compensation during disasters has a positive impact on lease-in behaviour.

The results show that farmland size has negative and positive significant influence on lease-in and lease-out behaviours, respectively. An increase in farmland size decreases lease-in behaviour by 5 per cent but it increases lease-out behaviour by 6 per cent. These are statistically significant at 5 per cent. For the price per mu, the results show that an increase in the price of farmland per mu increases lease-out behaviour by 8 per cent and it is statistically significant at 1 per cent. As price per mu increases, many households will be influenced positively to lease-out their farmlands as against keeping it and farming on their own.

Concerning household net annual income, the results show that an increase in net annual income leads to an increase lease-in behaviour by 6 per cent. It, however, leads to a decrease in lease-out behaviour by 0.7 per cent. These are statistically significant at 5 per cent and 1 per cent, respectively. For health status of the household head, the result shows that being healthy increases the chances of engaging in lease-in behaviour by 7 per cent and it is statistically different from zero at ($p < .0000$). The study further reveals that an increase in the years of schooling has a negative and positive impact on lease-in and lease-out behaviours at 6 per cent and 5 per cent, respectively. These are statistically significant at 1 per cent and 5 per cent, respectively. For age-square of the household head, the result shows that it decreases the lease-out behaviour by 2 per cent and it is statistically different from zero at ($p < .0000$).

Conclusion and Policy Recommendation

Rural farmland transfer has becoming one of the topical issues in public debate and has since gain the attention of researchers within and outside China. With limited farmlands, farmland transfer is seen as means to inject efficiency into agricultural production through the mechanisation of the sector by improving scale levels. Though a laudable policy, it is not without challenges as affects different stakeholders differently. The study brings to light various dimensions of farmland transfer by considering factors that influence choice of each dimension. These dimensions include those who engage in lease-in, those who engage in lease-out and those who engage in neither lease-in nor lease-out (autarky).

The results show that farmland certification has positive impact on both lease-our and lease-in decision of households. This implies that farmland certification reduces uncertainties surrounding farmland transactions. For smooth transfer of farmlands; lease-in and lease-out, there is the need to encourage households to

receive certificates for their farmlands to guarantee their ownership and promote investments in farmlands. The results further show that having crop insurance influences household's decision positively as they turn to engage in lease-in behaviour. This suggest that the availability of crop insurance will encourage people to invest more in farmlands as they are sure of insurance cover for any losses that might occur when disaster strikes. Having crop insurance boost farmer's confidence in acquiring more farmlands, thus engage in lease-in as against lease-out. The presence of crop insurance would encourage people to acquire more farmlands as they are certain that when disaster strikes their investment would not go waste due to insurance cover. This implies that farmland lease-in is a function of crop insurance.

The study shows that land size has a negative and positive impact on lease-in and lease-out, respectively, compared to the base category. This implies that farmland transfer decision, thus lease-out is a function of land size and any policy to encourage lease-out should take land size into consideration. Households who have large land size are willing to engage in lease-out. Large land size creates incentive for landowners to engage in lease-out, but that is not the case for lease-in. Farmland size influences lease-in and lease-out decision differently. In addition, price of land (per mu) has a positive influence on lease-out decision compared to the base category. As price for farmland increases, it creates incentives for households to engage in lease-out. However, if the price per mu increases, it decreases the desire to lease-in more farmland. Farmland price increase is an incentive for lease-out, but disincentive for those who want to engage in lease-in as it increases investment costs.

Increase in years of schooling shows a negative and positive impact on the lease-in and lease-out decision relative to the reference category, respectively. There are more opportunities for people who have spent many years schooling compared with those who have spent less years on schooling. Availability of opportunities for households who have spent many years schooling makes them feel safe to engage in lease-out against lease-in since they are capable of engaging in off-farm income activities. An increase in households' net income has a positive and negative impact of lease-in and lease-out decision relative to the reference category, respectively. This implies that as household income increases there is a likelihood of engaging in lease-in against lease-out to increase their farmland holdings for more investments. Having adequate knowledge about the land tenure policy positively influence both lease-in and lease-out decision making of households. This means with a proper education of the essence of the land transfer policy, there is likelihood of households to engage in both lease-in and lease-out.

Based on these findings, we, therefore recommend the following for policy consideration:

1. We propose for the setting up of price floor and price ceiling per mu of land to promote transparency in farmland transfer as influences household's farmland transfer decision;
2. We propose that crop insurance be made available and accessible to farmers to enable them subscribe to it since it influences farmland transfer decision;

3. Farmland certification process should be made easier and clearer to encourage landowners to register their farmlands and obtain certificates to enable households engage effectively in both lease-in and lease-out decisions;
4. Education in the form of making households understand land tenure policy should be encouraged at all levels as it emerges that people who have spent more years schooling and those who have knowledge of land tenure policy are influenced differently relative to the those with less education and lack understanding of land tenure policy.

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Article

Measuring Technical Efficiency of the Smallholder Crop Farms Using Stochastic Production Frontier Approach

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Abstract

Agricultural productivity in Africa is the lowest in the world with many households not being able to feed themselves. In Africa, women play a major role in agriculture sector constituting about 70–80 per cent of the labour force there. Regrettably, their farm productivity is relatively low mainly due to their inefficient use of farm inputs, which has a serious implication for their socio-economic condition as well as health and nutrition status. With this backdrop in mind, the study investigated the technical efficiency (TE) of the female crop farmers in Niger Delta, Nigeria. Stochastic production frontier approach and ANOVA models were applied to analyse the primary data collected on the 216 female farmers randomly selected from 18 communities of the 3 states in the Delta. It has been found that the farm size and the quantity of labour positively influence TE of these farmers. However, farmer's age shows a negative sign implying a decrease in technical inefficiency in age whereas the years of schooling shows a positive sign implying an increase in inefficiency with schooling thereby a resulting decrease in TE with schooling. Farm efficiency level in Delta and Akwa Ibom States was not significantly different. However, TE level in both Delta and Akwa Ibom States was significantly different from Rivers State. Since, the age of farmers showed positive influence on TE, farmers should form group and organise regular meetings to enable share knowledge and experiences on the efficient use of farm resources in the Niger Delta Region, Nigeria.

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Keywords

Female farmers, smallholders farms, technical efficiency, stochastic production frontier approach, Niger Delta Nigeria

Introduction

Agriculture is a major source of livelihood for people living in the developing world providing employment for 5.5 billion (Mehta et al., 2010). In the context of Asia and sub-Saharan Africa, smallholder farmers provide about 80 per cent of the food supplied there. In Africa, women make up 70–80 per cent of the labour force in the agricultural sector and produce about 80 per cent of the staple crops mostly used for household consumption (Gordon & Gordon, 2007). Women are key players of food production in most developing countries accounting for 43 per cent of the agricultural labour force there whereas the corresponding figure is 50 per cent for eastern and south-eastern Asia and sub-Saharan Africa (FAO, 2011). In a study conducted by Palacios-Lopez et al. (2017), it has been stated that the contribution of women to labour in African agriculture is in the range of 60–80 per cent. They estimated that the average female labour share in crop production is around 40 per cent.

Despite the substantial contribution of women in the labour force for food production, their performance is still low in terms of productivity. This has been attributed to their poor access to resources such as finance, skills training and information services (FAO, 2011). Farm operations such as sowing, weeding, fertilising and harvesting staple crops such as rice, wheat and maize are mostly carried out by women. Women's contribution to secondary crops, such as legumes and vegetables, is even greater. FAO reports show that women produce most of the food consumed locally in the rural area where majority of the world's hungry people live. Women tend to spend longer hours than men working in farms in developing countries but they lack in access to productive resources, which are responsible for their low farm productivity as believed by many. Contribution made by women in terms of production could be much greater if their access to essential resources and services, such as land, credit and training is improved. According to Anderson et al. (2021), a study on economic benefits of empowering women in agriculture, women have lower access to and control over agricultural inputs than men, contributing to lower agricultural productivity for women. The study argued that if women are given greater access to and control over inputs, their input use would increase leading to improved marginal yield. It is implied that directing new resources to women and/or reallocating resources within the household would increase the overall household productivity. Definitely, eliminating obstacles that hamper women in food production is the key to achieving better farm yields. Improving on women farmers' productivity and efficiency along with their better access to productive resources could help increase their farms yields by 20 per cent–30 per cent (FAO, 2011). This is because women are seen as the quiet drivers of change towards more sustainable production systems and a more varied and healthier diet.

Most of the farm technical efficiency (TE) studies were focused on farm resources and much studies have been conducted on TE of women farmers in relation to access to healthcare services. It has been noted that not many studies have been carried out on farm TE of farms owned by women in the study area (Audu et al., 2020; Egbetokun et al., 2012; Oladeebo, 2012; Simon & Shallone, 2013; Simonyan et al., 2011; Yisa et al., 2020). It is on this backdrop that this study adopted stochastic production frontier approach to estimate women crop farm TE level in Niger Delta Nigeria. Specifically, determinants of TE and inefficiencies of the women were estimated, TE ranges and averages were determined and lastly differences in TE levels were compared in the study area. Therefore, the study investigates and thereby identifies the factors behind the inefficiency of the female smallholder farmers of the Delta and recommends policies in that light.

Literature Review

There is a substantial literature to explain the underperforming agriculture sector in many developing countries. One of which is due to lack of resources and opportunities needed by women to make the most productive use of their time (FAO, 2011). It has been reported that Africa's agricultural productivity is the lowest in the world (Nilsson, 2013). Many are not being able to feed themselves, leaving the people vulnerable to shocks. In addition, domestic food production growth in Africa has remained low, about 2.7 per cent, which is barely above the population growth rate (Nilsson, 2013). Several studies on farm productivity in developing countries were centred on estimating technical efficiencies using direct farm resources like farm land, labour, seeds and other materials used in production. Worthy to note is, despite intervention programmes and actions by the governments aimed at improving farm-level efficiency in developing countries, the overall technical efficiencies of farms are still far away from the best frontier level, that is, 100 per cent.

The study of Ben-Belhassen and Womack (2002) on farm TE in Missouri hog production adopted stochastic production frontier function in determining TE. The study showed a mean farm TE of 82 per cent, implying that a large (18%) proportion of production was lost due to farm-specific inefficiencies. Furthermore, technology and managerial skills were the major determinants of TE (Aminu et al., 2013). It was also reported that a mean TE of dry season vegetable farmers in Ojo Local Government Area (LGA) in Lagos State, Nigeria, was 71.1 per cent, which showed a huge possibility for improvement for farmers. This suggested that an average farmer would need to a 28.9 per cent cost saving in the study area to achieve the best TE level. It was also found that coefficients of both illness episode and number of days absent from farm work showed positive and significant influence on TE of farms. The finding implied that farmers, who suffered prolonged numbers of illness episodes, had long days of absent from farm work, which increased farmers' inefficiency levels.

In the same vein, a study by Kussa (2012) on health and farm productivity finds that inputs such as land, labour, soil fertility and fertiliser significantly increased crop production but illness showed negative correlation and elasticity of 0.53. This is an indication that illness is an important factor that affects farm level production. Still more, households exposed to illness achieved an average TE of 33.5 per cent while households not exposed to illness achieved 48.9 per cent suggesting that health affects agricultural production.

According to Simon and Shallone (2013) report on the impact of farmers' health and nutritional status on agricultural TE in Masvingo rural communities showed that land, labour, fertiliser and seed show positive correlation to farm output. Adverse health, age, household sizes had positive effects on the inefficiency of the farmers. The report also viewed that health problem had direct and indirect cost on the productivity of farmers. The adverse health impacts on production outcomes are its effects on farm labour capacity. The assessment of impact of health on agricultural TE in Nigeria revealed that one per cent improvement in the health condition of farmers would increase efficiency by 21 per cent (Egbetokun et al., 2012).

A study by Yisa et al. (2020) on gender differential TE among cassava farmers argues that women face gender-specific constraints that reduce their productivity and limit their contributions to agricultural production, economic growth and well-being of their families in Nigeria. The study reported that male farmers earn higher gross margin of ₦140978.28 per hectare in cassava production than female farmers that recorded ₦131070.27 per hectare. The study still observes that male farmers were more technically efficient with mean efficiency score of 0.82 compared to 0.78 for female farmers. The authors position that there is a need for an improvement for female small-scale cassava farmers in their efficiency level to increase cassava production. However, Simonyan et al. (2011) observes that the individual TE index was 93 per cent for male and 98 per cent for female which implied that the average female farmer is technically more efficient than her male counterpart. Yisa et al. (2020) observe that factors which affected the TE of male farmers were farm size, educational level, extension contact, credit amount while that of the female farmers were age, farm size, cooperative membership, land ownership and off-farm income.

In a similar study conducted by Oladeebo (2012), it has been reported that both poor male and female household heads were not fully technically efficient in the use of productive resources. However, it has been observed that poor male-headed households were more technically efficient than their female-headed counterparts (with mean TE estimates of about 91% and 82%, respectively). Mean TE of women cassava farmers in Ankpa LGA, Kogi State, Nigeria was 76 per cent with a maximum of 98 per cent TE (Audu et al., 2020). Yisa et al. (2020) views that current situation of women farmers in terms of access to farm productive resources needs to be considered comprehensively in the formulation and implementation of policies that would improve farm productivity.

Obviously, most of the studies reviewed above are focused on farm resources and much studies have been conducted on TE of women farmers in relation to access to healthcare services. Not many studies have been carried out on farm TE

of farms owned by women in the study area and thus the topic of the current study is necessary to be explored.

Data and Methodology

Study Area and Sampling

This study was carried out in the Niger Delta, Nigeria. The region is situated in the southern part of Nigeria and bordered to the south by the Atlantic Ocean and to the East by Cameroon; it occupies a surface area of about 112,110 km^2 (Adeyemi, 2015). It represents about 12 per cent of Nigeria's total surface area and it is estimated that by the beginning of 2006 its population will be over 28 million inhabitants. The region has huge oil reserves and ranks sixth exporter of crude oil and third as the world's largest producer of palm oil after Malaysia and Indonesia. The states in the Niger Delta are Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Ondo, Imo, Rivers States, with an area of 112,000 km^2, a population of 27 million people, 185 LGA's, about 13,329 settlements (Adeyemi, 2015). Further, the delta region leads in the production of timber, pineapple and fish, also; cocoa, cashew, cassava, rice, yam, plantain, banana and oranges are produced in large quantities in the area and vegetables such fluted pumpkin, cucumber, pepper and food spices are produced in the area. Also, farming and fishing are the major occupation of the people (Omofonmwan & Odia, 2009).

A multi-stage sampling procedure was adopted in the selection of three states in Niger Delta, Nigeria. Two LGAs were chosen from Akwa Ibom, Delta and Rivers state each giving a total of six (6) LGAs. Three (3) communities were

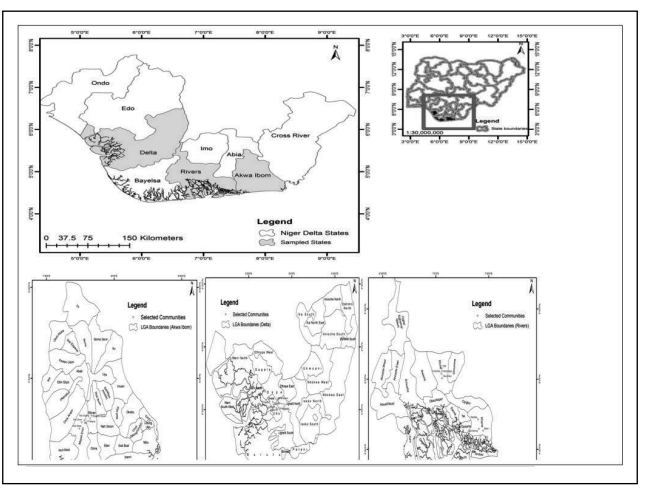

Figure 1. Map of Niger Delta Region Showing Study Locations

Source: The authors.

selected from each LGA constituting 18 communities and lastly 12 women farmers were randomly selected from each community making 216 farmers. The study involved the use of both primary and secondary sources of data collection. Primary data were generated using questionnaire and interview schedule while the secondary data was utilised from the existing literature. The interview schedule consists of semi-structured questions. Questions were centred on the socio-economic, demographic and institutional characteristics of households, quantity of inputs used in production alongside quantity of output generated during the period in view. The questionnaire was pretested using pilot survey to ascertain the reliability of the instrument.

