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Using the DSSAT-CROPGRO model to simulate gross margin and N-leaching of cowpea fertigated with human urine

David Lomeling* and Salah Joseph Huria

Department of Agricultural Sciences, College of Natural Resources and Environmental Studies (CNRES), University of Juba, P.O. Box 82 Juba, South SUDAN

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ABSTRACT

This study simulated the biophysical, economic and environmental implications of cowpea fertigated with human urine (equivalent to 60 kg N ha⁻¹) as source of organic N. The DSSAT CROPGRO model was used to simulate harvested cowpea yield, N\textsubscript{leached}, N\textsubscript{uptake}, monetary returns or gross margins in ($) under two different treatments: without fertigation or human urine (T₀) and with fertigation (T₁). Biophysical analysis using the Cumulative Probability Distribution (CPD) showed a 50% probability of the harvested cowpea yield under T₁ being higher than under T₀ at 1060 and 600 kg ha⁻¹ respectively, accounting for a 43.4% difference. The Mean Gini Stochastic Dominance (MGSD) analysis was used to assess the gross margin and helped in deciding on the best strategic and management option. The findings of this study revealed a 50% probability (CPD\textsubscript{0.5}), of higher gross margin under T₁ at $ -215 higher than under T₀ at $285. This was a $70 difference per season under T₁ and so enhancing a faster payback and a larger monetary return on overall investments. Similarly, seasonal analysis with fertigation showed that at CPD\textsubscript{0.5} the N\textsubscript{leached} was still < 4 kg N ha⁻¹ per season and so posed no environmental risks. The simulation results also showed a higher probability of N\textsubscript{uptake} of about 270 kg N ha⁻¹ during fertigation compared to about 95 kg N ha⁻¹ under T₀. Therefore, the DSSAT CROPGRO model can be used to successfully forecast future cowpea yields, gross margin, N\textsubscript{leached}, N\textsubscript{uptake} under different management practices to enable smallholder farmers in South Sudan make informed decisions on sustainable cowpea production.

INTRODUCTION

There are increasing concerns about the accessibility, availability and affordability of industrial N-fertilizers to boosting crop yields especially in developing countries. For most smallholder farmers in Africa, these are compelling reasons enough to start seeking alternative N-sources. Studies have shown that most soils in Sub-Saharan Africa are over 80% N-deficient (Liu et al., 2010), whereas other studies have reported increasing acidification due to poor agronomic practices and long term use of inorganic N-fertilizers like; Diammonium Phosphate (DAP (NH₄)₂HPO₄) or Calcium Ammonium Phosphate (CAN (Ca(NO₃)₂•NH₄•10H₂O) although with lesser acidic effect in soils than DAP. As in most rural and peri-urban settings in S. Sudan, over 95% of all human excreta (feces and urine) are disposed of, arbitrarily onto the environment, or through a decentralized sewer system comprising mostly of individual septic tanks at households that are occasionally emptied by commercial exhausters. For Juba City and its peri-urban surroundings with an approximated population of 450,000, it is estimated that the human urine amounts generated daily would be about 225,000 liters. If properly stored and handled, this nutrient rich and readily available organic N-source would augment the already scarce industrial fertilizer market supply in the country and be part of...
an ecosystem-based adaptation practice. However, current published data on the application of human urine (Sene et al., 2013; Ranasinghe et al., 2016; Andersson, 2016; Araújo et al., 2017) as a viable fertilizer option are derived from short term studies and are insufficient to adequately assess the agronomic, economic and environmental implications of its use. However, one critical risk component in the widespread use of human urine or fertigation (ferti-lizer + irri-gation) across many developing countries of Sub-Saharan Africa would be the local and regional water scarcity. Water scarcity compounded by the erratic spatial and temporal rainfall distribution variabilities would make its use difficult or outright impossible. Thus, it is imperative, that knowledge on the spatio-temporal water availability and accessibility for most smallholder farmers who practice rained agriculture, be integrated into the respective country agricultural policies and implementation programs when evaluating the use of human urine. Moreover, farmers’ willingness to adopt the use of human urine will depend not only on the available infrastructure in terms of hygienic storage, transportation and dosing, but also on the anticipated increased yields and profitability.

For the sustainable use of human urine as an economically and ecologically viable option for most households in Sub Sahara Africa, systematic research and long-term field tests need to be carried out and simulations conducted with dynamic crop models such as the CROPGRO of the DSSAT (Jones et al., 2003). The model under different management conditions can be used to quantify crop yields, economic returns as well as assess environmental impacts due to N-leaching.

Cowpea is one the major food crops in Central Equatoria State of South Sudan and an indispensable source of cheap and easily available plant protein. The young and tender leaves are consumed traditionally as yete while the ripened and mature seeds as pirinda (Lomeling et al., 2014a). With fertigation, cowpea can be produced in small farms or household backyards during any time of the year. It is a highly remunerative crop with price increase several times its normal value especially during the annual “hunger spells” of mid-July to Mid-August. However, increasing price of potable water and the large influx of Internally Displaced Persons (IDPS) due to current civil war, cowpea production per household has significantly decreased within and around Juba municipality. Similarly, cowpea production, as a cheap source of plant protein, is not only threatened by a reduced availability of irrigation water but also declining soil fertility caused increased and extreme elimination of soil nutrients as well as decrease in soil functional characteristics (Lomeling et al., 2016a). As a drought resistant plant, reduced irrigation is not necessarily a limiting factor, since soil moisture requirements during cowpea phenology show temporal variability between 15-30% (Lomeling et al., 2016b). However, soil moisture contents <15% at any one developmental stage of growth has adverse effects on the germination rate, flowering, canopy height, pod-setting and maturity (Abayomi and Abidoye, 2009; Suliman and Ahmed, 2010; De Souza et al., 2017). Reduction in cowpea yield is not only attributable to insufficient soil moisture during growth, but also to such abiotic stress factors like phosphate (P) deficiency (Jemo et al., 2017; Goufo et al., 2017; Fatokun et al., 2012; Agele et al., 2018). Although Eutric leptosols are the major soil type around Juba County and can be perceived to be of moderate to good fertility, sustained cultivation over longer period without any concerted soil amendments may ultimately pose serious soil fertility challenges. Cowpea is known to sustain soil health by fixing atmospheric N to about 200 kg N ha\(^{-1}\) (Giller, 2001; Rusinamhodzi et al., 2006; Adjei-Nsiah et al., 2008) social evaluation of productivity, yield and N\(_2\)-fixation in different cowpea varieties and their subsequent residual N effects on a succeeding maize crop and can leave a positive soil balance of up to 92 kg N ha\(^{-1}\) (Chikowo et al., 2004; Rusinamhodzi et al., 2006). The use of composted tannery sludge was also found to sustain cowpea yield during a six-year period (Araújo et al., 2016); increased cowpea yield after application of biochar in loamy sand soil (Pudasainia et al., 2016); increased cowpea biomass after addition of nitrogen fertilizers (Hasan et al., 2010).

The CROPGRO model as an ex ante analytical tool has been successfully demonstrated across a broad range of soil, management and climatic conditions in tropical environments (Bastos et al., 2002; Banterng et al., 2010; Lomeling et al., 2014; Zinyengere et al., 2015). It can be used for assessing the effects of diverse management options on crop phenology as opposed to that of “business as usual” or the status quo. It can also be used to assess the type of promising or similar climate smart technologies whose “low scale” investments are not only remunerative, but also financially affordable as is the case for most smallholder farmers in South Sudan. Model projections during simulations can be used as basis for long-term actionable trends in terms of assessing food demand and agricultural production based on projected changes in population, income, technology, and climate (Robinson et al., 2015). Examples on the use of CROPGRO models have been reported in several studies on bean (Oliveira et al., 2012); on saaflower (Singh et al., 2017); on faba bean (Boote et al., 2002); on peanut (Halder et al., 2017). Rainfall forecasts for South Sudan are mostly reported by (FEWSNET, 2018) and are generally limited to short-term one to three months lead time. South Sudan still lacks a good infrastructure, network of weather stations as well as skilled personal to capture and store weather data in real-time. The absence of such important historical weather data therefore makes any long-term predictions on rainfall occurrence, amounts and intensity difficult. The CROPGRO model requires daily, monthly or annual rainfall amounts as an input variable, thus, simulation of crop yield for most parts of South Sudan in the absence of such relevant data may simply be a speculative exercise. In our study, we sought to assess the effects of fertigation on cowpea yield and the economic and ecological implications using CROPGRO-DSSAT model.
MATERIALS AND METHODS

Study region
The experimental study was conducted as from May till September 2015 at the Demonstration and Research Plots of the Department of Agricultural Sciences, University of Juba. The study area is located in Juba County, Central Equatoria State at 4°51’33 N latitude, 31° 34’ E longitude and at elevation of about 500 m above sea level. The climate is sub-tropical with mean annual rainfall of 800–1200 mm and a predominantly unimodal distribution. About 80–90% of the rainfall occurs during the rainy months (April–October) with a short dry spell around July. The soil (Eutric leptosol) is sandy loam in texture, mild acidic to alkaline in reaction (pH 6.5 - 7.5), low organic carbon by weight (0.55%), CEC in soil (14 cmol/kg) (Table 1).

Experimental design and treatments
The experiment was a Randomized Complete Block Design (RCBD) with two different treatments with five replications each and was conducted from May to September 2015. Each trial was arranged in four randomized complete blocks. Traditional agricultural practices of tillage, seed bed preparation and pest control against aphids, grasshoppers, leaf sucking bugs using ashes from burnt plant leaves were applied. Occasionally, a broad-spectrum pesticide Malathion with application rate of 0.5 l/ha was applied, where the traditional pest control method proved ineffective. Each plot consisted of 5 rows, 2.5 m long, with a spacing of 30 cm between plants and 50 cm between rows. The size of each plot was 5.4 m² with seeds drilled at a sowing depth of 5 cm and density of 30 plants/m². The control treatment (irrigation water + No human urine) was designated as T0, while (irrigation water + human urine: 2 liters per 20 liters water) as T1. The calculated N fertilizer from T1 was about 60 kg/ha. Irrigation under both treatments was done once the soil moisture level reached about 15%v/v and was measured using the Theta Soil Moisture Sensor ML3 (Eijkelkamp Agrisearch).

CROPGRO model runs
All input variables and modules for soil (SAUR900001.SOL) and cultivar (CGRO045.CUL) were kept unchanged as reported by (Lomeling et al., 2014b). The required weather data for DSSAT WEATHR module, the WGEN subroutine was run to capture the daily rainfall, minimum and maximum air temperature, solar radiation, relative humidity, and wind speed. For Juba County, these data were obtained from the publicly accessible servers of the National Oceanic and Atmospheric Administration (NOAA) of the US Department of Commerce for the years 1980–2014. For the biophysical analysis, the simulated yield in kg ha⁻¹ was that valued at physiological maturity while the observed yield (kg ha⁻¹) derived from 1000-seed weight. For model calibration (Y2014), cowpea yield from 2014 was used.

Estimation of monetary returns
The seasonal analysis for the 2015 season was used to assess the gross margin and economic returns for a five-year period. In our study, the base production or total variable costs, that included: labor costs, material, costs (seed purchase, water for irrigation, insecticide, transport, ancillary cost, levy taxes) were constant during the simulation period. Similarly, the produce sale or accrued total revenue, ignoring price volatility due to inflation and price hiking were also kept constant. The Gross Margin (GM) per unit time or season was estimated as the difference between the Total Revenue (TR) and the Total Variable Costs (TVC) as (Eq. 1).

\[
GM = \sum_{i=1}^{n} [TR - (TVC + R)](t+1)
\]  

(1)

Where \(n\) is the number of growing seasons, \((n+1)\) each subsequent growing season and \(R\), an intrinsic and inevitable risk factor that is quantifiable and depends on unpredictable weather conditions, arbitrary tariff barriers (illegal taxes by corrupt officials), accidents, poor sale price as well as other unaccounted risks. \(R\), in an especially risk-prone production area like in S. Sudan, makes its assessment imperative, as it determines degree of risk aversion of most smallholder farmers. For our study, the breakdown cost-variables used for the seasonal analysis for the test plots are projected to real field dimensions are given in Table 2.

Strategy Analysis-Mean Gini Stochastic Dominance (MGSD)
The estimation of the GM in (Eq. 1) for both treatments may be used to examine and compare the MGSD. This is a measure of the most economically viable and preferable management option with a stochastic dominance. For two risky options, \(x\) and \(y\), then \(x\) dominates \(y\) by MGSD, should (Eq. 2 and Eq. 3).

\[
E(x) > E(b)
\]  

(2)

or if:

\[
E(x) \cdot \Gamma(x) > E(y) \cdot \Gamma(y)
\]  

(3)

Where \(E(*)\) is the means of the GM and \(\Gamma(*)\) the Gini coefficient, \(0 \leq G(*) \leq 1\).