Estimation Method

Descriptive statistics such as mean and percentages, stochastic production frontier function model and ANOVA were the analytical tools for the data analysis. The stochastic production frontier function model is an analytical technique used in the determination of TE and inefficiency of farmers' productivity at the same time. It is important to recall that studies in the past adopted two major methods in evaluating the TE: (1) a parametric approach and (2) a non-parametric approach. The parametric approach enables the use of econometric techniques, but the non-parametric approach is based entirely on mathematical techniques data envelopment analysis (DEA).

The econometric technique is stochastic in approach, which has the ability of splitting the impact of random error from the inefficiency effect. The econometric technique is parametric and is capable of controlling the impact of misspecification of practical form through inefficiency. Literature reveals that the econometric technique was used commonly to assess the TE of firms as revealed in the study carried out by (Gbigbi, 2011; Hassan & Ahmad, 2005; Tchale, 2009). The non-parametric technique is non-parametric and is assumed not so liable to the described error. It was also argued that non-parametric technique combines the two errors and, hence, is known as combination inefficiency.

The stochastic production frontier function model is an analytical technique used to determine TE and inefficiency of farmers' productivity at the same time. Stochastic production frontier approach was developed by Aigner et al. (1977). A study carried out by Mango et al. (2015) argued that initial studies to measure TE for a cross-section of producers used deterministic frontier approach, which assumes that any deviations from the frontier are due to inefficiency. They explained that the outcome was the difference between potential and observed yield for a given level of technology and inputs. The result of such method implied that any farmer producing below the frontier was assumed to be inefficient. It was reported by Chaudhuri (2016) that Aigner et al. (1977) independently developed the stochastic frontier approach to address some of the limitations in the deterministic frontier approach. However, it was argued that setback in the deterministic frontier model was that it ignored factors beyond the control of the farmers which could influence efficiency. Hence, the deterministic

approach was assumed to be sensitive to the selection of variables and errors in data generation.

Therefore, stochastic frontier model separates technical inefficiency (TI) from noise by incorporating two error terms. In the new approach, the error term consists of two components, one is random and the other being a one-sided residual term representing inefficiency. The first error component, also called a statistical noise account for random effects. The second component represents the systematic effects which are not explained by the production function but are attributed to TI, that is, reflecting measurement error or shocks beyond the control of the farmer. Maximum likelihood analytical procedure was utilised in the analysis.

Stochastic Frontier Analysis

Stochastic frontier analysis (SFA) is also known as a composed error model. The stochastic production frontier equation is stated as follows:

$$Y_i = f\left(X_i\beta_i\right)(i = 1, 2\ldots, n) \tag{1}$$

$$Y_i = \beta_i X_i + e_i\left(v_i - u_i\right)(i = 1, 2\ldots, n). \tag{2}$$

In this model, the dependent variable (Y_i) is the farmers' farm yield or output measured in kg while independent variables include (X_s) farm size in hectares, seeds or cutting (planting materials) in kg, quantity of farm labour in man-days. A unique feature of this model is the presence of collected unsystematic errors terms ($ui - vi$). The *ui* is the random error term, which takes care of error in measurement, while '*vi* ' is symmetric ($-\infty < vi < \infty$) and shows those random errors which are out of farmers control, but which affects or contributes to firm inefficiency level. The analytical tool is used to indicate farms operating at the best frontier region and the ones that are far away from the best frontier region of production.

It is expected that v_i is identically and independently distributed as $N(0, \sigma^2 v)$ (Gujarati, 2003). Farm specific technical inefficiency is denoted by μ_i. On the other hand, it shows the gap of output (Y_i) and its maximum possible output assumed by the SFA [$f(Xij, \beta) + v_i$] (Aigner et al., 1977). u_i arises from $N(0, \sigma^2 u)$ and is half normally distributed below (0). The terms v_i and μ_i are always independent for the input factors X_i.

Stochastic Frontier Model Specification

The SFA model was used to estimate the TE of crop production. This technique specifies the effect of TI that cannot be controlled by crop farmers. The Cobb–Douglas Production function is suitable for estimating TE in the study, because it is easy for interpretation and estimation. In addition, the elastic functional form addresses the difficulty of multi-collinearity. SFA equation is expressed as follows:

$$InY_i \sum_{i=0}^{n} \beta_i InX_i + e_i\left(v_i - u_i\right), \tag{3}$$

where Y_i, yield of crops in kilograms per hectares; X_1, farm land used for crop in acres; X_2, number of labour in man hours; X_3, stem cuttings/seed in kg; e_i, error (composed error term); ln, natural logarithm; β_i, the parameters.

Expanding Eq. (3), we have thus

$$\ln Y = \beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + e\left(U_{ij} - V_{ij}\right) \tag{4}$$

where β_0 = constant, $\beta_1 - \beta_3$ = estimated parameters, Y = yield/kg, X_1 = farm size in hectare,

X_2 = quantity of labour used in mandays,

X_3 = stem cutting/seeds in kg, $U_{ij} - V_{ij}$ = a composed error term,

V_{ij} = random error due to stochastic noise, U_{ij} = randomness (technical inefficiency)

Estimation of the Stochastic Frontier Model

The maximum likelihood estimation (MLE) technique was employed in the estimation of the SFA (Greene, 1980). The basic idea of the maximum likelihood principle is to choose the parameter estimates (β, $\sigma^2 e$) to maximise the probability of obtaining the data; thus,

$$InL = n/2In[\pi/2] - n/2In\sigma^2 + \sum_{i=1}^{n} In\left[1 - F\left(\varepsilon_{\mathrm{i}\sqrt{Y/\sigma}}\sqrt{1-Y_j}\right.\right.$$

$$1/2\sigma^2 \sum_{\mathrm{i}=\mp 1}^{n} \varepsilon_{\mathrm{i}}^2 \tag{5}$$

$$e_{i=Y_i -} X_i \beta_v, \tag{6}$$

where $\sigma^2 v$ and $\sigma^2 u$ are the variances in the equation for v and u, respectively; further, $\sigma^2\varepsilon = \sigma^2 v + \sigma^2 u$ and $\gamma = \sigma u/\sigma v$. The MLEs of β, γ and $\sigma^2\varepsilon$ at which the value of the likelihood function is the maximum were obtained by setting the first order partial derivatives with respect to β, γ and $\sigma^2\varepsilon$ as equal to zero and solving these non-linear equations simultaneously. It can be estimated by using a non-linear optimisation algorithm to find the optimal values of the parameters.

Specification of Technical Efficiency

In the model specification of TE estimation, it is expected that random v_i is normally distributed as $N(0, \sigma^2 v)$, whereas μ_i is half normally distributed as $N(0, \sigma^2 u)$:

$$\mu_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i}, \tag{7}$$

where μ_i denotes the specific technical inefficiency of crop yield; δ_0 is the constant, δ_1–δ_3 are the estimated parameters; Z_{1i} to Z_{3i} are the inefficient variable factors. Z_1 age of farmer (years); Z_2, education level of farmers (number of years spent schooling); Z_3, travel time to healthcare centre.

The following formula was applied to estimate the TE of the farmers:

$$\mathrm{TE}_i = Y_i / Y_i^*, \tag{8}$$

where Y_i, observed yield of ith farmer; Y_i* is the frontier output of ith farmer that is obtained; TE_i, technical efficiency of ith farmer in the range of 0–1. To obtain

the result of technical inefficiency (TI) of individual crop farmers, the formula below was employed.

$$TI_i = 1 - TE_i, \tag{9}$$

where $TI_i = 1 - (Y_i/Y_i^*)$, TI_i, technical inefficiency of ith farmers in the ranges of 0–1.

One-way ANOVA model was used to compare differences in the TE levels among three states in the study area while Scheffe's test of homogeneous subset further identified where differences exist among three states.

Results and Discussion

Table 1 showed MLEs of the parameters of TE of women farm productivity in the Niger Delta Nigeria. The result showed that farm size and number of farm labour used by the farmers showed positive signs at 1 per cent level of significance each. The significant value of labour input and farm size farm resources alongside their positive effects affirmed that these two inputs were the major factors driving the TE of farms in the region. The positive signed variables implied that increasing

Table 1. Result of Technical Efficiency of Women Farmers in the Study Area

Variables		Coefficient	Standard Error	*t*-Ratio
Technical efficiency variables				
Constant/intercept	Beta 0	6.393	0.628	10.174***
Farm size in hectare	Beta 1	0.627	0.106	5.908***
Labour in man-days	Beta 2	0.546	0.144	3.791***
Seeds/cuttings in kg	Beta 3	–7.124	1.440	–1.617 NS
Inefficiency variables				
Intercept	Delta 0	–2.794	1.296	–9.442***
Age of farmers	Delta 1	–8.324	3.639	–2.288 **
Years spent on schooling	Delta 2	0.224	0.123	1.820 *
Travel time to HCS	Delta 3	–0.148	8.768	–1.686 NS
	Sigma-squared	4.420	2.010	2.105 **
	Gamma	0.922	3.971	23.230 ***
Log Likelihood Function =	–236.751			
LR test of the one-sided error	18.251			
No. of restriction =	5			

Source: Researcher field survey data, 2018, using stochastic frontier 4.1C software.

Notes: ***, ** and * is 1%, 5% and 10%, respectively.

the use of those inputs would lead increase farm yield. The positive signs of the variables are in line with a priori expectations which implied that these resources contributed positively to the TE of farms in the region. Their respective elasticity of the farm output was 0.63 per cent and 0.55 per cent, respectively. This means that one unit increase in the size of farm land use and quantity of farm labour use would induce a 63 per cent and 55 per cent increase in farm output and vice versa.

Estimated gamma parameter of the model is 0.92, this implies that about 92 per cent of the total variation in the farm output could be attributed to the differences in technical efficiencies. Mean TE recorded in the region was 0.69 (i.e., 69%). This implied that farmers are still far away from their technological frontier by 31 per cent. Hence, there is a need for farmers in this region to strive harder in order to attain the best frontier of 100 per cent in farm production. Inefficiency result is interpreted differently, the negative sign of a parameter in the inefficiency model shows that the associated variable has positive effect on TE and vice versa (Simon & Shallone, 2013).

Inefficiency result showed that age of the farmers was negatively signed and number of years spent schooling showed positive influence on TI. The variables were significant at 5 per cent and 10 per cent level, respectively. The negative sign of farmer's age implied that as the farmer increases in age, she would gain more experience in farming which could increase farm TE in other words farm inefficiency will be reduced. A positive sign of the level of education means that the variable would likely reduce TE and increase farm inefficiency level. This is likely to happen because higher education level would mean better job options for farmers, which would result to paying less attention to farm business resulting to high TI. Although travel time to healthcare service centre used as a proxy for access to healthcare did not show a significant effect. This contradicts the report of Black et al. (2019) which suggested that health and nutrition of women showed significant impact on agricultural productivity.

Table 2 showed deciles of TE in the study area, it was observed that 33.3 per cent of the farmers recorded technical efficiencies range of 71– 80 per cent with a

Table 2. Efficiency Ranges of Farm Production in Niger Delta Nigeria

Ranges	Frequency	%
11–20	2	0.9
21–30	2	0.9
31–40	5	2.3
41–50	8	3.7
51–60	25	11.6
61–70	59	27.3
71–80	72	33.3
81–90	43	19.9
Total	216	100.0
Mean	68.8	

Source: Researcher field survey data, 2018.

mean efficiency of 68.8 per cent. This implied that 31.2 per cent of production is lost to TI. This supports the findings of Azumah et al. (2019), which shows that the mean TE of irrigation farmers was 68 per cent. Farmers who had TEs range of less than 50 per cent was 7.8 per cent. Those that recorded TEs range between 60 per cent and 70 per cent. Only 19.9 per cent of the farmers had TE range of 80–90 per cent and no farmer achieved 100 per cent TE in farm production during the period. It is implied that women farmers were not technically efficient in their farm business, but were still operating below the frontiers of TE. The result agrees with the findings of Asogwa et al. (2019).

Result in Table 3 showed mean differences between groups and within groups as 3347.243 and 48.960, respectively, in Rivers, Delta and the Akwa Ibom States. The test of significance showed a value of 0.000 at 1 per cent level. This suggests a further enquiry to identify the farm groups that showed significant difference in their farms' TE level.

Result in Table 4 showed multiple comparisons of farms TE of respondents indicated a significant difference in farm TE in Rivers, Akwa Ibom and Delta States at 0.00 per cent significant level. Mean comparison between Delta State and Akwa Ibom States showed no significant difference in TE level in the three states. Scheffe's test of homogeneous subset further identified where differences exist.

Table 3. Comparison of Women Farms Farm Technical Efficiency Level in the Three States

	Sum of Square	Df	Mean Square	*F*	Sig
Between Groups	6694.486	2	3347.243	68.367	0.000
Within Groups	909817.089	18,583	48.960		
Total	916511.576	18,585			

Source: Researcher field survey data, 2018.

Table 4. ANOVA Results Multiple Comparison of Farmers' Technical Efficiency

					95% Confidence Interval	
(I) State	(J) State	Mean Difference (I–J)	Std. Error	Sig.	Lower Bound	Upper Bound
Rivers	Delta	1.362*	0.161	0.000	0.967	1.756
	Akwa Ibom	1.134*	0.111	0.000	0.861	1.406
Delta	Rivers	–1.362*	0.161	0.000	–1.756	–0.966
	Akwa Ibom	–0.228	0.168	0.396	–.638	0.182
Akwa Ibom	Rivers	–1.133*	0.111	0.000	–1.406	–0.861
	Delta	0.228	0.168	0.396	–0.182	0.638

Source: Researcher field survey data, 2018.

Note: *The mean difference is significant at the 0.05 level.

Table 5. Homogeneous Subsets of Farmers' Technical Efficiency

Scheffe		Subset for Alpha = 0.05	
State	*N*	1	2
Delta	2,350	68.11	
Akwa Ibom	6,760	68.33	
Rivers	9,476		69.47
Sig.		0.31	1.00

Source: Researcher field survey data, 2018.

Note: (a) Harmonic mean sample size = 4418.323. (b) Since group sizes are unequal. Therefore, harmonic mean of the group size was used.

Table 6. Travel Time to Healthcare Service Centre

Minutes	Frequency	%
1–10	52	24.1
11–20	47	21.8
21–30	56	25.9
31–40	16	7.4
41–50	26	12.0
51–60	18	8.3
61 and above	1	0.5
Total	216	100.0

Source: Researcher field survey data, 2018.

Data in Table 5 classified mean differences to the homogeneous group. The result showed that farm technical efficiency level in Delta and the Akwa Ibom States are not significantly different. However, TE level in Rivers State is significantly different from both Delta and Akwa Ibom States farms. This means that farms in Rivers State were better managed than the farms in Akwa Ibom and the Delta States.

Result in Table 6 showed that 25.9 per cent of the women spent 21–30 minutes travelling to their healthcare service centre. Farmers who spent 1–10 minutes going to the nearest health provider was 24.1 per cent, 21.8 per cent spent on average 11–20 minutes, 12 per cent of the respondents spent 14–50 minutes travelling to the health service provider while 8.3 per cent of them spent about 51–60 minutes to the health service provider. Majority of the respondents spent 1–30 minutes visiting their healthcare providers.

Conclusion

Farm TE of women farmers in Niger Delta, Nigeria was analyzed using the stochastic production function model. The study showed that coefficients of farm

size and labour inputs were significant at 1% level and showed positive influence on farm technical efficiency. 92.1% of the women farmers achieved TE level above 50% with a mean TE level of 68.8%. However, no farmer was able to achieved TF range of 91 to 100%. Mean TE is higher in Rivers State than Akwa Ibom and Delta States. Age significantly increased TE while number of years spent schooling increased inefficiency level. Majority of the farmers spent 1-30 minutes travelling to their healthcare providers during visits. The study recommends that women farmers should be encouraged to increase on the use of farm land and quantity of labour resources in order the increase farm output. Also, experienced farmers should increase the use of farm resources in order to achieve the higher farm efficiency level. Since, age of farmers showed positive influence on TE, farmers should form group and organize regular meetings to enable them share knowledge and experiences on the efficient use of farm resources in the Niger Delta Region, Nigeria.

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Availability of Data

The authors hereby declare that they can submit the data at any time based on publisher's request. The datasets used and/or analysed during the current study will be available from the author on reasonable request.

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Article

Implications of Land Use Land Cover Transformation for Gendered Livelihoods: Insights from Moyna Basin of Purba Medinipur, West Bengal, India

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Abstract

The Moyna basin of West Bengal is experiencing a rapid transformation in land use and land cover (LULC) as waterbodies are rapidly increasing at the expense of low-lying agricultural lands. The transformation in the LULC pattern in Moyna basin has been studied earlier based on the focus of climate change, biodiversity and other environmental issues. However, very little is known about the implications of this transformation on gender roles, responsibilities and livelihoods. This study examines the interconnectedness between LULC transformation and its differential impact on the livelihoods and workload of men and women using an intersectional perspective in three villages across Moyna block. The data were collected using a mixed-method approach and comprised of three major sources of information—observations, photographs and interviews. Results show that the changes in LULC have occurred partly as an impact of climate change and partly due to the inclination towards aquaculture due to decline in profitability of agriculture and farming practices. In the context of these livelihood changes, a fundamental shift in gendered roles has occurred. It has been found that the switch to aquaculture has led to two prominent outcomes, that is, depeasantisation of agricultural workers and defeminisation of the overall workforce. While women and men were equally displaced from agriculture with the advent of aquaculture,

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women were faced with additional challenges of unequal social gender norms and limited opportunities for alternative employment. It further shows that, the impacts of land use change on livelihoods are diverse and is a complex process as factors, like—class, caste, patriarchal family relations, family structure and the nature of the labour market intersect with gender and it also makes some women more vulnerable than other men and women.

Keywords

Land use and land cover transformation, gendered livelihoods, depeasantisation, defeminisation, sectoral shift in agriculture

Introduction

Over the last few decades, there has been a rapid and prominent transformation in rural land use and land cover (LULC) especially across various parts of the global South with significant environmental and socio-economic implications (Dadhwal & Vulmurugan, 2010; Lambin & Meyfroidt, 2011). In the coastal blocks of Purba Medinipur district in the state of West Bengal, it is found that waterbodies are rapidly increasing at the expense of low lying agricultural lands (Sahu, 2014, 2016). In the Moyna basin, a large tract of land was used for agriculture, and local livelihoods were heavily reliant on paddy cultivation. Besides, farmers also practised integrated agriculture and aquaculture in this region for many years (Ghosh, 2020).

In recent times, with the increasing frequency of flooding due to excessive rainfall and tropical cyclones, submergence of low lying areas, poor drainage, etc., the soil and hydrological conditions have become extremely unfavourable for agricultural (paddy) production especially during monsoon (Acharyya et al., 2015; Ghosh, 2020; Sahu, 2014, 2016) and earning from paddy production reduced drastically in last two decades. Such instances of agricultural degradation are quite common in the coastal areas of India (Dar et al., 2017). Studies show that with the transformation of land use, communities often apply multiple livelihood strategies to cope with the changing condition (McCusker & Carr, 2006; Soini, 2005; Wangui, 2008). The livelihood outcomes of this transformation vary substantially for men and women based on their traditional gender roles around agriculture along with access to the economic, social and cultural capital of the households.

In the context of Moyna region, during the early 2000s, an increase in income from the production of fish through integrated agriculture and aquaculture encouraged farmers to adopt an alternative strategy for sustaining livelihoods and bringing regular income to households by leasing out agricultural land for commercial freshwater aquaculture (Ghosh, 2020). Realising such a benefit from this alternative livelihood option, a large number of farmers began to shift to

commercial aquaculture gradually. The increasing practice of commercial aquaculture has led to significant changes in the landscape configuration of the basin (Ghosh, 2020). While in recent years, the state fisheries department has accepted it as a highly successful model (Moyna Model)[1] of fish farming as well as rural development and poverty alleviation, the LULC transformation has placed a profound impact on the ecology, demography and livelihoods of people.

The transformation in the LULC pattern in Moyna basin has been studied by several scholars in relation to climate change, biodiversity and other environmental issues (Acharyya et al., 2015; Ghosh, 2020; Mondal et al., 2015; Sahu, 2016). However, very little is known about the implications of this transformation on rural communities in general and women in particular. Against this backdrop, this research focuses on gender mainstreaming, that is, the inclusion of gendered perspectives in research with the aim of promoting gender equality. This exploratory research[2] tries to assess the interconnectedness between LULC transformation and its differential impact on the roles, responsibilities and livelihoods of men and women using an intersectional perspective. This study essentially seeks to answer the following research questions: (a) what have been the implications of changing land use practices on livelihood strategies of local communities in Moyna basin? (b) How have the adopted livelihood strategies impacted the gender roles in agrarian society?

The rest of the study is organised as follows. The second section provides a brief description of the study area. The section three elaborates on the data and methodology used in this study. The changes in the LULC, especially in the context of agricultural degradation, are presented in fourth section of this study. The fifth section assesses the effect of the LULC transformation on gendered roles, responsibilities and livelihoods. First, it discusses the fundamental changes in work participation in general and in agricultural work in particular among men and women. Then it provides empirical evidence of a shift in gender roles related to the adaptation of present livelihood strategies. The section six concludes the study with a discussion of the complexity of the process.

Study Area

Moyna basin is located in the Northwest part of the district of Purba Medinipur in the state of West Bengal, India (Figure 1). It is extended from 22° 09′ 37″ N to 22° 18′ 58″ N latitude and 87° 42′ 17″ E to 87° 49′ 53″ E longitude. The total geographical area of the Moyna basin is approximately 131 km^2. It is a trough shaped region (Sahu, 2016) bordered by the Kansai/Kansabati rivers in the North and East, the Chandiya river in the West, the Keleghai river in the South and the Baksi canal in the North (Ghosh, 2020). Geologically, the Moyna basin is a remnant of paleo-coast and characterised by recent alluvium of the quaternary to upper tertiary period (Sahu, 2014, 2016).

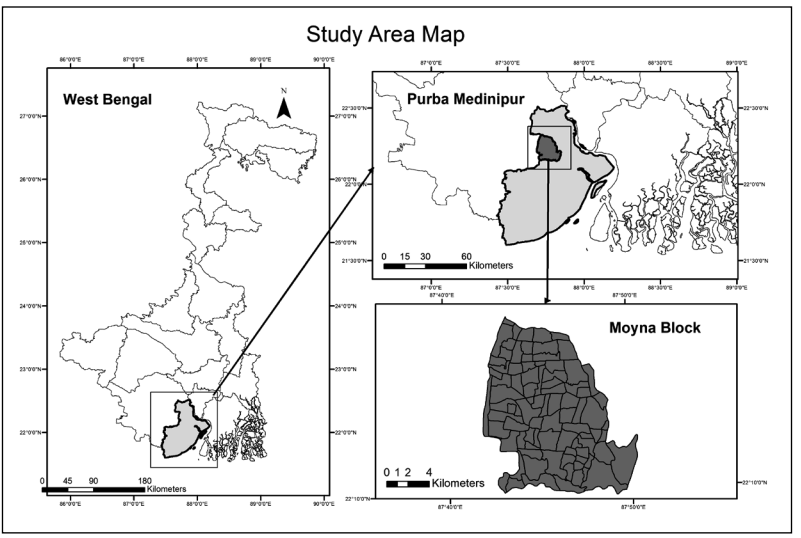

Figure 1. Study area map.

Source: The authors.

Data and Methodology

Three sets of data were required to answer the research questions: (a) images of LULC change; (b) data on work participation, both in the agricultural and non-agricultural sectors; and (c) data on traditional gender roles, how and why these have changed with changing land use practices. Information on the changing land use practices is obtained from Google Earth and other studies (Acharyya et al., 2015). In order to give a visual impression of the land use change on Moyna basis, imageries are taken from Google Earth for three points of time: 2010, 2014 and 2018. Other than this, land use change data is also collected from various published and unpublished research papers, blogs and reports.

The sex-disaggregated workforce participation data and the agricultural worker data at the village level used in this article are obtained from the primary census abstract, Directorate of Census Operations, West Bengal (2001, 2011). The census figures on work participation are helpful because they provide a basic understanding of workforce composition and the pattern of changes over time.

The data on the gendered impact of land use practices are obtained from the field survey. The data were collected in October 2018. The research team conducted a rapid rural appraisal across a number of villages. After consultations with the key persons, local authorities and grassroots level organisations with local expertise and outreach, it was decided to collect information from three villages (Charandas Chak, Janki Chak, Dakshin Changra Chak) across Moyna block where there is a prominent shift in LULC pattern. The data were collected using a mixed-method approach (Kelle, 2001) and comprised of three major sources of information: observations, photographs and interviews (key persons' interview, in-depth interviews and time-use survey (TUS)).

1. Observation: A qualitative research tool was used to get a basic understanding of the existing agricultural system, gender divides in work, that is, men and women's participation in domestic as well as in economic activities, the burden of common property resources (CPR) collection, etc. in the field site. Detailed field diaries were prepared based on such observations that included the exact instances.
2. Photographs: A tool essentially to supplement the observation, with narrations.
3. Interviews: This was the main survey tool. Interviews that informed the study were of three types.

Key persons' interviews: Those who are knowledgeable about the particular field site (i.e., village and tehsil) where the interviews are being conducted. On an average around two interviews were taken from each village, one typically being an elderly woman. The information collected was about the cropping pattern and crop production, agro-climatic condition, shift from agriculture to aquaculture, availability of water, social and religious structure, the gender division of work and education and mobility.

In-depth interviews with men and women to talk about their lives with a focus on their dependency on agriculture and aquaculture. The broad themes around which the interview was conducted were their occupation, the detailed nature of work (domestic and others) they do, major changes they have noticed in occupational structure and livelihoods, particularly if it has any relation with the transformation in LULC; their perception about climate change, its impact on agriculture, changes in the production cost, labour availability, labour out-migration and how these changes have altered the rural economy.

Time-use surveys: In order to capture the work burden of men and women, TUS were conducted with structured questionnaires. It collected data on how men and women spend their time differently and how it has changed with the shift from agriculture to aquaculture. To the extent possible, it was tried to collect data for husband and wife from the same household. The TUS have some general limitations: (a) It was an exploratory field survey and with the limitation of time and limited samples; (b) recall issues among the respondents (whether successfully recalled events actually occurred) (Hirway, 2009). Despite the limitations, a broad understanding can be drawn using the time-use method.

Changes in Rural LULC: A Shift from Agriculture to Aquaculture

Encircled by the Kansai/Kansabati river, the Chandiya river, the Keleghai river and the Baksi canal, Moyna basin is a flood-prone region. The basic analysis of the satellite imageries (Figure 2) shows that in the last decade, this area has witnessed a massive land transformation. The changes appear to be with regard to agricultural fields and water bodies (Figures 2 and 3). This change, accelerating over time, has occurred partly as an impact of climate change (Sahu, 2016) and

partly due to the changes in profitability of agriculture and farming practices (Ghosh, 2020). Sahu noted that the annual average rainfall of the Moyna basin is around 1500 cm, of which 80% takes place within a very short span during monsoon season (Sahu, 2016). Apart from that low elevation, low and negative slope, water holding capacity of the soil, presence of groundwater within a very short depth from the ground level and high drainage density with haphazard embankments also aggravate the condition of water inundation (Sahu, 2016).

Figure 2. Land Use Transformation in Moyna Basin of Purba Medinipur, West Bengal (2010–2018).

Source: Google Earth image.

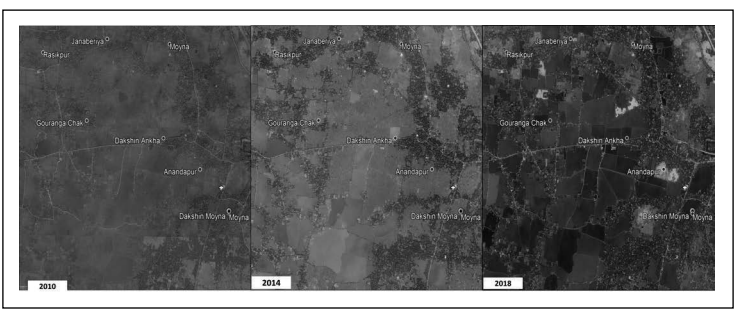

Figure 3. Agricultural Land Converted into Fisheries in Dakhin Changra Chak Village of Moyna, Purba Medinipur. A Low-lying Area, Suitable for Freshwater Fisheries.

Source: Authors' fieldwork in 2018.

Government officials interviewed in the district magistrate office of Purba Medinipur stated that, between 2008 and 2018, around 95% low lying agricultural fields in the villages of Moyna basin were transformed into water bodies for freshwater commercial aquaculture. There are about 200 fish farms exist in Moyna covering about 7,000 ha of land (Ghosh, 2020). Apart from this visible transformation, locals have also reported reduced access to both waterbodies as well as common village lands which were a major source of fodder and firewood.

Gendered Roles, Responsibilities and Livelihood

Before the switch over to aquaculture, the traditional agrarian society was comprised of petty commodity producers and agricultural wage labourers. There was a division of labour in agriculture based on gender. In the case of land preparation, women's participation was marginally less than men. While in certain activities, women's participation was more pronounced than their male counterpart. For instance, sowing and weeding of the field used to be exclusively done by women (Datta & Rustagi, 2012). The spreading of fertiliser and pesticides, harvesting was jointly performed by both men and women. Women were also entirely responsible for post-harvest activities, like—threshing, boiling and drying of rice. The work of livestock rearing used to perform by both men and women. Apart from that, women were also responsible for producing vegetables and other farm-based products for supplementing the household diet.

Aquaculture differs considerably from paddy cultivation as it requires significantly less labour for production and is primarily dominated by men (Table 1). Therefore, a shift to aquaculture has led to release of labour from farm activities. Several respondents stated that with the emergence of aquaculture, the scope of work has decreased locally, yet men and women have experienced these changes differentially. The shift to aquaculture has therefore led to two prominent outcomes—depeasantisation[3] (Singh et al., 2009) of agricultural workers and defeminisation[4] (Abraham, 2013; Sen et al., 2019) of the overall workforce.

Table 1. Gender Division of Labour in Paddy Cultivation and Freshwater Fisheries.

Paddy Cultivation	Gender Division of Labour	Fisheries	Gender Division of Labour
Preparation of land		Constructing fish ponds	
Fertiliser application		Inlets to let water into the pond	
Production of bio-fertiliser (manure)		Outlets to let water out of the pond	
Seed purchase		Bringing water to your ponds	

(Table 1 continued)

(Table 1 continued)

Paddy Cultivation	Gender Division of Labour	Fisheries	Gender Division of Labour
Seed cleaning		Controlling the water in the pond	
Seed drying		Preparing your pond	
Seed threshing		Stocking your pond with baby fish	
Preparation of seed field		Taking care of your pond	
Weeding		Taking care of your fish	
Irrigation		Harvesting your pond	
Protection from insects		Improving farm management	
Harvesting		Marketing of fish	
Carrying from field			
Crop threshing			
Crop drying			
Rice making			
Seed bed preparing			
Seed preservation			
Seed selling			
Seed plant production			
Seed plant harvesting			
Fertiliser purchase			
Shallow pump/paddle, tube well driving			

Source: Authors' fieldwork in 2018.

Figure 4. Change maps.

Source: Directorate of Census Operations, West Bengal (2001, 2011).

Depeasantisation

In Moyna, the leasing out land for commercial fishing by the small and marginal farmers indicates distress driven transformation.