RESULTS AND DISCUSSION

Biophysical Analysis: Grain yield and fertigation
The biophysical analysis compares the harvested yield (kg ha⁻¹) under both treatments and expressed as a cumulative function in 0, 25, 50, 75 and 100th percentiles. We used the Cumulative Probability Distribution (CPD) to estimate the probability of the tested variables (yield, \(N_{uptake}\) or \(N_{fixing}\)) under each treatment. The results of the five-year simulation with CROPGRO cowpea when considering the highest CPD0.75, were well simulated and consistent with the one-year empirical findings of the calibrated cowpea yields of 2014. The yield values were about 705 and 983 kg ha⁻¹ for \(T_0\) and \(T_1\), respectively, while the calibrated value in 2014 was at 588 kg ha⁻¹ (Table 3).
The observed yield difference between T₀ and calibrant Y2014 was 117.0 kg ha⁻¹ this was 16.6% higher, whereas the difference of the under T₁ to T₀ was 278 kg ha⁻¹ about 28.2%. The mean value between T₁ and calibrant Y2014 was about 394.8 kg ha⁻¹ and 40.2%. The simulated cowpea yield at CPD₀.25 for T₀ and T₁ were 760 and 1050 kg ha⁻¹ respectively, accounting for a 27.6% difference. At CPD₀.5, the simulated yields for T₀ and T₁ were 800 and about 1075 kg ha⁻¹ respectively accounting for 26% difference. At CPD₀.75 the simulated harvested yield for T₀ and T₁ were 750 and about 1115 kg ha⁻¹ respectively, accounting for 32.7% difference (Figure 1). The simulation shows that, the probability of having higher yields especially under fertilization was significantly high. The CROPGRO model satisfactorily simulated the positive effect of human urine on cowpea yield. This positive effect is particularly attributable to the role of macro- and micro elements contained in the urine (Lomeling and Huria, 2019).

In other words, even when considering the lowest CPD₀.25, there was still a 25% probability that the simulated yield under either T₀ or T₁ treatment would still be greater than the average yield of 588.4 kg ha⁻¹ (considering the calibrant Y2014). Furthermore, the yield range under both treatments was consistent with that reported by (Saka et al., 2018; Kamai, 2014) for semi-arid zone of Nigeria; but comparatively higher than that reported by (Kimiti et al., 2009) in the semi-arid zone of Eastern Kenya. The results of the five-years simulation study showed that, fertigation using human urine is a viable and stopgap indispensable option to obviate any shortcomings of inorganic fertilizer availability and supply for smallholder farmers in Africa. The simulated mean difference in cowpea yields under both treatments was consistent and invariable even at CPD₀.75 and CPD₁.0, respectively, suggesting the viability of T₁ treatment as a better option for most farmers to achieving higher yields than T₀.

Seasonal Analysis: Nitrogen uptake during cowpea phenology

During cowpea phenology, the five-years long-simulation results identified N uptake as the predominant pathway in the N-balance (Figure 2). At CPD₀.25 the N uptake for T₀ was about 85 kg ha⁻¹, while this about 250 kg ha⁻¹ for T₁ indicating a 66% difference of about 165 kg ha⁻¹. At CPD₀.30 the N uptake was at about 95 kg ha⁻¹ for T₀ and 260 kg ha⁻¹ for T₁ showing a 65.4% difference of about 165 kg ha⁻¹. At CPD₀.75, this was about 95 kg ha⁻¹ for T₀ and 275 kg ha⁻¹ for T₁ indicating a 65.5% of about 180 kg ha⁻¹. The study showed that at any rate, there was a high probability that the average N uptake between both treatments would be about 167 kg ha⁻¹. This is attributable to the positive effect of fertilization. Especially Phosphorous (P) contained in the urine must have enhanced further nodulation and N fixation (Kyei-Boahen et al., 2017) as well as boosted microbial activity within the rhizosphere. The resultant effect is, increased vegetative growth during phenology inevitably leading both to increased water as well as N-uptake. Unlike under treatment T₀, the significance of fertilization under T₁ in enhancing N-fixation and uptake can be understood from the role of “micronutrients” contained in the urine. Several micronutrients like Iron (Fe) are essential for legume-rhizobium symbiosis (Brear et al., 2013), copper (Cu) for the synthesis of cupro-proteins during N-fixation (Senovilla et al., 2017), zinc (Zn) whose role in Cu-rich soils can influence N-fixation (Stowhas et al., 2018). However, the sandy loam soil (Eutric leptosol) in our study, was found to have very low levels of Cu, Fe, Zn and so therefore, supplementing these micronutrients through fertigation was particularly critical for N-fixation and eventual uptake.

Figure 3 shows the effect of fertigation on cowpea yield in kg ha⁻¹ per irrigation schedule. At CPD₀.25 the simulated yield under T₀ and T₁ were about 12.5 and 15 kg ha⁻¹ per irrigation schedule respectively, accounting for about 2-3 kg or 16.7% difference between both treatments. The yield remained unchanged between 2-3 kg/irrigation schedule at both CPD₀.25 and CPD₀.75. Apparently, a ten-fold increase in irrigation schedules for both T₀ and T₁ would yield an agronomic response of between 20-30 kg. Therefore, increasing irrigation schedules to about 20 times especially during dry spells would yield a further 40-60 kg. It appears, that further increase in irrigation schedules would positively correlate with yield increase of cowpea under both treatments but could conversely increase production costs through purchase of further water barrels thereby reducing the gross margin.

N-leached during fertigation

The soil N leached varied considerably between both treatments, ranging from 0 to 14 kg ha⁻¹ (Figure 4). There was no significant difference in N leached for both treatments at CPD₀.25 and CPD₀.5, indicating that there was a 25 or 50% probability that the N leached would not exceed 2 kg ha⁻¹. The results of this study showed that the application of 60 kg N during fertigation did not result in higher N leached as when under T₀ suggesting that, this was an optimum N crop requirement for cowpea and reflecting good N-fertilizer use efficiency. Such low N leached would indicate higher N uptake of especially NO₃⁻ after both nitrification and ammonification processes in the soil. There was a slight difference at CPD₀.75 though not significant (p<0.05). The largest difference in N leached was at CPD greater than 0.75 at 7 and 13 kg ha⁻¹ for T₀ and T₁ respectively. The magnitude may be influenced by several soil and agronomic factors, e.g. type of soil, actual amount of soil moisture, preceding crops, type and quantities of manure or plant residues. Similar studies reported higher NO₃ leaching of about 20 kg ha⁻¹ y⁻¹ after faba bean cultivation, than after non-leguminous crops in clay soil (Stenberg et al., 2012), while during a 3-year test trial on loamy sand, the NO₃ leaching was about twice as high following a barley–pea intercrop compared with spring wheat or spring barley (De Notaris et al., 2018). Another study by (Kayser et al., 2010) on a sandy soil in northwestern Germany reported 83 kg N ha⁻¹ leached in triticale following field bean. Despite fertigation and the high anticipated N-leaching under T₁, the N leached under both treatments was correspondingly low and could be attributable to: a) the rapid rate of ammonification or mineralization of organic N to NH₄⁺; b) immobilization of NH₄⁺ by soil microorganisms.
Table 1. Some of the physical and chemical properties of sandy loam soil (Eutric leptosol) at University of Juba Research and Demonstration Farm.

<table>
<thead>
<tr>
<th>Soil physical and chemical features</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil mapping unit*</td>
<td>Eutric leptosol</td>
</tr>
<tr>
<td>Texture Classification</td>
<td>Sandy loam</td>
</tr>
<tr>
<td>Drainage Class (0-0.5)</td>
<td>Moderately well</td>
</tr>
<tr>
<td>Sand (average)</td>
<td>48.9%</td>
</tr>
<tr>
<td>Silt (average)</td>
<td>43.7%</td>
</tr>
<tr>
<td>Clay (average)</td>
<td>7.4%</td>
</tr>
<tr>
<td>pH (LaMotte STH Test Method)</td>
<td>7.0</td>
</tr>
<tr>
<td>Nitrate-Nitrogen</td>
<td>22.68 kg/ha</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>170.1 kg/ha</td>
</tr>
<tr>
<td>Sulphate</td>
<td>1000ppm (parts per million)</td>
</tr>
<tr>
<td>Iron</td>
<td>1.36 kg/ha</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Medium</td>
</tr>
<tr>
<td>Calcium</td>
<td>396.9 kg/ha</td>
</tr>
<tr>
<td>Bulk density</td>
<td>1.34 (gm/cm³)</td>
</tr>
<tr>
<td>Humus content</td>
<td>2.95%</td>
</tr>
</tbody>
</table>

Source: Harmonize World Soil Data viewer version 1.2.

Table 2. Cost-price for different input variables for cowpea under two different treatments.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cost/unit in $</th>
<th>Quantity(ies)</th>
<th>Mean amount ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation water</td>
<td>1.5³ per barrel (200 liters)</td>
<td>20,000 liters (ca. 2 water tankers)</td>
<td>150</td>
</tr>
<tr>
<td>Cowpea seed cost</td>
<td>1.2³ per kg</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Labor</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Fertilizer or organic amendments (N, P, K)</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Mean sale price (simulated under T₀)</td>
<td>1.6 per kg</td>
<td>800 kg ha⁻¹</td>
<td>640</td>
</tr>
<tr>
<td>Mean sale price (simulated under T₁)</td>
<td>1.6 per kg</td>
<td>1070 kg ha⁻¹</td>
<td>856</td>
</tr>
<tr>
<td>Mean sale price (observed under T₀)</td>
<td>1.6 per kg</td>
<td>705.4 kg ha⁻¹</td>
<td>563.5</td>
</tr>
<tr>
<td>Mean sale price (observed under T₁)</td>
<td>1.6 per kg</td>
<td>983.1 kg ha⁻¹</td>
<td>786.5</td>
</tr>
<tr>
<td>Mean sale price (under calibrant Y2014)</td>
<td>1.6 per kg</td>
<td>588.4 kg ha⁻¹</td>
<td>470.7</td>
</tr>
</tbody>
</table>

a) and b) 1 $ equivalent to 25 South Sudanese Pounds (2014) prior to inflation.

Table 3. The effects of fertigation on some phenology parameters of cowpea.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nr of pods/plant</th>
<th>Nr of seeds/pod</th>
<th>Nr of seeds/plant</th>
<th>1000-seed weight (gm)</th>
<th>Mean observed yield (kg/ha)</th>
<th>Mean simulated yield (kg/ha) at CPD₀.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>14</td>
<td>11</td>
<td>154</td>
<td>81.8</td>
<td>705.4</td>
<td>850</td>
</tr>
<tr>
<td>T₁</td>
<td>16</td>
<td>13</td>
<td>208</td>
<td>84.4</td>
<td>983.1</td>
<td>1125</td>
</tr>
<tr>
<td>Calibration Year 2014</td>
<td>12</td>
<td>11</td>
<td>132</td>
<td>79.6</td>
<td>588.4</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Nitrogen Use Efficiency (NUE) in cowpea fertigated with human urine.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Soil Nᵢndigenous (kg ha⁻¹)</th>
<th>Nᵢfertigation (kg ha⁻¹)</th>
<th>Nᵢuptake (kg ha⁻¹) at CPD₀.75</th>
<th>Nᵢreached (kg ha⁻¹) at CPD₀.75</th>
<th>Nᵢresidual (kg ha⁻¹)</th>
<th>NUE² = Nᵢᵩᵣ/[Nᵢᵩᵣ + Nᵢᵩₑ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>22.7</td>
<td>0</td>
<td>93</td>
<td>2</td>
<td>68.3</td>
<td>79%</td>
</tr>
<tr>
<td>T₁</td>
<td>22.7</td>
<td>60</td>
<td>272</td>
<td>3</td>
<td>186.3</td>
<td>76%</td>
</tr>
</tbody>
</table>

NUE= Nitrogen Use Efficiency; Nᵢᵩᵣ = amount taken up by plant kg ha⁻¹; Nᵢᵩₑ = amount of N lost by leaching in kg ha⁻¹; Nᵢᵩₑᵦ = residual amount of N in kg ha⁻¹.

Table 5. Mean-Gini Dominance analysis for two different treatments for cowpea.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>E(x)</th>
<th>E(x)-r(x)</th>
<th>Efficient (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀ (simulated)</td>
<td>640</td>
<td>454.4</td>
<td>N</td>
</tr>
<tr>
<td>T₁ (simulated)</td>
<td>856</td>
<td>710.5</td>
<td>Y</td>
</tr>
</tbody>
</table>

E(x): mean return $/ha. r(x): Gini coefficient $./ha.
owing to the relatively high C:N ratio, or c) fixation at the cation exchange sites of clay minerals contained in the soil. Since the soil at the test site lay fallow for 6 months with much of the plant residues let to bio-degrade in-situ, it can be assumed that, this enhanced soil microbial activity and accelerated N mineralization (Abiven et al., 2005; Chaves et al., 2007).

Poor understanding of the N-balance between applied N-fertilizer amounts, N_{uptake} by plants, N_{immobilized}. In the soil matrix is one of the main reasons leading to overuse of N-fertilizers and subsequently to N_{leached}. High concentrations and excessive use of human urine during fertigation may lead to Na-accumulation in soils (Sene et al., 2013; Sheneni et al., 2018) thus, inhibiting plant growth. Furthermore, excessive use of human urine may also increase the risks of NO_3 leaching and electric conductivity (EC). Studies by (Worcester et al., 2017) on both men and women subjected to prescribed diet, found out that the pH of women urine samples was higher than in men. Other studies also reported biochemical changes in urine samples stored for longer periods (Kuwornu and Obiri-Danso, 2015). These and other considerations are critical, if human urine is to be a viable option as a cheap source of organic fertilizer for most smallholder farmers. Due to the low levels of urine used in our study, there was therefore, no risk for N-leaching. However, long term and increased urine levels may under unfavorable environmental conditions lead to N-leaching.