> Now it is found that from aquaculture people are getting almost 1 lakh per year. While earlier when people used to cultivate rice, the only profit was from paddy husk and people used to get agricultural wages. When both men and women used to work in the field, they used to work really hard however profit was minimum. At present there is labour surplus.… They will get rice for the entire family for the whole year, that was the main purpose of agriculture here. People had hardly any cash with them. Now a days they are getting advantage in terms of cash, providing education to the children. Earlier it was not there. The standard of living was really not developed earlier. If you go back to 7 years from now, 2001–02 or till 2005 it was extremely under developed region. Now, if someone has 2–5 bigha land, they will get at least 1 to 1.5 lakh per year. Almost 12–14 thousand rupees per month. (Chinmoy Haik [Name changed], 40)

We find that during this transition period, due to the reduced labour demand of aquaculture, a large agricultural workforce is displaced (Table 1). The male workforce had a sharp transition into either non-crop agricultural activities or wage labour activities in the non-farm sector. On the other hand, the women workforce faced a huge decline (Figure 4b and 4c) with a majority of them challenged by severe decline in income. Though this transformation has not reduced the male work participation rate (WPR) much, however, it has brought a drastic change in the industrial composition of workforce. The transformation has particularly impacted the male workforce in three ways: (a) several small and marginal farmers,

who moved out of farming by leasing out the land to the contractors, revealed that the shift has increased their income security. Access to financial resources helped them to enter in a small business or wage activities available locally (Table 2); (b) on the other hand, the sharecroppers and agricultural labourers, those who did not have the legal ownership of land reported loss of livelihoods. From the interviews, it emerges that very few among the landless population could manage to find work in the non-farm sector, which has led to an increase in out-migration among the rural male youth population for sustaining livelihoods. Migration is essentially seasonal and some spoke of the risks and uncertainty associated with it (Table 2); and (c) a very small proportion among the rural male youth has received the opportunity as a paid labourer in the fisheries (Table 2).

Defeminisation

In the Moyna basin region, LULC transformation has impacted women differently than men not only in terms of opportunities to participate but also allocation of time in productive, reproductive and non-economic work. Our qualitative survey reveals that earlier women were very closely attached to farming and allied activities in all the villages we have studied. As traditionally, paddy has been the principal crop of this region, women possess knowledge and skills crucial to the paddy cultivation and also contributed to the production process to sustain their families. In both pre- and post-harvest agricultural activities for paddy, as well as supplementary food production through vegetables and livestock rearing, women's contribution was more than their male counterpart. While women and men were equally displaced from agriculture with the advent of aquaculture, women were faced with challenges of unequal social gender norms and limited opportunities for alternative employment (Table 2). To have a deeper understanding of the differential roles of women and men during an entire day (24 h) in both lean and peak seasons a TUS was carried out during the fieldwork. The distribution of time in the three types of activities has been presented in two ways: by time count table (Table 3) and graph (Figure 5).

The time count table (Table 3) shows that on average, men spend more hours (10.81 h and 7.87 h) in SNA activities as compared to women (5.10 h and 1.29 h) and the time difference has further increased with the emergence of aquaculture. There is a sharp decline in the paid work hours (SNA activities) for both men and women as there is a shift from agriculture to aquaculture, however, the change is more prominent among the women in comparison to men (Table 3 and Figure 5a). Out-migration of the male youth from the village has led to an increase in women's work burden in the household, particularly for care activities in the absence of the male member of the household (Figure 5b).

Due to the expansion of aquaculture over a large area in the last decade, the resources (waterbodies and barren land) which had been under a de-facto common property regime have been converted to de-jure private property regime. This has also had an impact on women's work participation as they need to spend more time for collection of fodder, firewood, etc. It has also been reported that due to

Table 2. Coding Tree.

Themes	Codes	Person	Quote	Examples
Depeasantisation	Earning from leased out land for fisheries	5	13	'Who owns land and leased out for fishing, profit for them only. Suppose some households has land a lot like 5–10 bighas. They will definitely get enough profit out of it'.
	No scope of work in agriculture for men	12	15	'Earlier I used to work as daily wage labourer in other's land. Now, there is no agriculture. Earlier people used to call us for rice harvesting. Now, there is no work in agriculture'.
	Scope in non-farm sector	4	4	'Jobs are available more or less in this region'.
	Scope of getting work in fisheries for youth male	7	9	'In a fish pond 25 to 30 people are employed and they have work all round the year. They are hired on contract basis for 1 to 5 years. They get monthly salary for it'.
	Out migration for work	4	11	'If people look for daily labour, then men get work here. Otherwise, they need to migrate out for work. There is ample scope of work in other states. Men migrate out for work to other states'.
Defeminisation	No possibility in fishing	10	14	'It is not true that fisheries cannot provide employment to the locals. But all of them are for men. Women do not get any kind of work opportunities in fishing'.
	Limited scope in household industries	3	5	'No no. We don't have any such opportunities here'.
	Dependency on MGNREGS for work	4	6	'We get a maximum of 15 days of work under MGNREGS. While in other places people continue to work for 2–3 months'.
	Involvement in household activities	5	7	'Apart from household works, we don't have anything to do'.

(Table 2 continued)

(Table 2 continued)

Themes	Codes	Person	Quote	Examples
	CPR collection	4	5	'We cook in Mud stove hence collect fire wood. Some we get from our household territory or domestic land. Some we get from the colony we have separate land to collect fire wood. I mean we have divided where to collect from'.
	Joblessness	8	15	'Sitting ideal at home. What they are supposed to do when there is no work'.
	Lack of interest in work	3	5	'When we were cultivating rice, we had a lot of work pressure.… Leasing out land for fisheries is much better. You do not need to work anywhere'.
	Involvement with SHGs	2	2	'We contribute 30 Rs each month total 390 Rs we submit in the grameen bank and keep the record. we keep the record in the copy who is taking what amount of loan and when returning back. We first we started the group on 25 Dec, 2004. We opened bank account in March, 2005. After one year, we got loan for 25000 Rs twice in a year because we paid back the first amount in six months. Then it got increased each year say 1 lakh, 1.5 lakh. Now we have 3.5 lakh sanctioned'.
	Lack of social, cultural and economic capital	2	4	'Many times, it is a matter of your contact with others. A woman who is having better education and contact with others will get it. While a poor woman like me hardly gets any opportunity. A well-off family will be able to afford the cost. I am neither educated, nor have money, how would I get it? That's is why we are not getting the opportunity. We don't get any help'.

Source: Authors' fieldwork in 2018.

Note: CPR: Common property resources; MGNREGS: Mahatma Gandhi National Rural Employment Guarantee Scheme; SHG: Self-help group.

Table 3. Daily Average Time Spent (h) on Various Activities (Before and After Aquaculture Introduced).

Activities	SNA Activity	Non-SNA Activity	Non-economic Activity
Male—before aquaculture introduced	10.81	0.87	12.33
Male—after aquaculture introduced	7.87	1.40	14.73
Female—before aquaculture introduced	5.10	5.40	13.50
Female—after aquaculture introduced	1.29	6.58	16.13

Source: Authors' fieldwork in 2018.

Notes: Time spent for a particular activity (Time count method) = Total duration of activity/Total number of persons.
SNA: System of National Accounts.

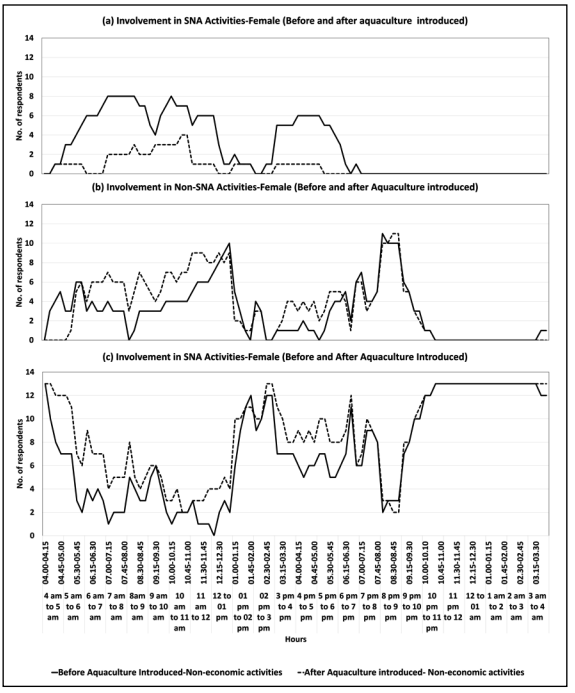

Figure 5. Time Use by Female Members Before and After Aquaculture Introduced.

Source: Authors' fieldwork in 2018.

Notes: SNA (System of National Accounts) activity includes farm activities, livestock and other allied agricultural activities, collection of water for livestock and irrigation of field, non-farm and other professional activities. Non-SNA activity includes child-care activities, domestic activities and collection of water for household. Non-economic activity includes personal care and maintenance, free time activity, mass media communication, social and cultural activities. Time use measure: (Total no. of participants performing activities = Doers of particular activity/All persons).

the decrease in paddy production, it has become difficult to feed the livestock. Most of the time, they need to buy feed for the livestock, which is very expensive. It was reported by several interviewees that many households in the village have sold cattle due to the increasing expenses of feed. As a result of that, the work of women has reduced as they were the ones responsible for livestock-related work.

Figure 4b shows that many villages of Moyna block have recorded a significant decline in women WPR and defeminisation of the workforce due to low women's participation in commercial aquaculture (Figure 4c). The narratives from the field reveal that the decline in paddy cultivation has not only affected those women who used to work on their family farms, but also those used to work as farm labourers on others' farms. We further found that women, particularly landless agricultural labourers, are the worst sufferers as their participation as well as earning from agriculture has reduced substantially. In the absence of home-based small-scale industries there is hardly any scope of work in the non-farm sector in or near the village, which has negatively affected work opportunities for women as they generally face restricted mobility.

In recent time, the Mahatma Gandhi National Rural Employment Guarantee Act is the only employment provider for women, which itself is also not devoid of gender discrimination. Several women have shared the problems they faced due to the reduction in the wage labour opportunities for landless women. 'Ever since people have started leasing out their land, there is hardly any work for the villagers, especially for women', Sujata Haik (40 years) says. She further added that 'men still can get work outside, but women do not have that option. Only 5–10 people are required for fisheries and it is a contractual job for around 5 years. For women, like us, do not have any scope of getting jobs in fisheries'.

Our study also reveals that in the absence of alternative options, women from lower caste (schedule caste) households often engage themselves in hair processing (a home-based work in the supply chain of the wig-making industry) at a very meagre wage. This activity is not taken up by women belonging to non-scheduled communities as they find this inappropriate and low (below the dignity of their caste).

> Women are sitting ideal at home. What they are supposed to do? Some women are engaged in hair processing. But I am not doing it. I am not allowed to do it. My family members have strictly said that if I do the work of wig making, they will not eat the food cooked by me. It is mainly done by the women belong to scheduled caste community. Jharna Das (40)

Caste distinctions in the impacts of the land use changes are therefore also visible among women. Women from the land-owning households have also dropped out of work since the earning from the leasing-out of land has increased the household income and therefore the work and wage earning of the women is no longer considered a necessity for the household. While this may have reduced their workload, this does not augur well for making of more favourable gender relations within the household.

Conclusion

The study yields two important insights. First, there is a strong correlation between changing LULC pattern and livelihoods and the impact is gendered. It has highlighted that the transformation has made female employment more scarce leaving them in a precarious economic situation, which has further worked against gender equality. Second, it shows that women labour force cannot be seen as a single homogenous category when studying the impact of land use transformation on livelihoods. Factors of class, caste, patriarchal family relations, family structure and the nature of the labour market intersect with gender for understanding the shift in work burdens for both men and women. Therefore, these are indicative of the complexity of the process and heterogeneous social structure which makes some women more vulnerable than men and another section of women.

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Notes

1. It is essentially a business model of fish cultivation, initiated by the farmers of the Moyna block of Purba Medinipur, West Bengal. Under this model, the farmers utilise the small water bodies in the agricultural fields for growing indigenous species of fish like *tangra* (black catfish), *chital* (clown knife fish) and *tilapia*.
2. Exploratory research in social science is a method of study that intends to address the research questions however, does not offer a very concrete and conclusive answers to those questions. This method of research is usually used to study a problem that has not been clearly defined yet.
3. Depeasantisation is a specific form of deagrarinisation in which farmers lose their economic capacity, social coherence and started decreasing in number (Singh et al., 2009).

4. 'Defeminisation' of labour force essentially means excluding women from their entitlements in the labour market (Abraham, 2013).

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Article

The Potential for Sustainable Organic Farming in Nagaland: A Case Study

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Abstract

In 2015, Sikkim, a North-Eastern state of India, achieved the state of being fully organic. Later, states like Nagaland, Mizoram, Meghalaya, Goa and Kerala have declared their intentions to be fully organic. In Nagaland, more than 47% of the population is engaged in agriculture and entirely dependent on the traditional mode of farming and has used organic manure like cattle dung, dried leaves-litter and crop residues for enhancing the capacity of soil from time immemorial. Also, studies have shown that the state of Nagaland has negligible use of inorganic supplements in their fields. Thus, Nagaland has a high potential to be converted into an organic state without making any significant shifts in their existing farming practices. Shifting cultivation, locally known as *Jhum-kheti*, is one of the oldest forms of the agricultural process in practice in Nagaland. However, some studies regard Jhum cultivation as harmful to the environment, but there is a scope to reinvent this farming method and move towards a more sustainable form of agriculture there. This study explores the relation between traditional farming and organic farming and the benefits of state-induced organic farming methods and their effects on the farmers of Nagaland. A survey was carried out in the Mokokchung district of Nagaland to understand the role of farmers in attaining sustainability.

Keywords

Traditional farming, organic farming, Nagaland, state policies, sustainability

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Introduction

The people of Nagaland are primarily engaged in agriculture, which comprises more than that of the national average, that is, 47% (Office of the Registrar General and Census Commissioner, 2011). Like other states in North-East India, Nagaland practises shifting cultivation (locally known as *Jhum-kheti*) and terrace cultivation (locally known as *pani-kheti*). The practice of *Jhum-kheti* is dominant among all the tribes except the Angami and Chakhesang (they practice *pani-kheti*). The Angami and Chakhesang tribe practised terrace cultivation for ages using traditional methods and tools (Kithan, 2014). Both *Jhum* and terrace cultivation methods are heavily dependent on the relief features, such as topography, climatic condition, rainfall, flora and fauna of the region and the place of inhabitancy of different tribes. As Allen (1905) stated, the Angami and Chakhesang practise terrace cultivation because of their location of inhabitancy that is 4,000 m above sea level. The other tribes of Nagaland practising *Jhum-kheti* vis-à-vis rest on the hilly region of the World, having a height not more than 2,000 m above sea level.

The agricultural practice in this state is subsistence in nature which depends on all primitive methods to meet their daily needs. Das (2006) argued that, 'shifting cultivation' has a production of food crops which is 'by default' organic because of the use of primitive tools (hoes, daos, digging stick, etc.), no use of chemical supplements and human labour. Although by the 19th century, the use of modern tools came into existence, the people of Nagaland continued to use primitive tools and their traditional knowledge for cultivation. Even the practice of terrace cultivation in Nagaland has its traditions for which only human labours are engaged. Apart from agriculture, the people of Nagaland also have practised weaving, blacksmithy, carpentry and other handicrafts but on a tiny scale to meet their daily needs (Bose, 1991, pp. 42–51).

However, there are some merits and demerits of *Jhum-kheti*, the dominant form of agriculture in Nagaland, which are debated across the World. One strand of the debate brings out the negative impact on the environment, land and community arguing that it is both economically and environmentally non-viable practice. The other strand argues that shifting cultivation is never harmful. It is a somewhat helpful agricultural practice and is deeply connected to indigenous peoples' culture. *Jhum-kheti* has been banned in many parts of the World showing its harmful effects, based on the argument like soil erosion, deforestation and air pollution and other environmental degradation. In 1957, the Food and Agriculture report strongly argued that shifting cultivation is harmful to the environment and was banned from many parts of the World (Mai, 2014–15). In India, there is no such evidence of banning such practise; instead, the state of Nagaland has started encouraging the method with different policy support to overcome the limitations on soil erosion, deforestation, etc., of *Jhum* cultivation.

The state government of Nagaland has adopted some specific policies since 2014. The state started extending support towards *Jhum* cultivation to meet the increasing needs of the rising population in Nagaland. The rising population is creating pressure on land as well as on *Jhum* cycles gradually. The Government of

Nagaland maintains a proper record and sustenance on such traditional practices like limiting the drawbacks of *Jhum-kheti*. At the same time, it aims to meet the increasing demand for sustained livelihood activities of the people of Nagaland. The traditional method of *Jhum-kheti* has been advocated by many scholars over its tested benefits towards the environment with some additional measures such as avoiding the burning of forests, keeping a check on the surrounding flora and fauna and creating fields without uprooting the trees, to check soil erosion. During the 12th Five Year Plan, the Government of India also launched several National Flagship Programmes to emphasise the activities for Sustainable Agriculture Development in India. For North-East India, the most remarkable policy was Mission Organic Value Chain Development for North East Region (MoVCD). Similarly, Parampragat Krishi Vikas Yojna, Participatory Guarantee System for India, etc., are some other such related policies (Department of Agriculture, Government of Nagaland, 2015–16, 2016–17, p. 1).

In this context, this study aims to understand the importance of conventional agricultural practises in the state of Nagaland of North-East India. It also aims to better understand the environment and topography, demography, economic practises of the people in such highland areas of Nagaland; and government policies to preserve and extend the age-old tradition of cultivation to achieve sustainability.

Background of Nagaland

Geography and Demographic Background

Nagaland is a small state situated in North-East India between the coordinates 26° 04' North and 94° 30' East. The topography of Nagaland consists of rugged terrain and valleys with altitudes ranging between 194 m and 3,048 m. The mountainous peak varies between 350 and 3,000 m above sea level. The state of Nagaland enjoys a favourable climatic condition, and the torrential monsoon rains are an integral feature of the weather. The state covers 16,579 km² with a population of 1,980 and 602 in 2011. Among the total population of Nagaland, about 71.14% resides in its rural areas, and 28.86% are in the state's urban areas. The average density of the state population is 119 persons per km² as against 382 persons per km² for India's population density (Office of the Registrar General and Census Commissioner, 2011). The state recognises 14 'Naga Tribes' such as Ao, Angami, Sumi, Lotha, Rengma, Konyak, Sangtam, Phom, Chang, Yimchunger, Khiamniungan, Chakhesang, Zeliang and Pochury (Ministry of Home Affairs, Government of Nagaland, 2016) and accounts for approximately 86% (1,710,973 persons) of the total population (Office of the Registrar General and Census Commissioner, 2011). Thus, the state has a large population under tribal communities, which resides in both urban (23.62%) and rural (76.37%) areas (North Eastern Council Secretariat, Government of India, 2015, p. 7).

Further, the difference in the altitudinal ranges also shows a difference in the climatic conditions like warm, sub-tropical types in the foothills, moderate and sub-moderate in the mid-slopes and lower range of the Western part and cold and temperate in the high hills. The rainfall is varied and has an average range of

200–250 cm with maximum receiving from the Southwest monsoon. The temperature varies from 5°C to 25°C and 12°C to 32°C in the hills and foothills, respectively. The major rivers in Nagaland are Dhansiri (the largest river in the state), Doyang, Jhanji and Dikhu (Government of Nagaland, 2014).

The flora is exceptionally rich in Nagaland and divided into evergreen and semi-evergreen, deciduous, sub-tropical pine forests and temperate types. Based on the interpretation of satellite data, the forest cover of Nagaland is 12,489 km², which accounts for 75.33% of the state geographical area (Forest Survey of India, 2017, p. 255). The soil is an essential resource for the production of food, fibre and fodder for human beings and livestock. The soil of Nagaland is largely alluvial, non-laterite red and forest soil with acidic nature and low fertility. The cropping intensity of the soil is 110%, which is less than that of India's share (136%). Still, the presence of natural or organic components in the soil of Nagaland makes it more appropriate for nutritious and healthy production (Department of Agriculture Research and Education, 2016–2017, p. 3). The use of fertilisers is negligible, though manure and compost are used sometimes in the fields (Singh & Munth, 2013, p. 473).

Thus, the above narrative shows that Nagaland has all the favourable conditions like climate, soil, indigenous knowledge of agricultural practices, minimum usage of chemical supplements and human labour to adopt a full-fledged organic farming approach in the state. Therefore, it is not surprising that the economy of Nagaland is predominantly dependent on agriculture and its related activities. For time immemorial, the livelihood of various tribal communities of Nagaland has been primarily reliant on nature, natural resources and having a single human nature relation at subsistence level.

Jhum Cultivation and Organic Farming

Organic farming is an agricultural system that originated in the early 20th century. This particular form of cultivation fertilisers on organic origins such as compost, manure, green manure and bone meal and its emphasis on techniques such as crop rotation and mixed cropping. Biological pest control, fostering of pests and insects all carried out with naturally occurring supplements. Organic farming has emerged as a significant activity and many of the countries worldwide adopted this idea. There are at least 141 countries that are now practising organic food production commercially. As estimated in 2007, 32.2 million organic food is produced globally (Reddy, 2010). Among various countries which have adopted organic agricultural production, developing countries comprise 65%. Oceania, Europe and Latin America, Australia, Argentina and Brazil are among the most significant countries, which have adopted an organic method in agriculture (Willer & Lernoud, 2017). India ranks 33rd in terms of total land under organic cultivation and 88th in agricultural land under organic crops to the total farming area.

Nagaland ranks 2nd after Manipur (53.46% in 2008–2009) and has the second-highest acreage under *Jhum-kheti* in India. The land use pattern here suggests that

16% of its net geographical area is under the net sown area. About 1,23,909 ha area is under *Jhum* cultivation, which accounts for 7.5% of total area, 42% of total cropped area and 47.5% of net sown area (Kuotsuo et al., 2014, p. 23). The indigenous people of Nagaland are practising organic farming for a long time, that is, *Jhum-kheti*. In this type of agriculture, the land is first cleared, vegetations are cut down and the residuals are burnt away. Then, the seeds are sown with the first flash of pre-monsoon rains. A particular land is used for a maximum of 2 years or seasons and then is left for growing forest at the same place. So that after 5 years the same plot of land can be selected for re-cultivation. Thus, the practice of *Jhum* results in the destruction of natural vegetation, soil erosion, production of greenhouse gases and nutrient loss. Due to these shortcomings of *Jhum* practises, it is not awarded with the organic certification certificate, though the farmers are growing the crops organically.

The characteristics which make *Jhum* cultivation organic in nature are as follows.

1. Clearing and burning of the field lead to eradication of pathogens and other pests that makes it easier for cultivation.
2. Zero tillage method, which includes stick digging method. This helps in the quick germination of the seeds without getting infected by the pathogens.
3. The upland paddy is also mixed with different crops; this protects from pests and pathogens and provides a food source for the farmers throughout the year.
4. Creepers (pumpkin, cucumber etc.) are also cultivated to check on the weeds and pests. Pungent odour spices like ginger and garlic are grown. Also, farmers use plants like *Clerodendrum serratum* near the paddy field to keep away the pests and weeds (Kuotsuo et al., 2014, p. 22).

But despite having the characteristics of organic farming, they are not provided with any certification because of the harmful effects caused by *Jhum-kheti* on the environment. The Government of Nagaland is taking initiatives to convert itself to an organic state because the demand for organic products is increasing day by day. Organic products fetch more value than conventional crops. Nagaland knows organic cultivation, but the disadvantages caused by *Jhum-kheti* create a barrier in the certification. But the farmers of Nagaland have expertise in this practice and have carried out some methods to limit the adverse effects of *Jhum-kheti* so that proper authentication of the organic products can be done.

Soil and Pest Management by the Farmers

Being a traditional practice, the farmers of Nagaland are well aware of the drawbacks of shifting cultivation. For this particular reason, they practise some methods to reduce its effect on the environment. Though these practices are not that much fruitful and have a very less positive impact on the environment, it still resists the maximum impact of *Jhum-kheti*. The following are the measures:

1. To reduce the impact of soil erosion, the farmers here only take out the central part of the crop, that is, paddy panicle, maize cob, etc. this helps in holding the topsoil and after its decomposition makes the soil fertile and best use for the next time.
2. Mixed cropping is done to balance the nitrogen demand of the crops. More than 10–20 crops are grown together, with paddy as the main crop in the same plot of land. This also provides other vegetables and food crops for the farmers.
3. Non-leguminous trees are also grown to meet the other nutrients of the soil beneficial for crop production.
4. Apart from nutrient management, for pest and weed control, salt is spread on the field. Salt is majorly used to remove the broad leave weeds and control their growth on the ground.
5. Also, dhatura (*Datura stramonium*) is used to overcome stem borer infection in the paddy. Dead frogs or crabs are used to control bugs.
6. The use of ash on the field before sowing seeds helps in reducing the chances of drying up crops due to unfavourable conditions (Field survey conducted by the author in 2017 and 2018).

Thus, in *Jhum* cultivation, no heavy types of machinery are used for cultivation. Minimum tillage is done manually, and the practice is dependent on human labour from time immemorial. Keeping these points in view, the Government of Nagaland took up measures to overcome the limitations of *Jhum-kheti* and provide the farmers with the desired benefits. Some of the methods taken up by the government are mentioned and discussed in the next section.

Role of Government Towards Organic Agrarian Economy

Organic products are gaining more importance worldwide. Every country is trying to bring more land under organic cultivation. Too much use of fertilisers and pesticides are harming the environment and also human health. In India, after the Green Revolution, the use of fertilisers and pesticides increased in the fields. It increased the amount of production but adversely affected the soil, soil microbes and quality of groundwater, food and food materials. The concept of organic farming is not new, but for the conservation of the environment and the health of human beings, it is propagated more in the recent period. Every country is trying to adopt organic farming with new technologies so that the environment can be saved and judicious use of the resources is done. Also, organic products earn more money than conventional crops leading to an increase in the economic condition of the farmers as well the country.

The Nagaland government is well aware of organic farming facts and produces the maximum amounts of organic products in their region. But the way of their cultivation is regarded as harmful to the environment. In this regard, they adopted few schemes to emerge as an organic state just like Sikkim. But in Sikkim, they practise terrace cultivation and hence could attain the status of being organic early. Also, Sikkim's total area coverage (7,096 sq km) and population (607,688)

are significantly less as compared to that of Nagaland's area (16,579 sq km) and population (1,980,602) (Office of the Registrar General and Census Commissioner, 2011). Sikkim has become India's first fully organic state with 75,000 ha of land under certified organic farming. In 2003, the first initiative was taken by Pawan Chamling, the Chief Minister, to convert Sikkim into an organic state, and it took 12 years to achieve the desired goal in 2015 (Oberst, 2015).

For this particular reason, after Sikkim, the Government of Nagaland is taking initiatives so that organic farming can gain status in their region. The state has knowledge about the cultivation of crops and biological methods to grow crops organically. Some of the significant steps taken by the Government of Nagaland are the National Project on Organic Farming (NPOF), National Organic farming, Agricultural and Processed Food Export Development Authority (APEDA), NPOF scheme and Marketing facilities farmers. The main aim of these policies is to encourage the farmers to grow organic products and get them certified so that they can easily get the benefits of organic farming and help them improve their economic status. Also, marketing facilities are enhanced by building infrastructures, such as roads, cold storages, advanced market places and collection of products from villages directly (Kuotsuo et al., 2014, pp. 25–26).

Methodology and Data

The study is based on the information collected from both secondary and primary sources. The secondary data include information from various government sources like *Statistical Handbook of Nagaland* (Directorate of Economics and Statistics, 2006–2016), *Basic Statistics of North-Eastern Region* (North Eastern Council Secretariat, Government of India, 2015), *District Census Handbook*, Forest Department, Agriculture Department and other published and unpublished records in various departments. In terms of primary data, a field survey was carried out in two villages, namely Chuchuyimlang and Mongsenyimti of Mokokchung district in 2018. This field survey was conducted to understand the different parameters and dimensions of shifting cultivation in contemporary Nagaland. Both the villages are dominated by the Ao community who practice such traditional agricultural farming. The study covers their different agricultural land use patterns and related environmental issues to understand the problems of shifting cultivation and the social implications of the farming communities. Further, an in-depth study has been carried out to understand the government policies implemented in the district and their effect on the livelihoods of such indigenous community.

During the field survey, data was collected through personal interviews, questionnaires and several discussions with the farmers, different meeting with the officials from the Agriculture Department Government of Nagaland and village heads. To understand the various dimensions of tradition and transition of such agricultural farming, the study has adopted a mixed method where both qualitative and quantitative methods are used. Thus, multiple interviews, discussions and interaction with different groups of people undertaken in the field

have been used to lay the perspective of the study. In contrast, the information from the questionnaire and data from various secondary data sources have been used to quantify and bring empirical understanding to this study.

The villages selected for the sample study are located in the Mokokchung district of Nagaland, namely Mongsenyimti and Chuchuyimlang. The villages were selected based on their similarity in ecology, culture and proximity to traditional agricultural practices. Both the villages are situated in the high altitudes and represent typical examples of shifting cultivation and their subsistence form of agriculture with the help of human labour and indigenous knowledge. Of the 547 households in Mongsenyimti, about 55 households were randomly selected, whereas in the village Chuchuyimlang, out of 905 households, 90 households were randomly selected. Thus, the sample size of 145 in two villages was chosen to make the study statistically significant, having a 10% sample size. Therefore, questionnaires were distributed among these households to collect data. Apart from this, many individuals like farmers, shopkeepers, government and private employees were interviewed to understand the ground realities of shifting cultivation and its various issues and challenges.

Survey Findings

The field visits provided a broad idea about shifting cultivation and the traditional practices of the Ao tribes. Further, it helped us in understanding the relevance of their practices the transitions which are taking place gradually in the villages and the reasons for such changes. The two sample villages of the study, Chuchuyimlang, avails the intervention schemes' benefits and has shown an upward trend in production. The major organic crops grown in the town are banana, cardamom, oranges, ramie beans, etc. These crops receive organic certification and help the farmers fetch an extra income apart from the organic *Jhum* paddy, which has no surplus and is only grown for consumption (Field survey conducted by the author in 2018). The Mongsenyimti village has a 'by default' organic production but is not covered by such schemes. Hence, they receive no certification for their products and remain unqualified for trade and export in other organic markets. Further investigation of the case study villages reveals the following differences among the organic farming in the case study villages (see Table 1).

Hence, organic farming schemes have affected the population of the Chuchuyimlang village. However, the farmers have raised concern regarding various existing problems such as the lack of market and transport facilities that are restraining them from selling their surplus product. The nearest market of Chuchuyimlang and Mongsenyimti village is 7 km and 4 km away, respectively, which are connected via NH-61. But currently, it has limited access and very few vehicles are now plying on the roads. Apart from such primary market, these villages also have their needs promoted by Nagaland, called *Mahila Goshtis*.[1] These markets were built to empower the local women of these respective villages. Chuchuyimlang village owns one *Mahila Goshti*, which is located within Chuchuyimlang village and three more outside the village, near the highway

Table 1. Differences in the Agricultural Practices of the Sample Village, Chuchuyimlang and Mongsenyimti in the Post MoVCD Scheme.

Sl No.	Chuchuyimlang	Mongsenyimti
1.	They have a systematic plantation of crops where fallow land is used for cultivation of horticultural crops.	They practice plantation along with the cultivation of *Jhum* paddy especially in home gardens.
2.	The village has proper methods of conserving the environment and have achieved the goals of soil and forest conservation in 2014.	They still practice the primitive methods and leave the land barren during fallow period, causing soil erosion.
3.	The village has a proper Council body of 108 members taking care of different issues of the village like health, land, crop, etc. Though, the Village Head has a prominent position.	The village has three council members and the Village Head takes care of all the happenings in the village.
4.	They grow 20 varieties of horticultural crops.	Whereas they have not more than 10 varieties of crops.
5.	The production of cash crops plays a vital role in their society and acts as an extra source of income to them.	They chiefly grow food crops for self-consumption and vegetables for selling and consumption.

Source: Field survey conducted by the author in 2017 and 2018.

NH-61. In contrast, the Mongsenyimti village holds three *Mahila Goshtis*, situated at a distance of one and a half kilometre from the village residential area. Thus, space remains a significant barrier for the farmers to sell their products in the markets.

A series of changes is taking place among the livelihood of the people of the state, where people are perpetually moving towards progression. From the beginning of civilisation, humans have a tendency to improve and innovate to meet his daily needs (Herbig et al., 1994). Thus, scholars have always identified the incremental innovation as a better form. These innovations have a direct effect on the livelihoods of the people, which can also improve various economic activities. Agricultural practices thus can also be improved through various effective innovations and can bring substantive changes in the lives of various communities who are dependent on it. The study of Byres (1986) stated that in a developing country the absence of agricultural transition has led to an economic backwardness. He suggested that country like India, where maximum of its human population is engaged in agriculture, needs a capitalist agricultural transition for economic betterment. Thus, transition and transformation of agricultural practice is a natural phenomenon came up with the changing time, increasing human population and capitalist economy, which brought massive changes in land tenure, organisation of production on farms, techniques and equipment on the farms, intensification of markets and capital investment of small-holding farmers.