**Nitrogen dynamics and balance**

The simulation results underlined the significant effect of fertigation on N-balance under both treatments (Table 4). For both treatments, the N_{uptake} and N_{residual} at CPD0.75 were close to three-fold more under T_1 than T_0 with correspondingly high NUE at 79 and 76% respectively. Like in most soils, much of the organic-N (oN) in the soil is in the form of amino acids (Brackin et al., 2015; Paungfoo-Lonhienne et al., 2012) and is known to increase NUE when compared to inorganic-N (iN) (Arkoun et al., 2012; Franklin et al., 2017). Such high NUE under both treatments indicates the ability of the cowpea in utilizing both oN and iN components that naturally coexist in soils. However, during fertigation, there is a correspondingly larger oN pool compared to iN, thus increasing the predisposition for preferential N_{uptake}. Under T_1 than T_0. Such preferential oN uptake by wheat plants was reported by (Geissler et al., 2009). The N_{uptake} under T_1 was 63% higher than under to T_0 and, would suggest the increased preferential oN uptake leading to increased cowpea biomass and grain yield (Franklin et al., 2017).

The amount of N_{residual} under T_1 was three-fold higher than under T_0 at 68.3 and 186.3 kg ha^{-1} respectively. Such a high N_{residual} amount invariably represents a large N-reserve initially taken up by the cowpea plants. Upon decay and decomposition, this would release significant amounts of organic-N that would subsequently be incorporated within the soil matrix. Much of the organic-N in the residues of leguminous plants have been reported to have positive effect on the yield of subsequent non-leguminous plants (Adeleke and Haruna, 2012; Njoku et al., 2015). Although not directly part of our investigation, inference on the four-fold N_{uptake} by T_1 than under T_0, would suggest the significance of fertigation as well as the role of N in enhancing cowpea nodulation, which in turn must have facilitated increase in N_{uptake}. Although cowpea plants symbiotically fix atmospheric nitrogen, the additional application of 60 kg ha^{-1} of organic nitrogen fertilizer enhanced a three-fold N_{uptake} and so positively affected cowpea phenology and yield significantly (Lomeling and Huria, 2019). The findings of (Xia et al., 2017) showed that low concentrations of nitrogen (<50 mg/L) added to soybean plants tended to increase nodule formation while higher concentrations (>50 mg/L) had an inhibitory effect. Similar results by (Singh and Kalindindi, 2011) found out that application of 40 kg ha^{-1} other than 120 kg ha^{-1} of urea to specific cowpea EC-244390 (G4) and EC-240900 genotypes significantly enhanced nodulation and nitrogen fixation.

However, depending on legume type, stage of phenology, applied inorganic N-fertilizers, there appears to be a varied influence on nodulation, N-fixation thus, bio-mas and yield. Studies by (Abayomi et al., 2008) on three legumes; cowpeas, groundnuts and soybean showed that addition of 30 kg ha^{-1} of urea yielded higher nodulation in the different three legumes than at 60 kg ha^{-1}. On the other hand, phosphorous has been reported to have an influence on legume nodulation (Teneke et al., 1995; Owolade et al., 2006). It can be presumed therefore, that the phosphorous contained in the urine dilution applied during fertigation may equally have enhanced cowpea nodulation.

**Strategic Analysis: Gross margin benefits of fertigation**

The seasonal analysis program of DSSAT 4.7 was used to compare two management options with and without fertigation. The simulations were carried out for a 5-year period with daily climate data consisting of rainfall derived from NOAA rainfall database for Juba from 1996-2015 historical time series. Figure 5 shows the differences in gross margin under both treatments as represented by the cumulative probability distribution (CPD). Analysis of Stochastic Dominance (SD) (Figure 5) showed that T_0 generally had a low variance in terms of monetary returns, and a correspondingly lower Mini-Gini Dominance (MGD) than T_1 and therefore represented a more riskier investment option. The economic incentives due to fertigation with human urine at CPD0.25 were about $-290 for T_0, while this was about $-250 for T_1 accounting for a 14% difference. At CPD0.5, T_0 was about $-285 while T_1 was about $-215 accounting for a 23% or $75 difference. At CPD0.75, the T_0 was $-280 while this for T_1 was at $-180 making out a 35.7% or $100 difference. The probability for higher returns increased with further increase in each percentage point especially under T_1, suggesting that all investments under T_1 treatment had the best options. For example, there was a 75% probability that the total revenues accrued under T_0 would not be more than $-260, while this would not be more than $-180 under T_1. In effect, the deficit under T_1 and other financial obligations incurred would easily be recovered during the subsequent growing seasons than under T_0. This study also suggests that for risk averse smallholders, the combined effect
Figure 1. Cumulative Probability Distribution curves on harvested yield of cowpea under T₀ and T₁ treatments.

Figure 2. A CPD on the N-uptake during fertigation under two different treatments.

Figure 3. A CPD on the estimated yield of cowpea per irrigation schedule under two treatments.

Figure 4. Simulation of N leached in kg ha⁻¹ during growing season of cowpea under different treatments.

Figure 5. Cumulative Probability Distribution (CPD) for monetary returns in $ under T₀ (no human urine application + irrigation) and T₁ (human urine application + irrigation) treatments of cowpea yields.
of fertigation especially during periods of less and erratic annual rainfall is remunerative and would have a faster payback period with comparatively large gross margins. Negative returns ($\text{ha}^{-1}$) on the CPD plot highlighted low gross margins, i.e. high TVC with low TR as in (Eq. 1) implying that there was less monetary return anticipated relative to the huge production costs per season.

The simulated gross margin of fertigated cowpea crop with human urine also indicated that investment of about 10-12 kg ha$^{-1}$, or the equivalent of about $12-15$, and 20 barrels of irrigation water (4,000 liters), or the equivalent of about $30-40$ translated into mean generated revenues of about $\$680$ and $\$900$ for T$_0$ and T$_1$ respectively, accounting for a 24% difference. When compared to the potential gross margin under measured values, the results showed that this was $\$563.5$ and $\$786.5$ for T$_0$ and T$_1$ respectively, accounting for 28.4% difference. In contrast, the gross margin under observed T$_1$ compared to the calibrate Y2014 alone was about $\$493.2$ that was about 40.2% difference. Assuming therefore, that all TVCs were constant for both simulated and observed treatments, the net returns would still be correspondingly higher for T$_1$ than for T$_0$.

The stochastic dominance analysis (Table 5) showed that for risk averse, cowpea production under T$_1$ than under T$_0$ was a better and less risky option, since this had lower variance in monetary returns and was to the left of T$_2$ in the CPD plot.

**Conclusion**

Given the low affordability, low availability and inaccessibility of industrial N fertilizers for most rural farmers in S. Sudan, whilst considering the low cowpea yield at less than 600 kg ha$^{-1}$, the use of human urine as a viable organic-N fertilizer has become an indispensable option. If properly applied, there is a 75% probability that cowpea yield levels, especially for - risk avert producers - this could be increased up to 1100 kg ha$^{-1}$ from the current low levels with positive monetary returns or gross margins. Risk assessment prior to crop production and prediction of gross margins during each season remains a big challenge for risk averse smallholder farmers who opt for fertigation. Further, climate change impact considerations due to urine application showed that, if at the current application levels and rate as predicted by the CROPGRo model, the relatively low N$_{\text{beach}}$ pose no immediate risks to the environment. However, possible N-leaching would be contingent on the use, type of soil and rainfall intensity or antecedent soil moisture conditions, which would have to be validated and calibrated under varying farming scenarios.

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**REFERENCES**


Growth, yield and quality of faba bean (Vicia faba L.) in response to sowing date and phosphorus fertilization

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ABSTRACT
An experiment was carried out to study the effect of date of sowing and level of phosphorus on the yield, yield components and seed protein content of faba bean (Vicia faba L.) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2018 to March 2019 to study the influence of sowing date and phosphorus fertilization on the growth, yield and quality of faba bean (V. faba). Three date of sowing viz. 25 November, 5 December, 15 December and five levels of phosphorus viz., 0, 10, 20, 30, 40 kg P ha−1 were used in this experiment laid out in a randomized complete block design with three replications. At 60 DAS, 25 November sowing fertilized with 40 kg P ha−1 showed significant influence on all characters except dry matter production. Early sowing on 25 November produced the tallest plant (42.95 cm), highest number of branches plant−1 (8.31), number of pods plant−1 (49.87), 1000-seed weight (97.55 g), seed yield (1.21 t ha−1), stover yield (1.98 t ha−1) and seed protein content (31.54%) while the corresponding lowest values were recorded from late sowing on 15 December. The crop fertilized with 40 kg P ha−1 produced the highest number of branches plant−1 (8.33), number of pods plant−1 (49.05), 1000-seed weight (97.40 g), seed yield (1.33 t ha−1), stover yield (2.28 t ha−1) and seed protein content (38.17%) while control treatment (0 kg P ha−1) produced the lowest values of all parameters. In case of interaction, the highest number of pods plant−1 (58.42), seed yield (1.59 t ha−1), stover yield (2.44 t ha−1) and protein content in seeds (39.60) were recorded with 25 November sowing fertilized with 40 kg P ha−1 whereas the lowest seed yield (0.54 t ha−1), stover yield (1.32 t ha−1) and seed protein content (25.90%) were obtained from 15 December sowing along with control treatment. Therefore, early sowing (25 November) with 40 kg P ha−1 appears as the promising combination for higher yield and seed protein content of faba bean.

INTRODUCTION
Faba bean (Vicia faba L.) is popular legume and used worldwide as an important source of protein for human and animal nutrition (Cazzato et al., 2012) and for nitrogen in the biosphere (Rubiales, 2010). Faba bean is grown in some limited locality of Bangladesh and it is locally known as Kalimotor, Baklakalai, Bhograkalai etc. It is commercially grown in Tangail, Gazipur, Manikgang, Faridpur, Rajbari and northern part of Bangladesh. Faba bean is grown in Bangladesh in winter after the T. aman harvest with minimum tillage or sometimes directly sown in low lying areas as a relay crop when Aman lodges in the field (Biswa, 1988). However no statistical data regarding its area and production are available. Pulse crop covered an area of 0.37 million hectares with the production of 0.39 million tons including very negligible contribution from faba bean (BBS, 2017). Most of the people of Bangladesh fulfill their protein requirement through pulses. Faba bean has been attributed with its certain medicinal
values and a drug used to treat Parkinson’s disease (Brauckmann and Latte, 2010 and Ramírez-Moreno et al., 2015). Determination of optimum date of sowing is important because during growing period of faba bean usually fields are occupied with rice in Bangladesh. Farmers might commonly sow faba bean late because they are wait until their existing crop harvest. Early date of sowing (at the onset of November) significantly increased vegetative growth, seed yield and its quality (Attia et al., 2009) and the greatest values of yield and its components were resulted from the sowing date 25 November (El-Metwally et al., 2013). Late sowing increased field emergence and reduced the number of days to flowering, fresh harvest, reduced green pod length and number of green seeds pod\(^{-1}\) and yield. Early sowing of faba bean gave the best values for yield components and seed yield was reported elsewhere (Badr et al., 2013; Abido and Seadh, 2014; Kumar et al., 2020). Phosphorus is a major nutrient, especially for legumes (Kumar et al., 2019). Faba bean may require P fertilizer in the range of 20 to 30 kg P ha\(^{-1}\) (FAO, 2000). Significant increases were achieved in faba bean yield and its attributes by increasing phosphorus fertilization rate up to 45-46.5 kg P\(_2\)O\(_5\) fed\(^{-1}\) (El-Habbasha et al., 2007). The present study was therefore, undertaken to generate information on the effect of sowing date and phosphorus fertilizer rate on growth, yield and quality of faba bean.

**MATERIALS AND METHODS**

**Experimental site, soil and climatic conditions**

The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from November 2018 to March 2019. The experimental site belongs to the Old Brahmaputra Floodplain agro-ecological zone (AEZ-9) and is located at 24.75°N latitude, 90.50°E longitude and an average altitude of 18 m. The experimental field was a medium high land with silt loam with pH 6.80 and low in organic matter content (1.29%). The experimental area is under the sub-tropical climate. The average monthly temperature (°C), relative humidity (%), total rainfall (mm) and suns hine (h) prevailing at the experimental site during experimentation are presented in Table 1.

**Crop husbandry**

The seeds of faba bean were collected from the local farmers of Gaibandha district. The experimental land was ploughed with a power tiller and kept open to sunlight. Afterwards the experimental plot was prepared by several ploughing and cross ploughing followed by laddering to break the clods and to level the soil. The weeds and stubbles were removed from the plot. Land preparation was completed on 20 November and was ready for sowing seeds. Seeds were sown in furrow as per treatments of the experiment maintaining 30 cm × 20 cm spacing with two seeds per hole. The land was fertilized with urea, muriate of potash and gypsum at the rate of 15, 60 and 45 kg ha\(^{-1}\), respectively. The entire amount of urea, muriate of potash (MoP) and gypsum were applied at final land preparation. Phosphorus was applied as TSP as per treatments of the experiment. Weeding and thinning were done at 25 days after sowing (DAS) when the plant attained a height of 8-10 cm. Second weeding were done at 45 DAS when the plant attained about 28 -30 cm height. During experimental period, there was no irrigation required. Bean rust was successfully controlled by spraying Copper Oxy Chloride 50WP @ 0.2% fungicide on 14 February and 21 February, 2019.