Nagaland has already experienced some such changes in their traditional fields. In fact, even the colonial capitalist has also experimented with certain policies of innovation in the traditional agricultural fields of Nagaland. During the colonial

period in India, a series of attempts was made to eradicate *Jhum* cultivation and inculcate the practice of settled agriculture. A similar trend was being followed in the post-colonial period, when different state governments provided grants for settled form of agriculture (Maithani, 2005; Malik, 2003; Planning Commission, 1981). A number of policies namely, the New Land Use Policy (2008), National Environment Policy (2006), Biological Diversity Act (2002) and so on were enacted to preserve the environment and its components (Maithani, 2005). Although, limited attention was given to the interests of indigenous communities and a forceful imposition of settled agriculture was done, which received resistance from the cultivators, as these policies never provided a space for their cultures and customary laws. However, the Union Nations Intergovernmental Panel on Climate Change (5th Assessment Report, 2015) identified that traditional agricultural practices like *Jhum* cultivation have the potential to flourish and adapt according to the climate change without causing much harm. Thus, traditional agriculture gained importance in the policy frameworks in the recent period and initiatives have been taken to uplift the production from traditional agriculture via minimum technological and scientific developments. Such incremental innovation in the state has taken a concrete shape in forms of organic farming. In this context, in the recent decade the villages of Mokokchung district namely Mongsenyimti and Chuchuyimlang have also seen some phase of transition in land use and agricultural practices. This has affected their existing traditional, social cultural and economic lives. Some of the transitions in the traditional fields in Nagaland which were visible during the field visit are highlighted below:

Reduction in Land Cover: The two sample villages denote that, the area of *Jhum* land occupancy ranges between 1 acre and 2.5 acres. The average land owned by *Jhum*mias in Mongsenyimti village is 1.25 acre and in Chuchuyimlang is 1.55 acre. Thus, the *Jhum*mias are small-holding farmers[2] dependent on low input agricultural practice. Further study reveals that, in both the villages a minimum of 1.5-acre land per household is always under *Jhum* practices. Chuchuyimlang has a higher share of land under plantation crop. The main reason for this situation is the use of advanced technology and organic supplements, and the funds from the government programmes enacting in the Chuchuyimlang village enables them to practice plantation and horticulture on the fallow *Jhum* lands. Whereas, the Mongsenyimti village is still practising the traditional mixed farming, that is, *Jhum* cultivation to meet their daily needs. The figures in Table 2 show that the two case study villages namely Mongsenyimti and Chuchuyimlang consist of small holding farmers occupying land in between 1 acre and 2.5 acre. Both the case study villages show that every household has minimum 1–1.5 acre of land for the *Jhum* cultivation which is used for the cultivation of both paddy and cash crops. Large fields are hardly noticed and cash crops are generally grown collectively on *Jhum* plots during the fallow periods.

Issue of Food Security: Both the study villages produce cash crops and have helped to improve the economic conditions of the *Jhum*mias as these crops help them to earn extra income from selling them to markets. Also, cash crops have much more surplus than that of cereal crops in Nagaland. Paddy is only cultivated for self-consumption. Though, the villages have not attained self-sufficiency in food grain production.

Table 2. Land Own by Per Household.

Land Own (in Acre)	No. of Households in Mongsenyimti	No. of Households in Chuchuyimlang
0.5–1	15	05
1–1.5	25	34
1.5–2	10	30
2–2.5	5	21
Total	55	90

Source: Field survey conducted by the author in 2018.

Data collected from the Village council of Chuchuyimlang show that, a household with six members consume 4 kg of rice daily. The village has a total number of 905 households, which shows that the village need approximate 3,620 kg of rice per day. Thus, to attain food security the village needs a yearly production of 220,095 tins (1 tin = 6 kg approx.) but has only reached halfway with a production of 110,047 tins in 2016. Mongsenyimti has also not attained food security as informed by the village head but they have a relatively high volume of *Jhum* paddy. Thus, the villages have the potential to meet the problems of food security but one of the major limitations is the increased involvement of the farmers in cultivating cash crops. This has shown a reduction in the share of land.

Previously, one family used to cultivate on the entire 1.5 acres land but with the introduction of cash crops, major portion of the land is always growing cash crops (ranges between 0.5 acre and 1 acre). Thus, the farmers get harvests throughout the year from such 'horticultural plots'. These horticultural plots are uneven in size and differ from family to family. It was noticed during the field survey that cultivation of cash crops is generally taken up by the small families because *Jhum* cultivation is a hard labour work and needs more working hands. On the other hand, production of cash crops generate money for them. Thus, the two villages have experienced an incremental transition where the land area has undergone reduction in terms of division under *Jhum* and cash crop cultivation, in the practice of *Jhum* cultivation (Field Survey conducted by the author in 2018).

Labour Mobility Towards Other Sectors: The Economic Survey of Nagaland (2016–2017) shows that the gross state value added from agricultural sector was 30.9% in the year 2011–2012 and is further reduced to 29.4% in 2015–2016. Although, 71% of the population in the state is dependent on agriculture, a gradual shift from agriculture to industrial sector can also be noticed. The major reason behind this shift is the low income of the farmers from the existing agricultural lands and practices. There is a persistent rise in aspiration amongst the people of the state and therefore people are taking efforts to provide formal education to their children, which they think can bring better life to them. Thus, a woman from the Mongsenyimti village stated that:

> We (narrator and her husband) are less educated but we are earning hard to educate our children so that they can lead a better life and can work in the offices or industries.

Conversation with another family of 10 members revealed that, eight of them have already migrated to the nearby or far-off towns for better life and job opportunities. Thus, such a trend of mobility from farming lands to urban areas has created a shortage of labours in the agricultural lands. The hard labour and various changing climatic conditions are additionally creating limitations for the villagers to continue their practice in their traditional *Jhum* fields. Thus, another farmer of Chuchuyimlang village narrated that:

> Jhum cultivation is a hard labour work and doesn't produce much of surplus resulting in low income whereas plantation and horticulture crops fetch a better value in the market (produces surplus) and also the State Government provides funding for the same and not for Jhum cultivation. (Field survey conducted by the author in 2018)

Another conversation with the Council member of Chuchuyimlang stated that:

> Jhum cultivation is a hard labour work and needs more working hands. But the new generation are not interested into agriculture and prefer to move to urban areas in search of better jobs. Also, the changing climatic conditions and uneven rainfall has affected the cultivation process. Thus, they have requested the District Agricultural Office that they want to practice Terrace Cultivation and want some help for the same.

However, in Mongsenyimti village, the field survey revealed that approximately 54% of the total people interviewed during field survey are engaged in traditional agricultural practices and its allied sectors (see Table 3). Whereas, in the Chuchuyimlang village approximately 55% of the interviewed population is working in agricultural fields. Thus, in both the villages the largest concentration of the population is in agricultural field followed by the younger generation who are students and aspired to have a 'better' life and job opportunity in future and they do not want to work in the fields.

Market-driven Farming: As discussed earlier, due to incremental transition (linear to market) the crops grown in Mokokchung district are highly influenced by the market. But sometimes this market-driven farming affects the farmers' economic status. The limited markets in the region give them less scope to sell out their products and are mostly dependent on the road-side Mahila Goshtis.[3] Also, the produce goes waste sometimes, because of the unavailability of storage area. As told by the farmers of Mongsenyimti Village:

> Last year (2016-17), the production of ginger was increased as the Government officials came to village and distributed seeds and other necessary items. But they have limited access to market and unavailability of storage places made the produce go waste. Further, the village is located far from the urban areas and lack of transportation creates problem for them to take their produces to the market place.

Thus, the diversification of government support towards transitions for the market economy in the existing structure is not helping the farmers in a significant way. Thus, marketing is a preeminent issue in today's contemporary World. Marketing facilities directly affect the production selling capacity. If the marketing facilities

Table 3. Main Occupation of the Villagers.

Main Occupation	Mongsenyimti	Chuchuyimlang
Cultivator	93	93
Shopkeeper	9	11
Cab Driver	6	4
Teacher	5	8
Student	46	42
Private worker	0	3
Not working (not working or under the age 5 years)	14	9
Total	173	170

Source: Compiled from field survey conducted by the author in 2018.

are improved, the products of the Jhum fields can earn higher prices than they receive in the local markets.

Conclusion

Nagaland is a state which is rich in its resources and has a varied type of climatic and physiographic conditions. This helps in the availability of diverse kind of flora and fauna in the region. This is one reason agriculture is the primary and main source of earning a livelihood in this state. Due to its varied physiographic conditions, agricultural practices are callous to be carried out. The hilly terrains and ridges makes it more difficult for cultivation. Also, the lack of technology and unawareness among the farmers creates a massive gap in the state's economic conditions. Traditionally, *Jhum* cultivation is practised, which includes cutting down of forest area for cultivation. But the nature of *Jhum* is subsistence in nature and thus makes it challenging for the state to meet the need of the increasing population. In this context, terrace cultivation was introduced, which increased the productivity in the region. On the other hand, the local farmers did not quit their old form of agriculture, that is, *Jhum* cultivation.

Thus, the tribes of Nagaland practise both *Jhum* and terrace cultivation. Organic farming is the cultivation of crops with natural supplements such as manures from compost, mixed farming, biological pest control, etc. The production of crops from *Jhum* cultivation is organic. Still, it has not achieved its status of being organic because of the drawbacks and limitations of *Jhum*, which causes adverse effects to the environment. But the products are entirely organic and the farmers do not fetch the actual amount of profit from it. But with the growing need for organic products in the market, the Government of Nagaland has to look into this matter more seriously. With many other organisations, the government is taking part to uplift the marketing of organic products in the neighbouring and international markets, but lack of communication and transport facility, lack of

awareness among the farmers and the subsistence nature of *Jhum* are adding up to the problem. For this particular reason, few initiatives have been taken by the APEDA, NPOF and National Programme for Organic Production (NPOP) organisation to bring up the productivity level by educating the farmers and making them aware of organic products that can earn them a good profit instead of the conventional products.

Nagaland can achieve the status of being organic as it has the knowledge of organic farming and is practising for generations. They are also aware of the drawbacks and have developed steps to limit them as well. Thus, the government schemes, together with the efforts of different organisations, made it possible to make the farmers keener about organic products and their benefits. This helped them to attain a better livelihood and a better economic condition of the state.

Thus, the scheme proposed by the Nagaland Government has shown an increase in the production of organic goods limiting the disadvantages of *Jhum* cultivation. The state's economic condition can be uplifted and the farmers can earn a reasonable amount for the produce. Also, some of the products such as King Chilli, squash, passion fruit have achieved the correct name in the international market, showing the achievement of Nagaland. Further, if these schemes work well and the initiatives are taken more precisely than Sikkim, it will also emerge as one of the organic states of India.

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Notes

1. Stalls alloted to women for selling organic agricultural products grown in home gardens and *Jhum* fields.
2. Farmers, pastoralists, forest keepers, fishers managing area less than 2.0 hectare. (FAO, 2002)
3. *Mahila Goshti*s are road side stalls appointed to the Women of a household, where she can sell agricultural products. This initiative was taken to improve the status of Women in agricultural practices in Nagaland.

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Case Study

Impact of Rural Roads in India: A Case Study Based on Spatial Data Analysis

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Abstract

The Government of India launched its National Rural Roads Program known as Pradhan Mantri Gram Sadak Yojana (PMGSY) to connect the 167 thousand unconnected villages in the country by all-weather roads to improve connectivity there. It is important to study the impact of such intervention on various socio-economic indicators of rural development there. This study assesses the impact of those roads on the different aspects of rural community. The assessment has been completed based on spatial visualisation of the impact created by various facility parameters in rural development using various questionnaires formed and applied on a few selected blocks. Spatial data was collected and integrated using open-source software (QGIS) and statistical analysis has been performed to understand the percentage change in socio-economic indicators related to education, healthcare, agriculture, marketing and employment opportunities which are essential elements of the integrated rural development in India. The analysis appears helpful in estimating the sensitivity of government policies in the context, and thus understanding the requirement of policy changes and implementation in rural India.

Keywords

Pradhan Mantri Gram Sadak Yojana (PMGSY), rural road connectivity, socio-economic impact, rural development, spatial data analysis

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Introduction

The link between economic growth and physical infrastructure (i.e., the expansion of transportation networks) is not an issue of debate for long. But it is always a critical issue when it comes to the fiscal allocation of the government in terms of where to spend more, what types of infrastructure to expand and so on. Rural infrastructure investments are becoming more widely recognised as a necessary precondition for poverty reduction methods in rural regions (Barrios, 2008). In terms of infrastructure, the building of rural roads has been prioritised in developing countries' efforts to reduce poverty (Oraboune, 2008). Despite the importance of rural road construction, access to rural areas in developing countries remains a key barrier. Furthermore, according to Gachassin et al. (2010), roads improve the connectedness of isolated rural areas, allowing access to social and economic opportunities. According to empirical studies, many poor rural villages are separated due to distance, poor road conditions and insufficient transportation services (Mclaren et al., 2013). These circumstances make it difficult for rural residents to gain access to vital services including education, healthcare, job opportunities and marketplaces (Mohapatra & Chandrasekhar, 2007).

It has been proposed in the Seventh Five-Year Plan of India to provide all-weather roads in areas with a population of 1,500 or above and 50 per cent of habitations having a population between 1,000 and 1,500 people. To achieve this target, development of about 130 thousand kilometres of road length with an expected cost of Rs. 31 billion (to give all-weather road connectivity to an extra 25,000 villages under the above criteria) had been proposed during the arrangement time frame between 1985 and 1990. In late 2000, the Government of India launched its National Rural Roads Program known as Pradhan Mantri Gram Sadak Yojana (PMGSY) to connect the 167 thousand unconnected villages in the

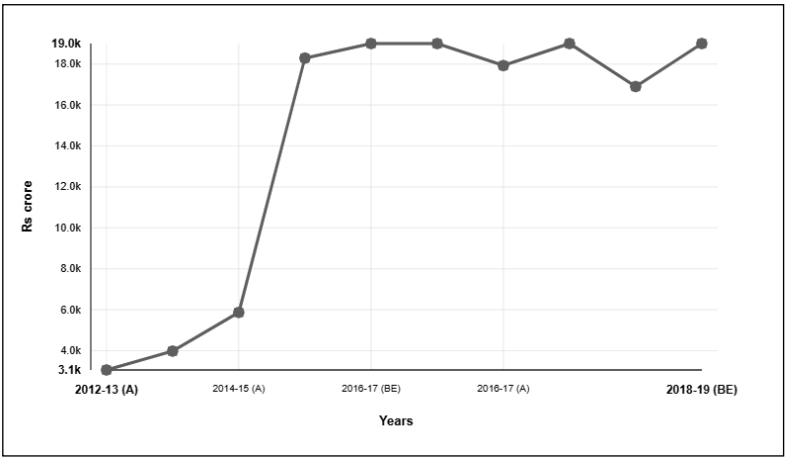

Figure 1. Budget Allocation in PMGSY Roads as in Rs.

Source: Union, 2018.

Note: A = actual estimate, BE = budget estimate.

country by all-weather roads and to improve rural connectivity. The main objective of this program is to provide connectivity to all the unconnected habitations in rural areas with a population of more than 500 persons in the plains and a population of 250–500 persons in hilly and tribal areas. Figure 1 shows the budget allocation for the financial year 2012–2019 as in Rs. (Cr) for the rural road connectivity program (PMGSY).

Obviously, the impact of providing such rural roads is expected to be substantial in terms of bringing various pecuniary and non-pecuniary benefits to the target rural households. In the past, many studies evaluated and reported the effects and impacts of rural road infrastructure on the rural communities. Using a natural experiment, Aggarwal (2018) provides evidence on the impact of roads on a wide variety of economic outcomes in rural areas. Asomani-Boateng et al. (2015) measured the pre and post changes that impacted the rural road improvements in Ghana to analyse the road investments that would yield benefits to eradicate poverty and improve the living standard of rural communities. Sewell et al. (2019) give an idea about how rural road infrastructure influence the poverty alleviation drive in rural areas of the South African community. Modinpuroju et al. (2016) developed a facility-based model to efficiently improve the planning and management of rural road networks. Garg (2008) carried out the GIS-based spatial planning of infrastructural facilities in rural areas.