**Data collection at vegetative stage**

At 60 DAS five plants were randomly selected excluding border rows to record the data on plant height, number of nodules plant\(^{-1}\). Chlorophyll content of five fully expanded young leaves from each five plants was measured by using a portable SPAD meter (model SPAD-502, Minolta crop, Ramsey, NJ). To determine the dry matter production, two plants were randomly uprooted from each plot excluding border rows. The total dry weight of plant was taken by using an electric balance after prop- er drying in an oven at 70°C until constant weight was reached.

**Data collection at harvest**

Data on plant height, yield components and yield of faba bean were collected at harvest. All data including plant height at harvest, number of branches plant\(^{-1}\), Number of pods plant\(^{-1}\), Number of seeds pod\(^{-1}\), 1000-seed weight except seed yield and stover yield, were collected from five randomly selected plants of each plot, while seed and stover yields data were collected from the whole plot after harvest. Protein content (%) in seeds was estimated by Micro-Kjeldahl method (AOAC, 1984) at Professor Muhammad Hossain Central Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh.

**Table 1.** Monthly record of air temperature, rainfall, relative humidity and sunshine of the experimental site during the growing season.

<table>
<thead>
<tr>
<th>Month</th>
<th>Year</th>
<th>Air temperature (°C)</th>
<th>Rainfall (mm)</th>
<th>Relative humidity (%)</th>
<th>Sunshine (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
<td>Average</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>2018</td>
<td>29.30</td>
<td>17.40</td>
<td>23.40</td>
<td>36.20</td>
</tr>
<tr>
<td>December</td>
<td>2018</td>
<td>26.00</td>
<td>13.50</td>
<td>19.80</td>
<td>17.70</td>
</tr>
<tr>
<td>January</td>
<td>2019</td>
<td>26.28</td>
<td>12.16</td>
<td>19.07</td>
<td>0.00</td>
</tr>
<tr>
<td>February</td>
<td>2019</td>
<td>27.03</td>
<td>15.55</td>
<td>21.29</td>
<td>30.00</td>
</tr>
<tr>
<td>March</td>
<td>2019</td>
<td>29.82</td>
<td>18.95</td>
<td>24.38</td>
<td>58.60</td>
</tr>
</tbody>
</table>
Harvesting
When 85% of the pods turned brown colour, the crop was considered to be matured. The crops were harvested plot-wise from the whole 5 m² (2.5 m × 2.0 m) area and then bundled separately, tagged and brought to the threshing floor of Agronomy Field Laboratory. The harvesting date for 25 November, 5 December and 15 December sowing were 14 March, 20 March and 22 March 2019, respectively. The crop bundles were sun dried for 7 days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks. The separated dried seeds and stover were cleaned and weighed. Seed and stover yields obtained from five sample plants were added with the respective whole plot harvest to get the actual seed and stover yields. Finally seed and stover yields were recorded and converted to t ha⁻¹.

Statistical analysis
Data were compiled and tabulated in proper form for statistical analysis. All the collected data were analyzed following the analysis of variance (ANOVA) technique and mean differences were adjudged by Duncan’s Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Vegetative characters
Effect of sowing date had significant effect on different parameters related to growth characters of faba bean (Table 2). Early sowing on 25 November produced higher results on plant height (26.45 cm), chlorophyll content (37.06) at vegetative stage while the corresponding lowest values were recorded from late sowing on 15 December. Uddin et al. (2017) showed significant effect on plant height due to early sowing date in bean where as Hasanvand et al. (2015) stated that due to delayed sowing chlorophyll content in leaves decreased. Application of 40 kg P ha⁻¹ showed higher results on plant height (24.12 cm), chlorophyll content (36.87), dry matter production plant⁻¹ (0.6833 g) at vegetative stage while the corresponding lowest values were recorded from control treatment (0 kg P ha⁻¹). Negasa et al. (2019) stated that plant height increased with increasing level of phosphorus while Mitran et al. (2018) observed that phosphorous plays very crucial role for increasing nodule number in leguminous plants. Root and shoot biomass increased significantly with increase in phosphorus levels, being lower and higher at low and high phosphorus levels, respectively was reported by Mourice and Tryphone (2012). On the other hand, 25 November sowing fertilized with 40 kg P ha⁻¹ produced the highest result on vegetative characters of faba bean except dry matter production (Table 3). The highest plant height (28.10 cm) was obtained at 25 November sowing fertilized with 40 kg P ha⁻¹ which was statistically identical at 25 November sowing fertilized with 30 kg P ha⁻¹. 25 November sowing fertilized with 20 kg P ha⁻¹ and 25 November sowing fertilized with 10 kg P ha⁻¹, respectively. The highest Number of nodules plant⁻¹ (40.23), chlorophyll content (39.83) at vegetative stage was obtained at 25 November sowing fertilized with 40 kg P ha⁻¹ while the lowest number of nodules plant⁻¹ (26.14) was obtained at 15 December sowing with 10 kg P which was at par with 15 December sowing fertilized with control treatment (Table 3).

Table 2. Effect of date of sowing and level of phosphorous on plant height, number of nodules plant⁻¹, chlorophyll content and dry matter production at 60 DAS of faba bean.

<table>
<thead>
<tr>
<th>Factor and treatments</th>
<th>Plant height (cm)</th>
<th>Number of nodules plant⁻¹</th>
<th>Chlorophyll content (SPAD value)</th>
<th>Dry matter production (g plant⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of sowing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-Nov</td>
<td>26.45a</td>
<td>33.62a</td>
<td>37.06a</td>
<td>0.586b</td>
</tr>
<tr>
<td>5-Dec</td>
<td>21.33b</td>
<td>34.21a</td>
<td>35.25b</td>
<td>0.612a</td>
</tr>
<tr>
<td>15-Dec</td>
<td>17.78c</td>
<td>31.98b</td>
<td>31.89c</td>
<td>0.550c</td>
</tr>
<tr>
<td>Level of phosphorous (kg P ha⁻¹)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>19.67c</td>
<td>30.12c</td>
<td>32.49c</td>
<td>0.4933e</td>
</tr>
<tr>
<td>10</td>
<td>21.61b</td>
<td>28.23d</td>
<td>34.69b</td>
<td>0.5367d</td>
</tr>
<tr>
<td>20</td>
<td>21.92b</td>
<td>33.18b</td>
<td>35.10b</td>
<td>0.5833c</td>
</tr>
<tr>
<td>30</td>
<td>21.97b</td>
<td>37.79a</td>
<td>34.51b</td>
<td>0.6167b</td>
</tr>
<tr>
<td>40</td>
<td>24.12a</td>
<td>37.03a</td>
<td>36.87a</td>
<td>0.6833a</td>
</tr>
<tr>
<td>Level of significance</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>CV (%)</td>
<td>7.87</td>
<td>5.21</td>
<td>2.25</td>
<td>5.76</td>
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</table>

Figures in a column under each factor of treatment having the same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** =Significant at 1% level of probability.
Table 3. Interaction effect of date of sowing and level of phosphorus on plant height, number of nodules plant\(^{-1}\), chlorophyll content and dry matter production of faba bean at 60 DAS.

<table>
<thead>
<tr>
<th>Date of sowing</th>
<th>Level of phosphorus (kg P ha(^{-1}))</th>
<th>Plant height (cm)</th>
<th>Number of nodules plant(^{-1})</th>
<th>Chlorophyll content (SPAD value)</th>
<th>Dry matter production (g plant(^{-1}))</th>
</tr>
</thead>
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<tr>
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<td>31.96h</td>
<td>0.500</td>
</tr>
<tr>
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<td>32.28cd</td>
<td>32.77gh</td>
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<td>38.91a</td>
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<td>0.600</td>
</tr>
<tr>
<td></td>
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<td>18.83 cd</td>
<td>34.86bc</td>
<td>34.09fg</td>
<td>0.610</td>
</tr>
</tbody>
</table>

Level of significance

* = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant.

CV (%)

7.87, 5.21, 2.25, 5.76

Table 4. Effect of date of sowing and level of phosphorous on yield components, yield and seed protein content of faba bean.

<table>
<thead>
<tr>
<th>Factors and treatments</th>
<th>Plant height (cm)</th>
<th>Number of branches plant(^{-1})</th>
<th>Number of pods plant(^{-1})</th>
<th>Number of seeds pod(^{-1})</th>
<th>1000-seed weight (g)</th>
<th>Seed yield (t ha(^{-1}))</th>
<th>Stover yield (t ha(^{-1}))</th>
<th>Biological yield (t ha(^{-1}))</th>
<th>Harvest index (%)</th>
<th>Seed protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of sowing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 November</td>
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<td>8.31a</td>
<td>49.87a</td>
<td>3.45a</td>
<td>97.55a</td>
<td>1.21a</td>
<td>1.98a</td>
<td>3.19a</td>
<td>37.61a</td>
<td>31.54a</td>
</tr>
<tr>
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<td>44.19a</td>
<td>8.17a</td>
<td>42.67b</td>
<td>3.19b</td>
<td>93.04a</td>
<td>1.07b</td>
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<td>2.87b</td>
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</tr>
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<td>39.25c</td>
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<td>0.78c</td>
<td>1.74c</td>
<td>2.52c</td>
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<td>30.24b</td>
</tr>
<tr>
<td>Level of phosphorous (kg P ha(^{-1}))</td>
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</tr>
<tr>
<td>0</td>
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<td>7.88c</td>
<td>40.29d</td>
<td>2.99b</td>
<td>84.24c</td>
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<td>2.03e</td>
<td>31.64c</td>
<td>28.00c</td>
</tr>
<tr>
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<td>7.88c</td>
<td>41.85c</td>
<td>3.16b</td>
<td>88.44bc</td>
<td>0.848d</td>
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<td>49.05a</td>
<td>3.26b</td>
<td>97.40a</td>
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<td>CV (%)</td>
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<td>8.63</td>
<td>6.58</td>
<td>6.79</td>
<td>1.69</td>
<td>2.01</td>
<td>3.12</td>
<td>2.86</td>
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</tbody>
</table>
Crop characters, yield components, yield and seed quality

Date of sowing significantly influenced yield components, yield and seed protein content of faba bean (Table 4). Early sowing on 25 November produced higher results on yield components and yield such as plant height (42.95 cm), number of branches plant$^{-1}$ (8.31), number of pods plant$^{-1}$ (49.87), number of seeds pod$^{-1}$ (3.45), weight of 1000-seed (97.55 g), seed yield (1.21 t ha$^{-1}$), stover yield (1.98 t ha$^{-1}$), biological yield (3.19 t ha$^{-1}$), harvest index (37.61%) and seed protein content (31.54%) of faba bean compared to 5 December and 15 December sowing (Table 4). Early sowing gave the highest number of pods plant$^{-1}$ was reported by Moosavi et al. (2014) and Mozumder et al. (2015). Similar result was reported by Uddin et al. (2017) who reported that 20 November sowing increase yield attributes including 1000-seed weight in French bean. Level of phosphorus also showed significant difference among all parameters related to yield components and yield. Application of 40 kg P ha$^{-1}$ produced higher results on yield components and yield such as plant height (45.31 cm), number of branches plant$^{-1}$ (8.33), number of pods plant$^{-1}$ (49.05). Zebire and Gelgelo (2019) mentioned that effect of phosphorus significantly increase number of branches plant$^{-1}$ of bean. Application of 39.6 kg P ha$^{-1}$ gave the highest number of pods plant$^{-1}$ in common bean (Phaseolus vulgaris L.) stated by Tesfaye and Balcha (2015). Application of 40 kg P ha$^{-1}$ also produced higher results on weight of 1000-seed (97.40 g), seed yield (1.33 t ha$^{-1}$), stover yield (2.28 t ha$^{-1}$), biological yield (3.62 t ha$^{-1}$) and seed protein content (38.17%) of faba bean compared to other level of phosphorus. However, 30 kg P ha$^{-1}$ had higher result on number of seeds pod$^{-1}$ (3.55) of faba bean (Table 4). Interaction between 25 November sowing fertilized with 40 kg P ha$^{-1}$ produced higher number of pods plant$^{-1}$ (58.42), seed yield (1.59 t ha$^{-1}$), stover yield (2.44 t ha$^{-1}$), biological yield (4.03 t ha$^{-1}$) and seed protein content (39.60%) except plant height, number of branches plant$^{-1}$, 1000-seed weight of faba bean at harvest. Sowing on 25 November fertilized with 30 kg P ha$^{-1}$ had higher result on number of seeds pod$^{-1}$ (4.27) and 25 November sowing fertilized with 20 kg P ha$^{-1}$ had higher result on harvest index (41.62%) of faba bean. 15 December sowing fertilized with 0 kg P ha$^{-1}$ also produced lower results on number of pods plant$^{-1}$ (35.74), seed yield (0.54 t ha$^{-1}$), stover yield (1.32 t ha$^{-1}$), biological yield (1.86 t ha$^{-1}$), and seed protein content (25.90%) of faba bean at harvest. 15 December sowing fertilized with 10 kg P ha$^{-1}$ produced the harvest index (28.74%) of faba bean (Table 5). In case of interaction, the highest seed yield (1.59 t ha$^{-1}$), and protein content in seeds (39.60) were recorded at 25 November sowing fertilized with 40 kg P ha$^{-1}$ whereas the lowest seed yield (0.54 t ha$^{-1}$) and seed protein content (25.90%) were obtained at 15 December sowing along with control treatment (Table 5 and Figure 1). It can be concluded that early sowing (25 November) along with higher dose of phosphorus fertilization (40 kg P ha$^{-1}$) appears as the promising practice for maximizing seed yield and seed protein content of faba bean.

Functional relationship between number of nodules plant$^{-1}$ and seed yield of faba bean

Nodule numbers plant$^{-1}$ and seed yield of faba bean had a positive linear relationship which could be adequately defined by regression equation. The regression equation specifies that increase in number of nodules plant$^{-1}$ would lead to increase in the seed yield of faba bean (Figure 2). The functional relationship was significant at p ≤ 0.01. The functional relationship can be determined by regression equation $y = 0.8228 + 0.0554x$ ($R^2 = 0.5422$). The functional relationship revealed that 54% of the variation in seed yield could be explained from the variation in number of nodules plant$^{-1}$ at vegetative stage of faba bean.

Table 5. Interaction effects of date of sowing and level of phosphorus on yield components, yield and seed protein content of faba bean.

<table>
<thead>
<tr>
<th>Date of sowing</th>
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<th>Plant height (cm)</th>
<th>Number of branches plant$^{-1}$</th>
<th>Number of pods plant$^{-1}$</th>
<th>Number of seeds pod$^{-1}$</th>
<th>1000-seed weight (g)</th>
<th>Seed yield (t ha$^{-1}$)</th>
<th>Stover yield (t ha$^{-1}$)</th>
<th>Biological yield (t ha$^{-1}$)</th>
<th>Harvest index (%)</th>
<th>Seed protein (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 November</td>
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<td>8.20</td>
<td>45.56cd</td>
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<td>92.98</td>
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<td>2.23j</td>
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<td>45.91cd</td>
<td>3.23b</td>
<td>98.75</td>
<td>0.89g</td>
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<td>79.56</td>
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<td>1.32k</td>
<td>1.63i</td>
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</tbody>
</table>

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). * = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant.
Conclusion

Early sowing on 25 November produced the tallest plant, highest number of branches plant$^{-1}$, number of pods plant$^{-1}$, 1000-seed weight, seed yield, stover yield and seed protein content while the corresponding lowest values were recorded from late sowing on 15 December. The crop fertilized with 40 kg P ha$^{-1}$ produced the highest number of branches plant$^{-1}$, number of pods plant$^{-1}$, 1000-seed weight, seed yield stover yield and seed protein content. The highest number of pods plant$^{-1}$, seed yield, stover yield and protein content in seeds were recorded with 25 November sowing fertilized with 40 kg P ha$^{-1}$ whereas the lowest seed yield, stover yield and seed protein content were obtained from 15 December sowing along with control treatment. From the results of the study it can be concluded that 25 November sowing fertilized with 40 kg P ha$^{-1}$ appears as the promising combination for higher seed yield and protein content of faba bean.

ACKNOWLEDGEMENTS

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REFERENCES


Role of credit in maize (Zea mays L.) production and assessment of food security in a selected area of Bangladesh

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ABSTRACT

Credit provides the means for many farmers to adjust their operations to keep up with the constant changes and, by doing so, to improve their operations. It also contributes to achieve food security of households. Tabular method is used to analyze credit profile, multiple regression analyses are used to determine the impact of credit on maize production and “Modified” OECD scale is used to measure calorie intake level of the 60 maize farming households who has got agricultural credit from Rajshahi Krishi Unnayan Bank in Lalmonirhat district of Bangladesh. Data were collected through field survey by using pre-designed and pre-tested interview schedule. TK.10500, 26333.33, 92103.77 (US$ 125, 313.49, 1096.47) for small, medium and large categories, respectively, which was 100% of the total applied amount. The total principal received by the household was about TK. 50,02,500 (US$ 59553.57) and at 9% interest it became TK. 54,52,725 (US$ 64913.39). The repayment performance of the households was about 100%. It is also revealed from the study that credit had a positive impact on fertilizer demand and irrigation demand and overall a positive impact on maize production. The coefficient of maize production with respect to agricultural credit was 0.081. The elasticity of fertilizer and irrigation demand with respect to credit was 0.016 and 0.543 respectively.

The calorie intake situation of the sample households depicts that about 6.67% of the respondents belonged to the ultra-poor whose per day calorie intake was 1481.991 k.cal. About 20% of respondents were hardcore poor whose per day calorie intake was 1722.133 k.cal. The persons belonged to the absolute poor about 21.67% and per capita calorie intake was 1934.605 k.cal. The rest 51.67% belonged to the non-poor group. Different financial institutions should disburse sufficient agricultural credit to fulfill the requirement of the farmers.

INTRODUCTION

Bangladesh is one of the world's most densely populated countries, with its people crammed into a delta of rivers that empty into the Bay of Bengal [BBC, 2019]. Most of the people are dependent on agriculture and it is essential to diversify crops for increasing population to ensure food security. Maize is one of the most important cereal crops and it is one of the most leading crops in the world. Maize is a versatile crop and is the nutritious than rice in terms of protein, phosphorus, fat content. Among different districts of the country Dinajpur, Lalmonirhat, Rangpur, Bogra, Kushtia, Chuadanga and Dhaka are observed to be more progressive in maize cultivation. Bangladesh has 14.09 million hectares of cultivated land and it is estimated that nearly 2.8 million hectares are suitable for maize cultivation. But presently it covers only 3.5 lakh hectares and the production is...
about 23 lakh metric tons (BBS, 2016).
Credit is a catalyst in production, the increasing flow of which may result in improved per hectare productivity. Agricultural credit is also important to consumer in achieving food security. Different credit sources and institutions have geared towards the development of agriculture and achievement of food security (Okeke and Chukuemeka, 2018). Food security refers to the situation ‘when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life’ (FAO, 2011). Food security encompasses three elements: availability, accessibility and utilization (USAID, 1996). Bangladesh’s high poverty and under nutrition rates are exacerbated by frequent natural disasters and high population density. The country’s poverty rate is now 21.8%, having fallen by 1.3% over the past year (BBS, 2018). The present rate of ultra-poor is 11.3%. BBS drew up its estimated based on the 2010 household income and expenditure survey. From 2005 till the proceeding five years, poverty fell by 1.7% and 1.2% between 2010 and 2016. Now BBS estimates a similar type of poverty reduction. In the corresponding period of 2016, the ultra-poverty rate was 12.9%.
According to the World Bank, Bangladesh’s poverty rate fell from 82% in 1972, to 18.5% in 2010, to 13.8% in 2016, and below 9% in 2018, as measured by the percentage of people living below the international extreme poverty line. Based on the current rate of poverty reduction, Bangladesh is projected to eliminate extreme poverty by 2021, first nation in South Asia to do so.
Maize or corn (Zea mays) is a plant belonging to the family of grasses (Poaceae). It is cultivated globally being one of the most important cereal crops worldwide. In some parts of the world, maize is used as food grain for human consumption. In addition, it is used as an important feed and fodder for animals. Nearly, 500 products of maize have been listed in the USA. It is also being recently used as biofuel. Maize is an excellent crop for food, feed and industrial utilization. Vitamin A rich maize is an example that has potential in addressing micronutrient deficiencies and promoting dietary diversity among the populations. Maize is frequently used as fish feed in small scale fish farming and has been used successfully as energy sources in the diet of many carnivorous fish. Maize is relatively low production costs, along with the increasing consumption of maize flour and cornmeal where micronutrient deficiencies are common public health problems; make this food staple an ideal food vehicle for fortification (Ranum et al., 2014).
The necessity of credit for rural producers in adopting modern technology like the maize production has been realized long since. Access to credit would enable credit-demanded farmers to take advantage of the available productive opportunities and increase maize productivity (Awunyo-Vitor and Al-Hassan, 2014). Emphasis has been given too many institutions to increase more fund in agriculture. Various nationalized commercial banks, other private commercial banks, and different big or small NGOs insisted by the Government of Bangladesh (GoB) have also been to finance agriculture. Various NGOs, however, are involved providing credit to the millions of landless, marginal and small farmers in rural areas of Bangladesh. Among these, Bangladesh Krishi Bank (BKB) and Rajshahi Krishi Unnayan Bank (RAKUB) are the key institutions for providing increased amount of credit to the farmers with a view to developing agricultural sector by and large, different agro based industries, proper marketing of farm products in Bangladesh.
Maize is not only highly productive, but also nutritious crop used as a human food, feed for poultry and fodder for livestock. Maize helps in improving the nutritional status of the rural people. It also indicates that the livelihood and standard of living of the maize farmers will be improved to some extent. The specific objectives of the study are assessing the credit profile, impact of credit on maize production, the calorie intake level of the sample households.

MATERIALS AND METHODS
On the basis of higher concentration of maize production, four villages namely Njisheksundor, Parshekhsundor, Moddhogod-dimari and Dalalpara under Hatibandha upazila of Lalmonirhat district were randomly selected for the study. The random sampling technique was applied for the selection of the sample. A total of 60 different categories of maize farmers was selected from four villages who were the beneficiaries of Rajshahi Krishi Unnayan Bank of Dowani branch. Survey method was followed to collect data from the respondents. Data were collected by the researcher herself through personal interview. The period covered in this study was July 2017 to June, 2018. Data were collected during September to October, 2018. Repeated visits were made to collect the necessary data.

Analytical tools
In order to explain the effects of different inputs on maize production, multiple linear regression function was chosen on the basis of the theoretical background (Gujarati, 2004). A general specification of the production function was considered by assuming that area under maize production, seed, fertilizers, manure and labour man days have an impact on maize production. When data were tested to check the multicollinearity problem among the independent variables and the researcher found that the variables area under maize production and labour man days significantly correlated with other variables. So the researcher removed these variables from the classical production function.
The general specification of the function was as follows (Eq. 1)
\[ Y = f(S, F, I, P, M, C) \]  
Where
\[ Y = \text{Amount of maize production (kg)} \]
\[ S = \text{Cost of seed (Tk.)} \]
\[ F = \text{Cost of chemical fertilizer (Tk.)} \]
\[ I = \text{Cost of irrigation (Tk.)} \]
\[ P = \text{Cost of pesticide (Tk.)} \]
\[ M = \text{Amount of manure (kg)} \]
\[ C = \text{Amount of credit (Tk.)} \]
As the objective is to assess the impact of credit on maize production, credit has no direct impact on maize production, but it has an impact on inputs utilization mainly on chemical fertilizer and irrigation. It was assumed that the price of fertilizer and bank credits have an impact on the amount of fertilizer used for maize cultivation and similarly, the price of irrigation and bank credits had an impact on irrigation per hectare employed.

To estimate the impact of agricultural credit on maize production the following hypothetical model had been developed (Eq. 2).

\[ Y = f (F, I) \]  

Where
\[ Y = \text{Amount of maize production (kg)} \]
\[ F = \text{Cost of chemical fertilizer} \]
\[ I = \text{Cost of irrigation} \]

\[ F = f (F_p, BC) \quad (3) \]
\[ I = f (I_p, BC) \quad (4) \]

Where
\[ F_p = \text{Price of chemical fertilizer} \]
\[ I_p = \text{Price of irrigation water} \]
\[ BC = \text{Bank Credit} \]

Equation (2) gives the maize production function while equation (3) and (4) gives chemical fertilizer, and irrigation water demand function.

Empirical model

By applying the theoretical model, the empirical model was specified as (Eq. 5)

\[ Y = \alpha S^{\beta_1} F^{\beta_2} I^{\beta_3} P^{\beta_4} M^{\beta_5} C^{\beta_6} \epsilon^{\mu_i} \]  

Where
\[ Y = \text{Amount of maize production (kg)} \]
\[ \alpha = \text{Constant term} \]
\[ S = \text{Cost of seed (Tk.)} \]
\[ F = \text{Cost of chemical fertilizer (Tk.)} \]
\[ I = \text{Cost of irrigation (Tk.)} \]
\[ P = \text{Cost of pesticide (Tk.)} \]
\[ M = \text{Amount of manure (kg.)} \]
\[ C = \text{Amount of credit (Tk.)} \]
\[ \mu_i = \text{Error term} \]

Taking log on both side of equation (6) we get.

\[ \ln Y = \ln \alpha + \beta_1 \ln S + \beta_2 \ln F + \beta_3 \ln I + \beta_4 \ln P + \beta_5 \ln M + \beta_6 \ln C + \mu_i \]  

Now, the empirical model for the impact of agricultural credit on maize production is

\[ F = \alpha F_p^{\beta_1} BC^{\beta_2} \epsilon^{\mu_i} \]

Or, \[ \ln F = \alpha + \beta_1 \ln F_p + \beta_2 \ln BC + \mu_i \]  

\[ I = \alpha I_p^{\beta_1} BC^{\beta_2} \epsilon^{\mu_i} \]

Or, \[ \ln I = \alpha + \beta_1 \ln I_p + \beta_2 \ln BC + \mu_i \]

To assess the calorie intake level of the sample households, the consumption data of the households of seven days were measured by the per person per day calorie intake level, each food item which was consumed by the family members of the sample households converted through standard value of 100 gm each food item. For the calculation, "Modified" OECD scale was used, family members are defined as one adult male and one adult female is 1:1, the child whose age is below 5 years considered as zero and 5–10 years considered as half of an adult member.