Gosh et al. (2009) developed a GIS-based spatial decision support system for planning of education and health infrastructure by prioritising the rural areas and facility indices were calculated using principal component analysis for infrastructural planning. Asher and Novosad (2018) estimated the impact of the national rural road construction program using fuzzy regression discontinuity design by using household and census data. Haloi et al. (2021) study the impact of the MGNERGS rural roads connectivity's initiatives on the socio-economic spheres at the village level. Shamdasani (2016) evaluated the impact of PMGSY on agricultural decision making. This study revealed that the provision of rural roads led to the diversification of crops, household began cultivating the commercial crop and also led to the modernisation of cultivation practices through the adoption of improved technologies. Navatha et al. (2015) have used the facility index calculation method in determining the availability and access to the infrastructure by giving ranking to the facility indices using the weighted index method and entropy method. A study by Kanuganti et al. (2015) has attempted to quantify the impact of National rural road program (PMGSY) investment in the health sector; this study revealed that the flagship program has eased the approachability to health facilities.

There are very few studies that focus on estimating the impact of rural roads built through the PMGSY scheme. This study mainly focuses on analysing the impacts of rural roads on rural development under the PMGSY scheme in selected regions of Andhra Pradesh and identified the Mandal having the highest number of rural roads as the study area. The primary purpose is to identify the parameters that impact the rural roads for rural development. The proposed methodology of this study is to spatially visualise the impact created by various facility parameters in rural development using various forms of the questionnaires.

Description of the Study Area

To understand the impact of rural roads on various sectors of the communities, Addateegala Mandal (Block) of East Godavari district and Araku Mandal (Block) of Vishakapatnam district in the Andhra Pradesh have been selected, where the highest number of rural roads were constructed under PMGSY scheme (during 2007–08) as shown in Figure 2. A total of 53 habitations are selected for the study out of which 23 habitations are of Addateegala block of East Godavari district and 29 habitations are of Araku block of Vishakapatnam district, which are shown in Table 1.

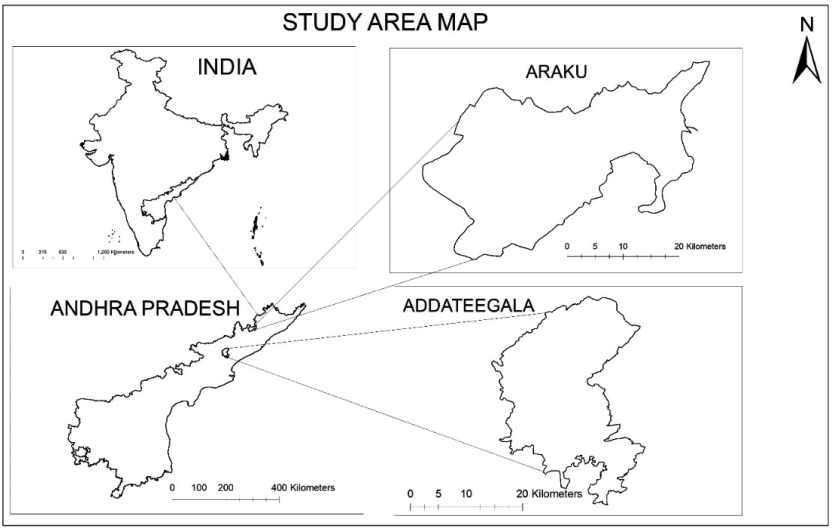

Figure 2. Location of the Study Area Considered for Impact Analysis.

Source: The authors.

Table 1. List of the Villages in the Study Area in Two Regions.

	List of the Villages	
S.No.	Addateegala Region	Araku Region
1	Makavaram	Karaiguda
2	Veeravaram	Swarnayaguda
3	Mitlapalem	Rampuduvalasa
4	Rollagadda	Dernee
5	Ducharti	Gangudi
6	D.Ramavaram	Kandamamidivalasa
7	Danyampalem	Thudumu
8	Vedurunagaram	Malasingaram

(Table 1 continued)

(Table 1 continued)

S.No.	List of the Villages	
	Addateegala Region	Araku Region
9	Dabbapalem	Kaguvalasa
10	Duppalapalem	Vanthamuru
11	Jalluru	Dummuguda
12	Anukumpalem	Dolliguda
13	Seetharam	Gathuguda
14	Chikkapugadda	RK Nagar
15	Patapadu	Majjivalasa
16	Gavvarayyapeta	Nuvvaguda
17	Tinaparthi	Kusiguda
18	Languparthi	Ranajileda
19	Chinnamunakanagadda	Sirlamamidivalasa
20	Rayapalli	Yendapuvalasa
21	Matlapadu	Bheemudivalasa
22	Vangalamadugu	Doravalasa
23	Uppalapadu	Gondivalasa
24	Bongaralapadu	Bishnuguda
25	-	Pittamamidivalasa
26	-	Gadyaguda
27	-	Similiguda
28	-	Kappalagondi
29	-	Thuraiguda

Source: The authors.

Addateegala Mandal has a total area of 540.38 km^2 with a population of 37,241 as per the 2011 census and Araku Mandal has a total area of 264 km^2 with a population of 56,674 as per the 2011 census (LGD, 2019). Addateegala and Araku are the main administrative centres and are located at the intersection of three major routes leading to villages. Addateegala and Araku forms the primary development node of the Mandals and is important for the industry, commerce and other economic activity. Besides these, healthcare, education and marketing centres are the primary base for operations and services. The distribution of services and roads in both study areas is shown in Figure 3.

Methodology

The parameters that impact the rural development were the number of students going to school, mode of travel to school, enrolment in schools, access to

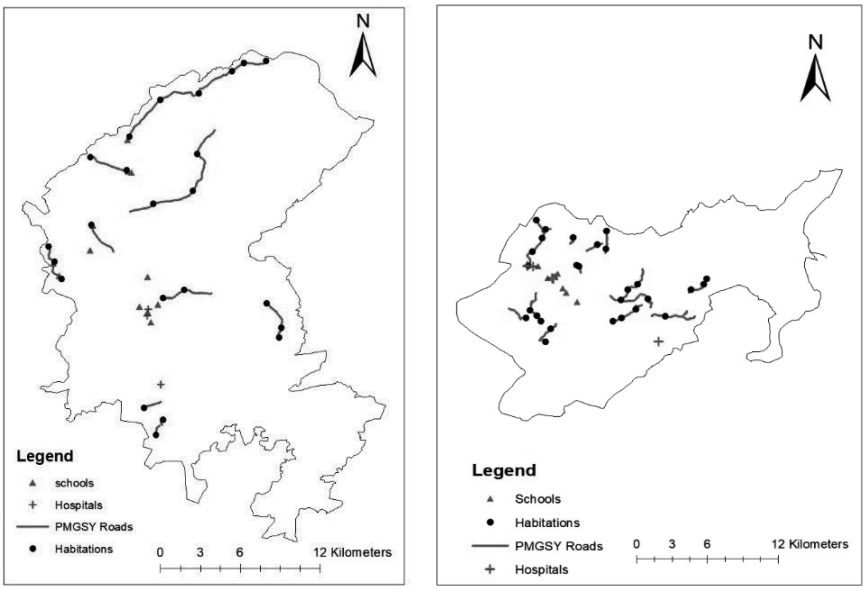

Figure 3. Distribution of Services and Roads in (A) Addateegala and Araku Region.

Source: The authors.

healthcare, time taken to reach the health care centre, health facility visits, availability of seeds and fertilisers, agricultural productivity, crop pattern, crop pricing, access to market, type of marketing, employment through vehicles, employment through establishments, usage of vehicles and transportation cost and so on. A quantitative research design is adopted in which household questionnaire survey was conducted in all the villages of the Mandal in which the scheme was implemented. Random sampling technique was adopted in the study areas, which covered three different age groups by considering male and female, proportionate large, medium and small formers where most of them are middle and poor classes. The collected spatial and non-spatial data were integrated for quantitative and spatial analysis for pre (2007–08) and post (2017–18) road impact using GIS. The socio-economic conditions of 53 villages from two regions are collected to evaluate the impact on the rural roads. Socio-economic data of pre- and post-implementation of the scheme was collected by identifying the various parameters which impact rural development. All the parameters are consolidated to various themes such as education, healthcare, agriculture, accessibility to market, employment and road condition and these themes are categorised into three categories to effectively evaluate the impact of rural roads on rural development.

Spatial data is the information of the physical objects of the earth and it stores geometric coordinates of geographic features as well. Spatial information is generally stored as coordinates and topology, which can be mapped. It is often accessed, manipulated or analysed through GIS using open-access tools such as

QGIS and field observations using DGPS, which produces high accuracy of the spatial location also SW Maps for geotagging of the assets was used. Spatial data is considered an important and unavoidable component in any development planning process. The temporal improvement in the lifestyle of the people in the rural community mainly by the initiatives undertaken by the government can be portrayed by using geospatial technology and it provides a perfect platform for the same (Mandla et al., 2020). All spatial along with the non-spatial database of PMGSY roads were prepared from the field. The non-spatial data that was collected from the study area are tabulated in the spreadsheet and are combined with their corresponding spatial features using GIS tools. Statistical analysis was performed on this data to evaluate the impact of rural roads on rural development.

Discussion of Results

Education Sector

The people in many areas of India lack in proper education due to difficulties in accessing schools. After the implementation of the PMGSY scheme, there is a marked improvement in the education sector because of the improved road leading to better access to the schools and the betterment of the transportation facility. Enrolment in most of the schools has also increased because of the better rural road networks in the village. The changes observed in the education sector of Addateegala region based on the response collected is that the percentage of poor has come down to 4 per cent from 65 per cent, whereas the average has gone up to 67.19 per cent from 17.41 per cent and good is also increased from 17 per cent to 28.49 per cent. Makavaram and Mitlapalem villages also indicated good positive change, that is, from 60.60 per cent to 81.81 per cent and from 66.66 per cent to 94.11 per cent respectively, whereas in Tinaparthi village it is only 12 per cent. There is a canal between the villages Gavvaryyapeta and Tinaparti. Due to

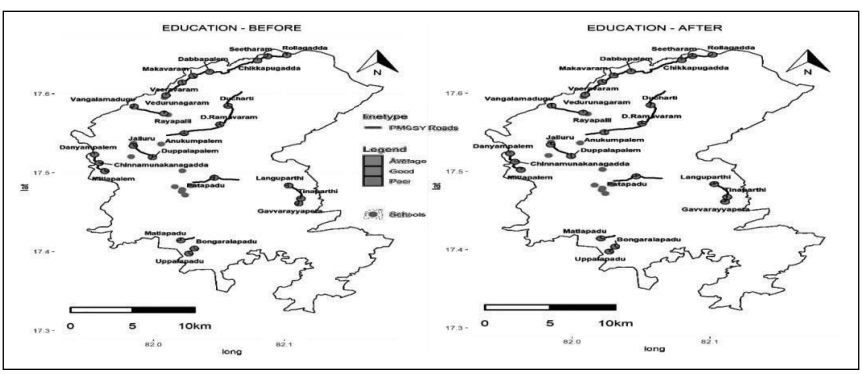

Figure 4. Pre (2007–08) and Post (2017–18) Impact of Education Sector in Addategala Region.

Source: The authors.

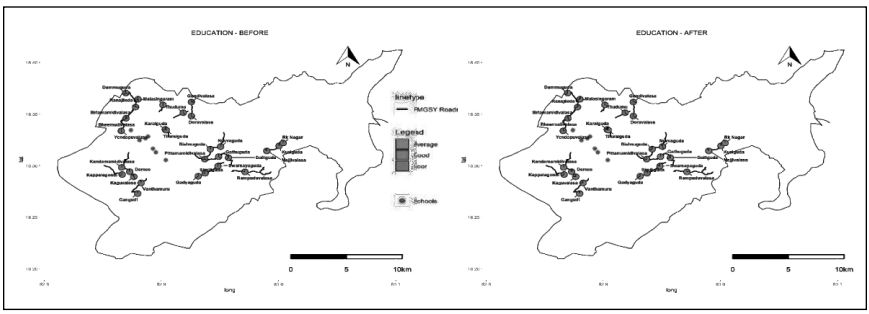

Figure 5. Pre (2007–08) and Post (2017–18) Impact of Education Sector in Araku.

Source: The authors.

the absence of a bridge between the villages, students, as well as many villagers, are facing problems in travelling to distant places and feel isolated. Pre (2007–08) and post (2017–18) improvement of the education sector in both the study areas are shown in Figures 4 and 5.

Before implementation of the scheme (2007–08), the response of the villagers recorded in the villages of the Araku region regarding the education sector graded as poor, average and good was 36.54 per cent,11.53 per cent and 51.91 per cent, respectively. It has however been noticed that after the implementation of the scheme, the overall response has tremendously increased. Not only has the percentage that was graded as poor reduced to 10 per cent, but from the response, it is also observed that the average has increased to 28 per cent from 11.53 per cent and a 10 per cent increment is observed in the good category from 51.91 per cent to 61.62 per cent. The villages with the highest to lowest impacts observed include Similiguda, Gangudi and Kusiguda and Kappalagondi, Gondivalasa and Malasingaram, respectively.

Healthcare

Healthcare is another important socio-economic indicator in rural development, where access to healthcare is the biggest hurdle for rural residents. To analyse the health services in these villages the responses of the villagers are collected and analysed and it is observed that before the implementation of the scheme villages like Rollagadda, Seetharam and Chikkapugadda did not have proper access to hospitals, whereas post-implementation of the scheme had better access as compared to the situation before implementation. From the respondents, the response about the health facilities both before and after the road construction project has revealed that the responses that were graded poorly have reduced from 43.20 per cent to 16.06 per cent, whereas the responses graded as average and good have increased from 22.05 per cent to 27.81 per cent and 34.74 per cent to 56.1 per cent, respectively. Pre (2007–08) and post (2017–18) improvement of healthcare in both the study areas are shown in Figures 6 and 7. In Araku region,

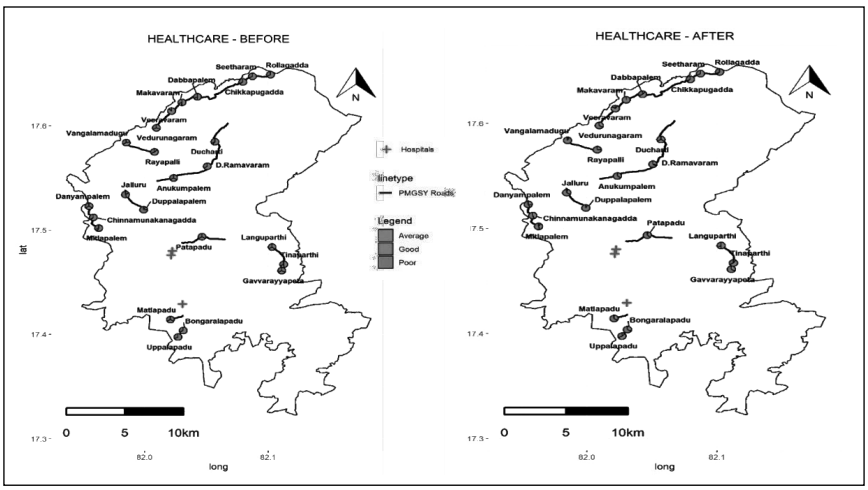

Figure 6. Pre (2007–08) and Post (2017–18) Impact of Healthcare in Addateegala Region.

Source: The authors.

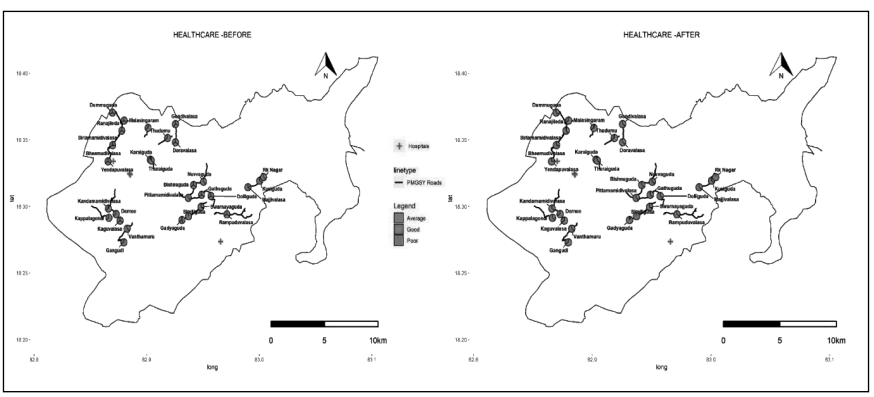

Figure 7. Pre (2007–08) and Post (2017–18) Impact of Healthcare in Araku Region.