RESULTS AND DISCUSSION

Credit profile of the respondents
Sources of credit, interest rates and purpose of the loan are very important factors, both for the lender and receiver of credit. In this study, an attempt has been made to see whether credit receipt, its interest rate and payment status have any effects on maize production. Timely loan receipt, loan adequacy, utilization patterns and proper supervision are closely related to the repayment of a loan. The borrowers generally divert the funds mostly for unproductive or consumption purposes, as they cannot avoid the subsistence need of the family particularly among lower income people resulting in unnecessary delay in loan payment and default late delivery of credit also affects to its improper use. Proper supervision must be needed to increase the higher loan repayment rate otherwise loan overdue will be increased.

Sources and purpose of loan of the respondents
The respondents are engaged in many activities, but most of them were engaged in cultivating maize crop. In that case, RAKUB provides loan for maize production to the farmers. They provided loans for different income generating activities (IGAs) rather than maize production. It was observed that RAKUB provided loans for different purposes to their beneficiaries. Respondents of the study were the beneficiaries of RAKUB, Dowanipur branch, Hatibandha. They applied for a loan for the purpose of maize production and the branch also provide loan for this purpose.

Adequacy of loan received
Table 1 shows that the adequacy of loan for the sample households. The lone receivers were categorized in three categories, small amount (< Tk. 15000 (US$ 178.57), medium amount (Tk. 15000 to Tk. 30000) (US$ 178.57-357.14) and above Tk. 30000 (US$ 357.14). Table 1 reveals that average amount applied for
loan in small category was Tk. 10500 (US$ 125) and the average amount of loan received was Tk.10500 (US$ 125) which was 100% of the total applied amount. On the other hand, average amount applied for loan in the medium category was Tk. 26333.33 (US$ 313.49), and average amount of loan received was Tk. 26333.33 (US$ 313.49), which was 100% of the total applied amount. But Islam et al. (2018) found their research on Banana cultivation in Bangladesh that the overall average amount of loan received was 85.4% of applied amount. Average amount applied for loan in large category was Tk. 92103.77 (US$ 1096.47) and average amount of loan received was Tk. 92103.77 (US$ 1096.47).

Repayment of the loan
Agricultural Credit repayment is one of the challenging aspects of agricultural financing, especially in rural communities of developing countries (Ahiaba, 2018). But the repayment tendency of loan among the respondents of Dowani branch in Bangladesh was very satisfactory. They will pay the loan next year after harvesting their crop fully. They tried to pay the loan fully without any problem as they know if they pay the amount in due time and fully, they will get more loan which will help them to expand their production and get more profit. By cultivating maize production, the respondents improved their economic position. Ahiaba (2018) found in Nigeria that the farmers who repaid input credit with a part of the harvest (The Kind Farmers), performed better in repayment than those who were repaying with cash (The Cash Farmers). Table 2 shows the repayment performance of the respondents. From the Table 2 it shows that total principal received by the household was about Tk. 50, 02,500 (US$ 59553.57) and at 9% interest it became Tk. 54, 52,725 (US$ 64913.39). The households repaid the loan after harvesting their crop. That’s why the repayment performance of the households was about 100%.

Maize production model
The average maize production for the sampled farmers was 11261.82 Kg/ha. The results of the maize production model are presented in Table 3. Maize production was assumed to be influenced by six different variables, namely seed, fertilizer, irrigation, pesticide, manure and credit. Having a log linear specification, OLS model has been applied to estimate the parameters of the variables in the production function. Generally production increases as the area under crop increases. But in this analysis, we found that area under maize production estimated model had a multicollinearity problem which affected the independent variables. That’s why we omitted area under crop as independent variable.

### Table 1. Adequacy of loan received (Tk.) by the respondents.

<table>
<thead>
<tr>
<th>Category</th>
<th>No. of Respondent</th>
<th>Average amount applied for loan (Tk.)</th>
<th>Average amount received loan (Tk.)</th>
<th>Amount received in % of amount applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small amount (&lt;Tk.15000) (&lt;US$ 178.57)</td>
<td>4</td>
<td>10500 (US$ 125)</td>
<td>10500 (US$ 125)</td>
<td>100</td>
</tr>
<tr>
<td>Medium amount (Tk.15000-30000) (US$ 178.57-357.14)</td>
<td>3</td>
<td>26333.339 (US$ 313.49)</td>
<td>26333.33 (US$ 313.49)</td>
<td>100</td>
</tr>
<tr>
<td>Large amount (&gt;Tk.30000) (&gt;US$ 357.14)</td>
<td>53</td>
<td>92103.77 (US$1096.49)</td>
<td>92103.77 (US$1096.49)</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: Tk.84 =1US$. Source: Field Survey, 2018.

### Table 2. Amount (Tk.) received and paid by the respondents.

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount (Tk.)/Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal amount received by the respondents</td>
<td>50,02,500 (US$ 59553.57)</td>
</tr>
<tr>
<td>Interest after one year (9%)</td>
<td>4,50,225 (US$ 5359.82)</td>
</tr>
<tr>
<td>Total amount</td>
<td>54,52,725 (US$ 64913.39)</td>
</tr>
<tr>
<td>Repayment by the respondents</td>
<td>54,52,725 (US$ 64913.39)</td>
</tr>
<tr>
<td>Repayment performance (percentage)</td>
<td>100%</td>
</tr>
</tbody>
</table>


### Table 3. Results of the multiple log linear regression function of maize production.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>t-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.222</td>
<td>1.002</td>
</tr>
<tr>
<td>Cost of Seed (Tk.)</td>
<td>0.271</td>
<td>2.899</td>
</tr>
<tr>
<td>Cost of fertilizer (Tk.)</td>
<td>-0.075</td>
<td>-0.201</td>
</tr>
<tr>
<td>Cost of irrigation (Tk.)</td>
<td>-0.092</td>
<td>-2.678</td>
</tr>
<tr>
<td>Cost of pesticide (Tk.)</td>
<td>0.119</td>
<td>2.701</td>
</tr>
<tr>
<td>Amount of manure (kg.)</td>
<td>0.734**</td>
<td>2.099</td>
</tr>
<tr>
<td>Amount of credit (Tk.)</td>
<td>0.081**</td>
<td>2.371</td>
</tr>
<tr>
<td>R²</td>
<td>0.951</td>
<td></td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.957</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>219.539</td>
<td></td>
</tr>
</tbody>
</table>

** indicates significance at 5% probability level; Source: Author’s estimation.
Regression analysis

On the basis of the theoretical conception, the following values of empirical model were found. The estimated coefficient and related statistics of the equation are presented in the Table 3. The fitness of the model was good as indicated by $R^2$. About 96% of the total variation in the dependent variable was explained by the five variables used in explaining the maize production model. The coefficient of fertilizer and irrigation are negatively related to maize production because the cost of fertilizer and irrigation are so much which increases the cost rather decreases. That’s why, the coefficient becomes negative.

The arguments in fertilizer demand function are price of fertilizer and bank credit (Table 4). It was assumed that demand for fertilizer was influenced by the price of fertilizer and current year’s capability to buy fertilizer was indicated by the amount of credit received and used. The coefficient of demand for fertilizer with respect to price of fertilizer was .998 and with respect to bank credit was .016.

The irrigation demand function includes two independent variables, the price of irrigation and the bank credit. The Table 5 shows that the coefficient of bank credit and the irrigation function is 0.543. It indicates that use of irrigation water was positively influenced by bank credit. Availability and use of credit properly enhanced the uses of irrigation water. The coefficient of irrigation demand with respect to price of irrigation and bank credit were 0.897 and 0.543 respectively. The value of $R^2=0.596$ indicates that the fitness of the model is good.

0.16%. The elasticity of irrigation demand with respect to bank credit was 0.543. It means that an increment of credit by 10% increased that demand for irrigation by 5.43%. Here, the impact of maize production with respect to bank credit (BC) was 0.081 which indicates that if credit was increased by 10% the maize production would increase by 0.08%. Credit affects the demand for inputs. Thus, production is affected by credit via input demand function. Abbas et al. (2015) also found that agricultural credit; maize cropped area and agricultural labour force are positively significant related to maize production. The foregoing discussion reveals that credit had a positive impact on maize production. Increasing cost of fertilizer and irrigation affected, by decreasing maize production with respect to credit.

Calorie intake situation

Calorie intake status is an important socioeconomic aspect of the sampled household. To assess the calorie intake level of the sample households, the consumption data of selected households of seven days were measured by the per person per day calorie intake level, each food item which was consumed by the family members of the sample households converted through standard value of 100 gm each food item.

Per capita calorie intake

To measure the weekly calorie intake level of the sampled households, a structured question, including all commonly consumed food items was developed. On the basis of the amount of food taken by the respondent and their family members per capita calorie intake was measured. It was classified into the following four categories in Table 6.

<table>
<thead>
<tr>
<th>Category</th>
<th>Calorie (k.cal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra poor</td>
<td>&lt;1600</td>
</tr>
<tr>
<td>Hardcore poor</td>
<td>1600-1804</td>
</tr>
<tr>
<td>Absolute poor</td>
<td>1805-2122</td>
</tr>
<tr>
<td>Non-poor</td>
<td>Above 2122</td>
</tr>
</tbody>
</table>

works like a catalyst for maize production. It affects the crop
Credit is important for the improvement of the respondents. It
might not possible as a whole.
Without accelerating rural development, reduction of poverty
be accomplished only by reducing poverty in the rural areas.
this regard. Accelerating the rate of the decline in poverty can
those people, the government may take special programme in
standard of their capacity, intellectual ability, etc. To assist
cannot get benefit from growth equally due to the different
family became poor and food insecure. However, it is true that,
expenses compared to his income. That's why; he along with his
households. As a result, he alone couldn't maintain the family
found that there was only one earning member in most of the
large family size also affects a lot for being poor. Because, they
don’t maintain family planning and birth rate increases. It is
more than their income. They can’t save a single penny for the
future. As a result, they can’t maintain food security level and
became food insecure and thus belongs to poor. Moreover, their
large family size, low income, high food consumption, education fees, health facilities, etc. Their
expenditure, including food, clothing, education, health etc. was
more than their income. They can’t save a single penny for the
future. As a result, they can’t maintain food security level and
became food insecure and thus belongs to poor. Moreover, their
large family size also affects a lot for being poor. Because, they
don’t maintain family planning and birth rate increases. It is
found that there was only one earning member in most of the
households. As a result, he alone couldn’t maintain the family
expenses compared to his income. That’s why; he along with his
family became poor and food insecure. However, it is true that,
despite having an economic growth in the country, all people
cannot get benefit from growth equally due to the different
standard of their capacity, intellectual ability, etc. To assist
those people, the government may take special programme in
this regard. Accelerating the rate of the decline in poverty can
be accomplished only by reducing poverty in the rural areas.
Without accelerating rural development, reduction of poverty
might not possible as a whole.

Conclusion
Credit is important for the improvement of the respondents. It
works like a catalyst for maize production. It affects the crop
production via input demand and positively influenced by credit.
The impact of maize production with respect to credit was posi-
tive. Borrowed money has been used to a greater extent for the
productive purposes by the loanee farmers. Although they used
the loan in productive purposes, they cannot get enough prices
of the product or due to the uncertain loss of product they can-
not repay their installment on time. The findings revealed that
households producing maize have higher income and better
food security status than those households who have not been
cultivating maize in the study area.

CONFLICT OF INTEREST
The authors declare that there is no conflict of interests regard-
ing the publication of this paper.

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Table 7. Percentage of calorie intake taken by the sample households.

<table>
<thead>
<tr>
<th>Categories</th>
<th>No. of respondents</th>
<th>Per person per day average calorie intake (k.cal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra-poorn&lt;1600</td>
<td>4(6.67)</td>
<td>1481.991</td>
</tr>
<tr>
<td>Hardcore poor (1601-1804)</td>
<td>12(20)</td>
<td>1722.133</td>
</tr>
<tr>
<td>Absolute poor (1805-2122)</td>
<td>13(21.67)</td>
<td>1934.605</td>
</tr>
<tr>
<td>Non-poorn(Above 2122)</td>
<td>31(51.67)</td>
<td>2650.374</td>
</tr>
</tbody>
</table>

Source: Author's calculation. Figures with parenthesis indicate percentage of total respondents.