Source: The authors.

the healthcare facility has improved after the implementation of PMGSY scheme with poor, average and good changing from 34.02 per cent to 3.57 per cent, 19.79 per cent to 32.92 per cent and 46.18 per cent to 64.49 per cent, respectively.

Agriculture

In Addateegala and Araku region, the major crop production is paddy, cashew, cotton, coffee, red gram and green gram. Due to the implementation of the scheme, there is a tremendous change for the better, in the agricultural sector, as compared

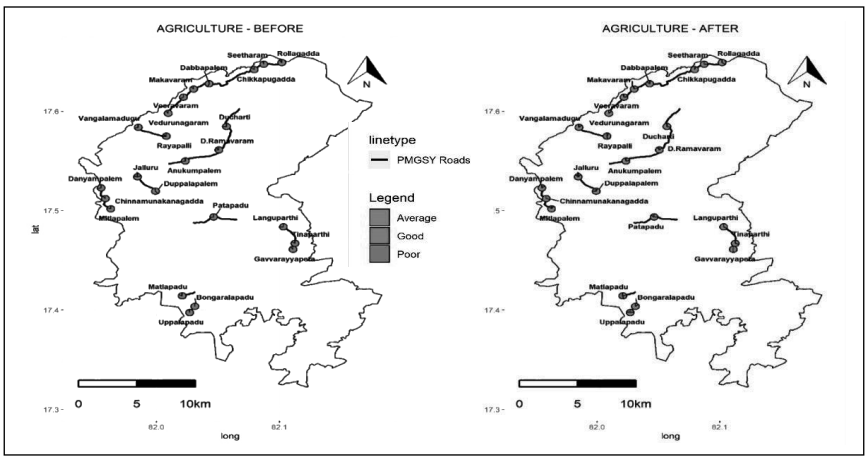

Figure 8. Pre (2007–08) and Post (2017–18) Impact of Agriculture Sector in Addateegala Region.

Source: The authors.

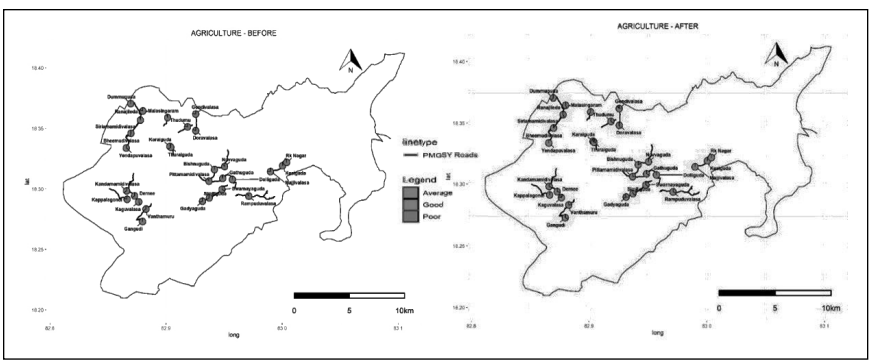

Figure 9. Pre (2007–08) and Post (2017–18) Impact of Agriculture Sector in Araku Region.

Source: The authors.

to the situation before initiating the scheme. An average increase in the agriculture sector from 19.90 per cent to 70.55 per cent and this increase can be attributed to the betterment in road transportation and increased availability of seeds and fertilisers, due to the road network and people were able to sell their produce for a better price. The villages of Araku block are mainly dependent on producing crops like coffee, red gram and green gram. Based on the response of the respondents in the village, there is an average impact on the percentage change in the agriculture sector in the Araku region, that is, 22 per cent to 70.62 per cent before and after the implementation of the scheme. Pre (2007–08) and post (2017–18) improvement of agricultural sectors in both the study areas are shown in Figures 8 and 9.

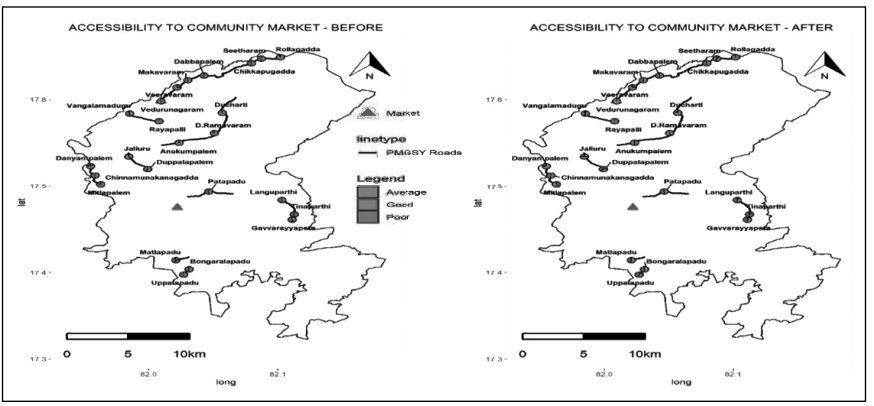

Figure 10. Pre (2007–08) and Post (2017–18) Impact of the Market on Accessibility in Addateegala.

Source: The authors.

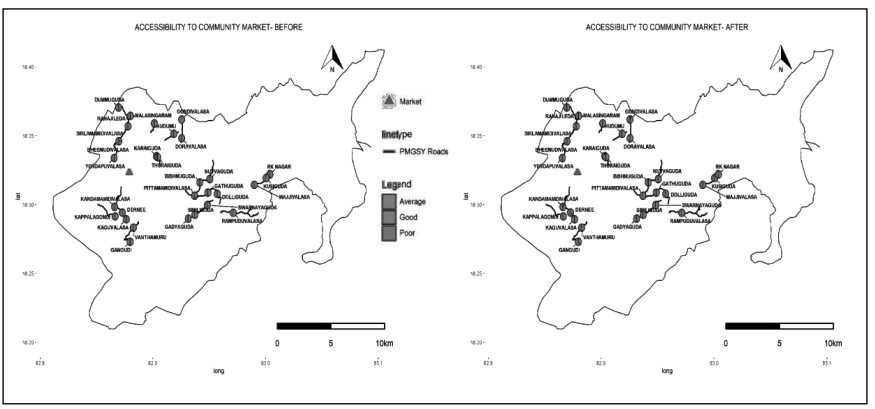

Figure 11. Pre (2007–08) and Post (2017–18) Impact of the Market on Accessibility in Araku.

Source: The authors.

Market Access

Due to the implementation of the scheme, market network efficiency has also improved, which enables the farmer's interactions with different markets to sell their farm produce. The road improvement program has extended the reach of recipient communities' markets. This is demonstrated in the capacity of farmers to access higher-order markets and the related benefits of better pricing for food commodities. Due to improper roads, people used to sell their products in the villages themselves but after the implementation of the rural road network, people

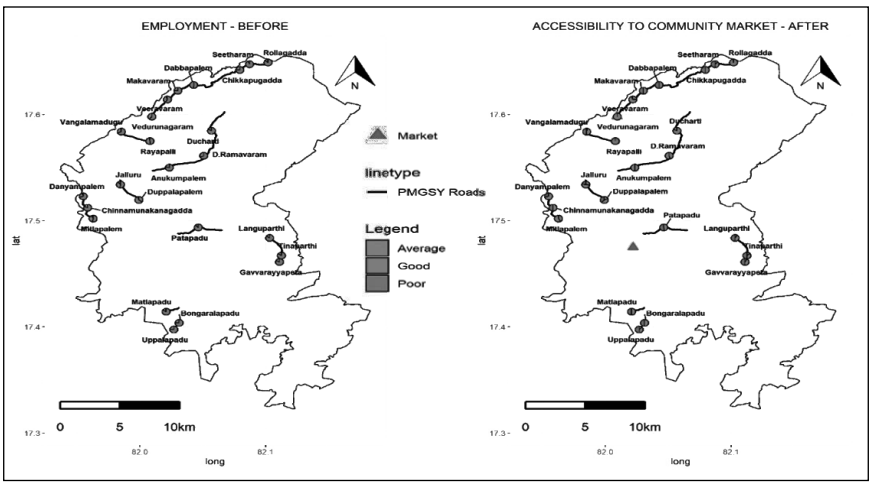

Figure 12. Pre (2007–08) and Post (2017–18) Impact of the Road on Employment in Addateegala.

Source: The authors.

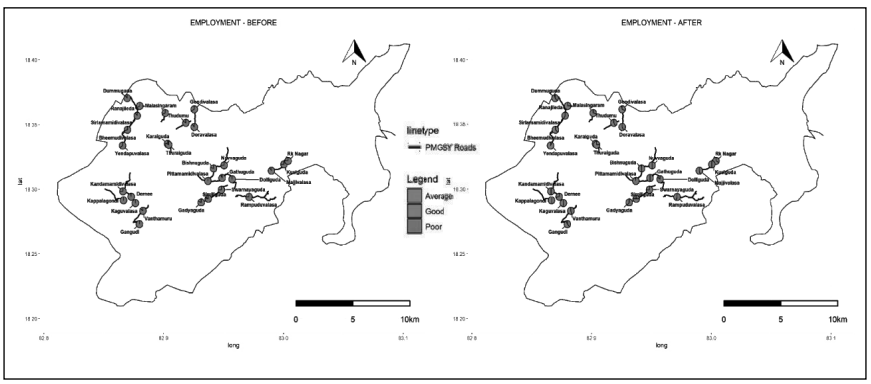

Figure 13. Pre (2007–08) and Post (2017–18) Impact of Rural Roads on Employment in Araku.

Source: The authors.

began transporting their produce to the district centres for better pricing. Pre and post improvement of access to the market in both the study areas is shown in Figures 10 and 11. People in these regions have been benefitted from better access to market facilities after scheme implementation. People used to suffer from improper road access to markets in order to sell their farm products, but now it has become easy. Commerce in this area has also increased, the market accessibility improved from 32.4 per cent to 35.34 per cent after the construction of the rural roads in the Addateegala region. Due to average agricultural production in the Araku region, there is an average percentage change in the people accessing the

district and village markets. Before (2007–08) and after (2017–18) the implementation of the scheme the average market accessibility increased from 1 per cent to 45 per cent.

Employment Opportunities

Rural roads not only impacted sectors like education, healthcare and agriculture but also created employment opportunities for many households. Due to road and access improvement, employment opportunities have been created in villages. People bought autorickshaws and load transport vehicles (three and four wheelers) to facilitate transportation of commuters and goods. New establishments like hotels and shops sprang up all along with the road network, creating more job opportunities. Villagers in villages also got employment and formed a major workforce in farmlands to carry out farm work. Pre (2007–08) and post (2017–18) impact on employment in the study areas are shown in Figures 12 and 13. Employment of farm and non-farm labour has increased after the implementation of the scheme and there is a marginal growth in the employment opportunities as compared to before the implementation of the scheme, that is, 1 per cent to 13.34 per cent. In Araku region it is observed that there is a more than average employment generation in this region, an increase from 16.59 per cent to 52.68 per cent before and after the implementation of the scheme.

Road Condition

Before (2007) the implementation of the PMGSY scheme, the people of many villages faced difficulty selling their goods in district markets that are located in distant places. Due to the lack of properly paved roads, many students and villagers in the villages faced problems while travelling to school or for healthcare. During the rainy season, people used to suffer a lot because of the muddy roads. After (2018) the construction of PMGSY roads, it has resulted in an increase in ease of transport of their goods to the markets and faster access to both education and health facilities. This also reduced the transportation cost and there has been an improvement in the ownership of vehicles after the implementation of the program. Pre (as a metal road) image cannot be obtained since geotagging was not introduced and post improvement of road condition is shown in Figure 14, and Figure 15 shows that A is the Google Earth maps and B shows that the Geotagged road condition at the time of field observation.

Before the road construction program, people found difficulty in accessing basic facilities like education, healthcare and marketing. The implementation of the PMGSY scheme has changed the face of road conditions in villages. The average of all villages that benefitted from better access under the scheme.

Road condition in Araku region is not so good. Before the implementation of the scheme, people found it difficult to travel to distant places. However, after the implementation of the PMGSY scheme, the condition of the roads changed for the better from nearly 0 per cent to 49.61 per cent.

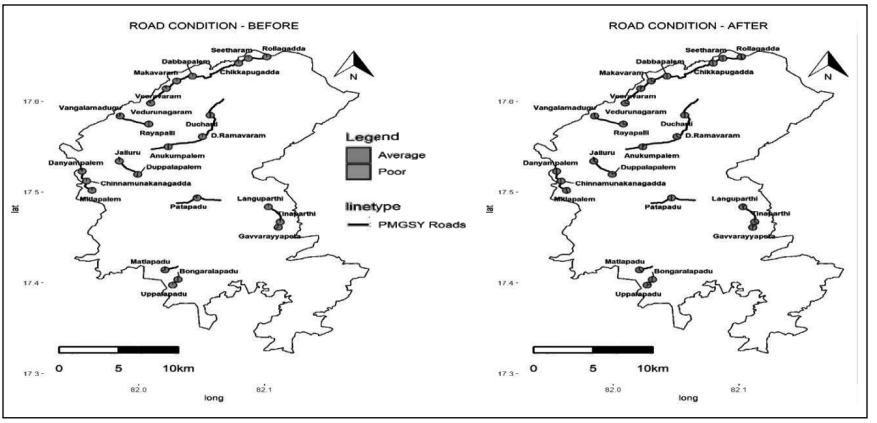

Figure 14. Pre (2007–08) and Post (2017–18) Improvement of Road Condition in Addateegala.

Source: The authors.

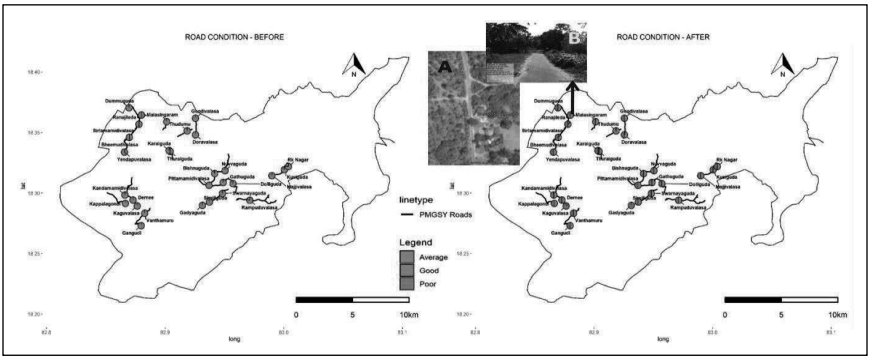

Figure 15. Pre (2007–08) and Post (2017–18) Improvement of Road Condition in Araku Region.

Source: The authors.

Note: A is the road showing on Google earth image and B shows that geotagged road condition.

Conclusion

The results in the article specify the level of impact on various socio-economic parameters on rural development during 10 years (2007–2018). This spatial and statistical analysis helps to understand the percentage change in each of these socio-economic parameters, such as education, healthcare, agriculture, marketing and employment opportunities, which has an indirect influence on the overall development of the rural community. Healthcare in the Addateegala region has a high percentage impact compared to other sectors whereas employment opportunities showed very little impact. Also, results indicate the influence of

rural roads on the education sector is high for few villages, such as Makavaram and Mitlapalem, where the indicated good positive changes are in areas that are not covering many canals/rivers, whereas the topography covering/crossing these rural roads by canal/rivers have indicated less impact; therefore, in times of sectioning these kinds of roads, the government policymakers should consider improving or connecting these canals/rivers with small bridges.

The agriculture sector indicated an average improvement and the availability of seeds and fertilisers are improved at local agriculture stores/offices. However, a slight adverse impact is observed in the agriculture due to water scarcity and the financial status of people in the Araku region which indicates that a few government schemes are needed to be converged towards watershed management there. Rural roads are provided better marketing facilities and they are not restricted themselves at local selling and expanded to regional marketing and exports. Therefore, this indicates that an increased income of the agriculture might have helped poverty alleviation. Comparatively, Addateegala has a high impact than the Araku region. This, to some extent, influences the standard of living of the people of the rural community.

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