Table 7 depicts the percentage of calorie intake with respect to
amount of credit taken by the sample household. About 6.67%
of the respondents belonged to the ultra-poorn whose per day
calorie intake was 1481.991 k.cal. About 20% of respondents
were hardcore poor whose per day calorie intake was 1722.133
k.cal. The persons belonged to the absolute poor about 21.67%
and per calorie intake was 1934.605 k.cal. The rest 51.67% be-
longed to the non-poorn group. From the above discussion, it can
be summarized that most of the respondents were non-poorn and
they were the beneficiarys of credit. Rahman et al. (2014)
also found that credit has a positive impact on caloric intake of
farm households in Bangladesh. Although most of the respond-
ents are non-poorn, still there are ultra-poorn and hard-core poor
group of 6.67% and 20% respectively. This is due to uncon-
sciousness and lack of knowledge about nutritious items of food.
Since, food security has three fundamental components and
dimensions, meeting only one or two still lets person for food
insecurity position.
From the study it is found that about 48.33% of the respondents
were poor who belongs to the category ultra-poorn, hardcore
poor and absolute poor. The reasons behind their poverty were
many, such as their large family size, low income, high food
consumption, education fees, health facilities, etc. Their
expenditure, including food, clothing, education, health etc. was
more than their income. They can’t save a single penny for the
future. As a result, they can’t maintain food security level and
became food insecure and thus belongs to poor. Moreover, their
large family size also affects a lot for being poor. Because, they
don’t maintain family planning and birth rate increases. It is
found that there was only one earning member in most of the
households. As a result, he alone couldn’t maintain the family
expenses compared to his income. That’s why; he along with his
family became poor and food insecure. However, it is true that,
despite having an economic growth in the country, all people
cannot get benefit from growth equally due to the different
standard of their capacity, intellectual ability, etc. To assist
those people, the government may take special programme in
this regard. Accelerating the rate of the decline in poverty can
be accomplished only by reducing poverty in the rural areas.
Without accelerating rural development, reduction of poverty
might not possible as a whole.


Economics of production and marketing of natural rubber \((Hevea brasiliensis)\) in Jhapa, Nepal

**Subodh Raj Pandey***, Surya Mani Dhungana and Govinda Prasad Sharma

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\(^3\)Ministry of Agriculture and Livestock Development, NEPAL

**ABSTRACT**

A study was carried to assess the production and marketing status of natural rubber in Jhapa district in 2019, from a random sample of 70 households and 5 traders. Results were drawn using descriptive and inferential statistics employing SPSS and MS-Excel. The average area under natural rubber cultivation was 2.2 bigha and the productive area was 1.21 bigha. The average rubber sheet produced per household was 1167.092 kg and average yield was found to be 958.77 kg/bigha in the study area. The average annual household income from natural rubber was found to be NRs. 233418.57 which contributes 58.54 percent in the total household income. Three marketing channels were identified and the price spread ranged from NRs. 20 to 40. The producers' share in consumers' price ranged from 81.82% to 90.91%. The major production problem identified was the lodging by wind (0.80) and the major marketing problem faced by producers and traders was the absence of grading facility (0.82). Rubber farms were found to be a profitable farm enterprise with a discounted benefit-cost ratio of 1.88. The calculated NPV was 410992.40, IRR was 22% and PBP was 8.52 years respectively denoting the sustainability of rubber cultivation. RRIM 600, RRII 105 and GT1 were the major growing varieties of rubber in the study area. The cost of establishment in the first year (48.702%) is highest compared to the following years. The selling price of latex and sheet was found higher in 2015 and 2016 with a reduction of price in 2017 due to the high import of Indonesian rubber sheet. This research tries to present the general idea on the overall production and marketing status in the study area.

**INTRODUCTION**

Rubber Plant \((Hevea brasiliensis)\) is the perennial crop and the natural source of rubber. There are 79 families, 311 genera and 2000 species associated with natural rubber production. The various species associated with rubber production are \(Hevea brasiliensis\), \(Parthenium argentatum\), \(Ficus elastica\), \(Manihot glaziovii\), \(Taraxacum kok-saghyz\) etc. Among them, \(Hevea brasiliensis\) is best for extraction of latex. The rubber holds the 3rd largest position of the world industry after iron and steel. About 20 million of the world populations are directly dependent upon rubber for the source of income. About 400 types of surgical equipment and 50,000 types of other equipment are prepared from the synthetic and natural rubber. The synthetic rubber is prepared from the remains of petroleum products \((\text{RRII}, 1980)\). Economic and socio-politics in the world, currency exchange and speculation of rubber market influence the price of the rubber \((\text{Ismail and Aziz}, 2018)\). Nepal imported rubber and articles thereof of NRs. 8,307,815,000 and export of NRs. 18,207,000 per annum \((\text{MoAD}, 2017)\) with a trade deficit of NRs. 8,289,608,000 in the FY 2016/2017 \((\text{MoF}, 2018)\). Prime Minister Agriculture Modernization Project \((\text{PMAMP})\), Project
Implementation Unit, Rubber zone, Jhapa is responsible for up-lifting the standard of rubber cultivation in Nepal (NPC, 2003). These plants have 30 years of economic life but may live up to 100 years or even more than that. The plantation would start yielding from the 5-6th year onwards. The natural rubber (latex) is processed to convert into a storable and marketable form. The height of the rubber plant is about 30 m. They have trifoliate leaves and are pollinated by insects. The 3 budded seed can burst up to 15-18m. The latex can be extracted from any parts of the plant but the high amount can be extracted from the trunk. The area under rubber cultivation is limited to four districts of Nepal namely Jhapa, Morang, Sunsari, Illam. The market for natural rubber in developed countries is mostly saturated and is not expected to grow in the future, but it is expanding in the nations of “New Asia”, which includes India, Asian countries and especially China (Manivong, 2007). To achieve a high yield of rubber latex, good variety, high fertility of the soil and appropriate cultural management both in the immature and tapping stage are important (Onthong, 2015). The favorable condition required for rubber farming includes the height of 450 masl, 5-15° elevation, the temperature of 21°C to 28°C (due to the agro-ecological diversity 29°-30°C was also found better in Nepal), the relative humidity of 70-95%, rainfall of 2000-3000 mm and pH of 4-6.5. Areas within 8 degrees north of the equator, 10 degrees south of the equator, high temperature, altitude below 400 m and high humidity are the ideal conditions for the natural rubber-producing plant (Yogish, 2017).

The history of natural rubber cultivation started from 2046 B.S. with the establishment of Gorakhkali Rubber Udyog Ltd. (estd. in 2041 B.S.) in Deurali, Gorkha by the aid of the Chinese Government. It had an objective of import substitution by the production of raw materials required for the industry. The contract was done with Sudha Fal Ras, Sanishare, Jhapa to trial rubber cultivation in 5 ha in 2047 B.S. The task force was formed with the co-ordination between Ministry of Agriculture and Gorakhkali Rubber Udyog in 2050 B.S. The rubber development committee was established in the same year. The Indian team gave the highly optimistic note on the promising potential of rubber cultivation in Jhapa, Morang, Sunsari and Illam of Nepal (Khanal, 2003). Crop development division under Department of agriculture was given the role for rubber upliftment in 2052 B.S. Crop development directorate started subsidy for the rubber co-operatives in 2061 B.S. The Institute of Rubber and Jatropha Research Institute-Nepal was established in 2067 B.S. by non-resident Nepalese of America. Small farmers natural rubber producer’s association, Jhapa and Natural rubber farmer’s cooperative organization, Buddhhasanti was established in 2069 B.S. and 2071 B.S. respectively. Rubber zone was established in 2075 B.S. The task force was again formed in 2075 B.S. to study the possible expansion of rubber in the eastern part of Nepal (Jhapa, Morang, Sunsari, Illam, Saptari and Udhayapur), respectively. The rubber cultivation has now expanded to Jhapa, Morang, Sunsari and southern part of Illam. There are no formal details on the number of rubber farmers and coverage of rubber plant in Nepal. The varieties grown in Nepal are Rubber Research Institute of India (RRII) 105, Rubber Research Institute of Malaysia (RRIM) 600 and Godang Tapen (GT) 1. This study will help students, stakeholders, farmers and policymakers to get knowledge on the general overview of production and marketing status of natural rubber.

MATERIALS AND METHODS

Study area

For this study, Jhapa district was purposively selected as it is one of the important districts in terms of rubber cultivation and a sole prioritized district by PMAMP. The district lies in the 26.20° to 26.50’N latitude and 87.39° to 88.12’E longitude with 1606 square km of land. It is located in the southeastern part of Nepal with estimated rubber cultivated area of 311 hectares as registered by PMAMP-Rubber zone, Jhapa (MoAD, 2017).

Sample size and sampling procedure

The simple random sampling design was adopted to select municipalities, rural municipalities, villages and farmers. Altogether 70 farm households were selected among 6 municipalities (Birtamoad, Dhamak, Mechinagar, Bhadrapur, Kankai and Arjundhara) and 3 rural municipalities (Kechanakawal, Barhadashi and Buddhhashanti) (PMAMP-Rubber zone, 2019). An available roster at PMAMP zone office was used to select the farmers.

Data collection techniques

Household survey: The household survey was conducted employing interview technique using a pre-tested semi-structured questionnaire. All selected farmers aged 25 and above were interviewed for primary data collection. The interview was taken carefully to generate more realistic, reliable and complete responses. Respondents were interviewed with questions seeking demographic, educational, sociocultural, behavioural, economic and other information regarding production and marketing of natural rubber.

Focus group discussions (FGDs): A total of 3 focus group discussions were conducted with farmer leaders and active commercial farmers by using a standard checklist. The information obtained from focus group discussions were used to supplement and verify the data collected from the household survey. FGD also enabled to generate alternative data beyond the questionnaire survey.

Key informant interview (KII): The key informant used in the survey included the important stakeholders of the study area such as local leaders, extension workers, heads and executive
member of farmer groups and cooperatives, heads of community-based organizations, etc. Key informants were interviewed using an interview checklist and the information obtained was used in verifying the information obtained from the household survey.

**Case study:** A case study of a typical natural rubber farmer of the study area was conducted for an in-depth search of all relevant information. Farmer’s perception, decision making, technology adoption, package of practice, social organization, gender roles, production and marketing economics and its impacts on rural livelihood was studied.

**Field observation and verification:** Field observation was done at different times to witness the situation, which was assistive to validate the information received from the household survey.

**Data and data types**
Both quantitative and qualitative information regarding objectives were gathered using primary and secondary sources.

**Primary data:** The study was based on primary data. Primary data were obtained from the selected farmers through a personal interview during 2019 using a pre-tested and structured questionnaire. The questionnaire was developed to generate information regarding preparation of land, seeds, costs incurred on the purchase of various inputs, total production and its costs, price and marketing of rubber. The questionnaire was pretested before final administration. The collected data were cross-checked and confirmed from key informants interview, direct observation, and individual interview.

**Secondary data**
Secondary data was collected from district profile, journals, research articles, thesis, MoALD website, FAO website, Central Bureau of Statistics (CBS), Krishi diary, PMAMP zone profile etc. The secondary data was generated and tabulated elsewhere possible and used in further analysis to find out the appropriate finding.

**Data analysis technique**

**Data coding, entry and cleaning:** The collected data were coded and entered in Statistical Package for Social Science (SPSS). The data was further cleaned by removing errors, inconsistencies and overlapped responses using SPSS. The data was analyzed using SPSS and Ms-excel.

**Qualitative data analysis:** The qualitative data were further quantified to carry out the quantitative analysis.

**Quantitative data analysis:** The collected quantitative data were analyzed using both descriptive and analytical analysis.

**Economics of rubber production:** Rubber is a perennial crop which can be economically cultivated up to 30 years. The gestation period is six to seven years. From the seventh year onwards, it will start yielding which can be realized after 12 years.

**Establishment cost:** The cost incurred for establishing and maintaining the rubber orchards up to the bearing age was considered as establishment cost. It was calculated at current factor prices. Establishment cost included the expenditure on material cost and labour cost.

**Yields and returns:** Yield and returns were calculated per bigha basis. Prices received for rubber at the time of data collection was considered to compute the incomes from farms.

**Benefit-cost ratio:** It was taken as the ratio of the present worth of incremental benefit stream (cash inflow) to present worth of incremental cost stream (cash outflow) for the enterprise.

\[
\text{Discounted BC Ratio} = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}
\]

Where,

- \(B_t\): incremental benefit in \(t^{th}\) period due to farm enterprise
- \(C_t\): incremental cost in \(t^{th}\) period due to farm enterprise
- \(n\): number of years
- \(i\): interest rate

Keeping farm enterprise by the farmer will be financially feasible if the present worth of incremental benefits is greater than the present worth of the incremental cost or in other words, B-C ratio exceeds one.

**Net present value (NPV):** It is used as a discounted cash flow measure of absolute profitability. NPV is computed as present worth of incremental benefits (cash inflows) less present worth of incremental cost (cash outflows) due to farm enterprise. Positive NPV value indicates the feasibility of the business.

\[
\text{NPV} = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t}
\]

Where,

- \(B_t\): Benefit; \(C_t\): Cost; \(t\): Time in years; \(r\): Interest (discount rate) %

**Scaling technique:** Qualitative data were taken into account to prepare the index. Based on responded frequencies, weighted indexes were calculated for the analysis of farmer’s perception on the extent of production and marketing problems. Farmer’s perception of the different production and marketing problems were ranked by using five-point scales. The scale value of 1, 0.8, 0.6, 0.4 and 0.2 were used to most severe, severe, moderate, serious and least serious, respectively. The index of importance was computed by using the formula:
RESULTS AND DISCUSSION

The percentage of area covered by RRIM 600 was 75%, RRII 105 was 16% and GT1 was 9% in the studied area (Figure 1) but RRII 105 was majorly grown in Karnataka (Yogish, 2017). The area and production of the natural rubber in the studied area is 85.21 bigha and 81696 kg with the productivity of 958.77 kg/bigha (Table 1). The productivity was found lower than that of Kerala, India (George and Chandrashekar, 2014).

Investment evaluation of rubber plantation

The data of the rubber plant was calculated on the year basis. Eight years of data were collected from the farmers and 30 years of data on the cost and yield were projected based on profit and cost. The discounted BC ratio was calculated to be 1.88. Similarly, the Net Present Value (NPV) was calculated as NRs. 410992.40. The Internal rate of return was calculated as 22%. Similarly, the payback period of the rubber plantation system was found to be 8.52 years (Table 2). The majority of expenses in the production system is in the 1st year of the plantation (48.702%). International Mountain Society (2017) also reported the maximum expense in the 1st year. Similarly, 14.567% of the expenses took place in the 2nd year. The expenses in the 3rd, 4th, 5th and 6th year of the plantation is 8.106%, 8.042%, 10.226% and 13.355% respectively (Table 3). The planting cost of the materials is very high. The ratio of material cost to labour cost is greater than 1 which means that the material cost in the establishment phase is higher than the labour cost (Table 4).

Price variability in the rubber sheet and latex

The trend analysis was conducted to find out the maximum and minimum price of rubber sheet of 5 years. There was a maximum price in 2015. There was a decreasing trend in the price up to 2017. There was a dramatic fluctuation in the price of rubber sheet in 2017 due to the high import of Indonesian rubber in very low price but the price fluctuation in other countries such as India, China, Japan and USA depends on their production unlike Nepal (Fong et al., 2018). There is little price fluctuation in the year 2018 and 2019 (Figure 2). The trend analysis was conducted to find out the maximum and minimum price of the latex of 5 years. The latex was sold at a higher price in 2015 and 2016. The price decreased during 2017 due to the high import of rubber sheet at a low price. There is very little fluctuation in the price of the latex in 2018 and 2019 (Figure 3).

Table 1. Area, production and productivity of study area.

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (bigha)</td>
<td>85.21</td>
</tr>
<tr>
<td>Production (kg)</td>
<td>81696.79</td>
</tr>
<tr>
<td>Productivity (kg/bigha)</td>
<td>958.77</td>
</tr>
</tbody>
</table>

Table 2. Investment appraisal of the rubber plantation system.

<table>
<thead>
<tr>
<th>Investment appraisal</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discounted BC ratio</td>
<td>1.88</td>
</tr>
<tr>
<td>NPV (NRs.)</td>
<td>410992.40</td>
</tr>
<tr>
<td>IRR</td>
<td>22%</td>
</tr>
<tr>
<td>PBP</td>
<td>8.52 years</td>
</tr>
</tbody>
</table>
Table 3. Cost of establishing 1 bigha of rubber plantation.

<table>
<thead>
<tr>
<th>Items</th>
<th>I year</th>
<th>II year</th>
<th>III year</th>
<th>IV year</th>
<th>V year</th>
<th>VI year</th>
<th>Total</th>
<th>Percentage to total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A Material cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Planting material</td>
<td>80000</td>
<td>8000</td>
<td>12920</td>
<td>1300</td>
<td>1300</td>
<td>1300</td>
<td>88000</td>
<td>28.286</td>
</tr>
<tr>
<td>2 Shading material</td>
<td>8000</td>
<td>2000</td>
<td>12920</td>
<td>1300</td>
<td>1300</td>
<td>1300</td>
<td>10000</td>
<td>3.214</td>
</tr>
<tr>
<td>3 Manures and fertilizers</td>
<td>12920</td>
<td>12920</td>
<td>12920</td>
<td>17416</td>
<td>17416</td>
<td>86512</td>
<td>14220</td>
<td>7.149</td>
</tr>
<tr>
<td>4 Insecticides and Pesticides</td>
<td>1300</td>
<td>1300</td>
<td>1300</td>
<td>1300</td>
<td>7800</td>
<td>25020</td>
<td>10800</td>
<td>2.507</td>
</tr>
<tr>
<td><strong>Total material costs</strong></td>
<td>102220</td>
<td>24220</td>
<td>14220</td>
<td>14220</td>
<td>18716</td>
<td>18716</td>
<td>192312</td>
<td>61.814</td>
</tr>
<tr>
<td><strong>B Labour cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Land preparation</td>
<td>3200</td>
<td>600</td>
<td></td>
<td>3800</td>
<td></td>
<td></td>
<td></td>
<td>1.221</td>
</tr>
<tr>
<td>2 Digging and pit filling</td>
<td>15000</td>
<td>5000</td>
<td></td>
<td>20000</td>
<td></td>
<td></td>
<td></td>
<td>6.429</td>
</tr>
<tr>
<td>3 Planting</td>
<td>8800</td>
<td>2000</td>
<td></td>
<td>10800</td>
<td></td>
<td></td>
<td></td>
<td>3.471</td>
</tr>
<tr>
<td>4 Shading</td>
<td>8800</td>
<td>2500</td>
<td></td>
<td>11300</td>
<td></td>
<td></td>
<td></td>
<td>3.632</td>
</tr>
<tr>
<td>5 Weeding</td>
<td>5000</td>
<td>2000</td>
<td>1500</td>
<td>800</td>
<td>600</td>
<td>500</td>
<td>10400</td>
<td>3.343</td>
</tr>
<tr>
<td>6 Manures and fertilizer application</td>
<td>8000</td>
<td>8000</td>
<td>8000</td>
<td>8000</td>
<td>10000</td>
<td>10000</td>
<td>52000</td>
<td>16.714</td>
</tr>
<tr>
<td>7 Insecticide and Pesticide application</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>3000</td>
<td>10500</td>
<td>3.375</td>
</tr>
<tr>
<td><strong>Total labour costs</strong></td>
<td>49300</td>
<td>21100</td>
<td>11000</td>
<td>10800</td>
<td>13500</td>
<td>118800</td>
<td>151520</td>
<td>14.567</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td>151520</td>
<td>45320</td>
<td>25220</td>
<td>25020</td>
<td>31816</td>
<td>32216</td>
<td>311112</td>
<td>100.000</td>
</tr>
</tbody>
</table>

Table 4. Summary of cost of establishment of 1 bigha of rubber plantation.

<table>
<thead>
<tr>
<th>Year</th>
<th>Labour cost</th>
<th>Material cost</th>
<th>Ratio of material cost to labour cost</th>
<th>Total cost</th>
<th>Percentage of the total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>49300</td>
<td>102220</td>
<td>2.073</td>
<td>151520</td>
<td>48.702</td>
</tr>
<tr>
<td>II</td>
<td>21100</td>
<td>24220</td>
<td>1.147</td>
<td>45320</td>
<td>14.567</td>
</tr>
<tr>
<td>III</td>
<td>11000</td>
<td>14220</td>
<td>1.292</td>
<td>25220</td>
<td>8.106</td>
</tr>
<tr>
<td>IV</td>
<td>10800</td>
<td>14220</td>
<td>1.316</td>
<td>25020</td>
<td>8.042</td>
</tr>
<tr>
<td>V</td>
<td>13100</td>
<td>18716</td>
<td>1.428</td>
<td>31816</td>
<td>10.226</td>
</tr>
<tr>
<td>VI</td>
<td>13500</td>
<td>18716</td>
<td>1.386</td>
<td>32216</td>
<td>10.355</td>
</tr>
<tr>
<td>Total</td>
<td>118800</td>
<td>192312</td>
<td></td>
<td>311112</td>
<td>100.000</td>
</tr>
</tbody>
</table>

Figure 2. Price variability of rubber sheet.

Figure 3. Price variability of latex.
Problems in natural rubber farming

Several problems hinder the production and marketing of the natural rubber. Major problems in production and marketing of rubber were identified and analyzed separately which are given below:

Pre-production and production problems

Five major problems in rubber production were identified from focus group discussion, key informants survey and field visits. Farmers were asked to rank these problems based on severity. Five-point scaling technique (1, 0.8, 0.6, 0.4 and 0.2) was used to measure the relative severity of those production problems. Lodging by the wind before economic life was identified as the most severe problem in rubber cultivation with the index value of 0.953. The heavy wind during March and April was reported to lodge the rubber plant. It takes about 5-6 years to reach economic life, so delayed return was identified as the second most severe problem with an index value of 0.73. The 3rd, 4th and 5th severe problem identified were inability to distinguish variety (0.60), lack of sufficient saplings (0.49) and lack of technical knowledge (0.36) (Table 5). Umar et al. (2011) identified that the replacement of natural rubber by synthetic rubber, as the major threat in African countries.

There were various production problems identified in the rubber farming system, the wind was identified as major production problem with the index of 0.823. Similarly, the 2nd most severe problem identified was the lack of skilled manpower with an index of 0.713. The 3rd, 4th and 5th severe problem identified were lack of processing facilities, lack of instruments and chemicals and diseases with the index of 0.593, 0.530 and 0.34 respectively (Table 6). Siyilatha (2018) identified the absence of technical knowledge as one of the major problems in small farmers in Kalutara district of Sri Lanka.

Marketing problems

Five major marketing problems faced by producers and traders in rubber farming were identified and five-point scaling technique (1, 0.8, 0.6, 0.4 and 0.2) was used to rank the seriousness of those problems. The most severe marketing problem faced by the producers was identified as the absence of grading with the index of 0.820. The 2nd most severe problem was identified as price fluctuation with an index of 0.743. Similarly, the 3rd, 4th and 5th problem were identified as trader offer low price, delayed payment to the farmers and inadequate storage facilities with the index value of 0.573, 0.567 and 0.297 respectively (Table 7) but Kerala, India faced the problem of reduced productivity due to reduced farm sizes (Kannan, 2013).

The most severe marketing problem faced by the traders was ungraded goods with an index of 0.76. Due to the inability to grade the rubber sheets, the factories don’t offer enough prices as regulated by the international market. The 2nd most serious problem identified as lack of sufficient production (0.72), undried raw materials (0.64), seasonal supply (0.48) and difficulty in transportation (0.40) as shown in Table 8.

### Table 5. Ranking of pre-production problems.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Pre-production Problems</th>
<th>Index</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lack of technical knowledge</td>
<td>0.36</td>
<td>V</td>
</tr>
<tr>
<td>2</td>
<td>Lack of saplings</td>
<td>0.49</td>
<td>IV</td>
</tr>
<tr>
<td>3</td>
<td>Inability to distinguish the variety</td>
<td>0.60</td>
<td>III</td>
</tr>
<tr>
<td>4</td>
<td>Lodging</td>
<td>0.80</td>
<td>I</td>
</tr>
<tr>
<td>5</td>
<td>Delayed return</td>
<td>0.73</td>
<td>II</td>
</tr>
</tbody>
</table>

### Table 6. Ranking of production problems.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Production Problems</th>
<th>Index</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lack of skilled manpower</td>
<td>0.713</td>
<td>II</td>
</tr>
<tr>
<td>2</td>
<td>Lack of processing facilities</td>
<td>0.593</td>
<td>III</td>
</tr>
<tr>
<td>3</td>
<td>Lack of instruments and chemicals</td>
<td>0.530</td>
<td>IV</td>
</tr>
<tr>
<td>4</td>
<td>Wind</td>
<td>0.823</td>
<td>I</td>
</tr>
<tr>
<td>5</td>
<td>Disease</td>
<td>0.34</td>
<td>V</td>
</tr>
</tbody>
</table>

### Table 7. Ranking of marketing problem faced by producers.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Marketing Problems</th>
<th>Index</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Price fluctuation</td>
<td>0.743</td>
<td>II</td>
</tr>
<tr>
<td>2</td>
<td>Absence of grading</td>
<td>0.820</td>
<td>I</td>
</tr>
<tr>
<td>3</td>
<td>Delayed payment to the farmers</td>
<td>0.567</td>
<td>IV</td>
</tr>
<tr>
<td>4</td>
<td>Traders offer low price</td>
<td>0.573</td>
<td>III</td>
</tr>
<tr>
<td>5</td>
<td>Inadequate storage facilities</td>
<td>0.297</td>
<td>V</td>
</tr>
</tbody>
</table>

### Table 8. Ranking of marketing problems faced by traders.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Traders Marketing Problems</th>
<th>Index</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seasonal supply</td>
<td>0.48</td>
<td>IV</td>
</tr>
<tr>
<td>2</td>
<td>Undried raw materials</td>
<td>0.64</td>
<td>III</td>
</tr>
<tr>
<td>3</td>
<td>Lack of sufficient production</td>
<td>0.72</td>
<td>II</td>
</tr>
<tr>
<td>4</td>
<td>Difficulty in transportation</td>
<td>0.40</td>
<td>V</td>
</tr>
<tr>
<td>5</td>
<td>Ungraded goods</td>
<td>0.76</td>
<td>I</td>
</tr>
</tbody>
</table>
Marketing of natural rubber

Marketing of agriculture produce is equally important to farming for better performance (Acharya and Agarwal, 2011). A sound market is essential for promotion and commercialization of agriculture sector. The rubber sheet and latex were not directly used by the producer so the industry is considered as the consumer. The market structure in the study area is presented in Figure 4. As per the information collected from different intermediaries involved in rubber marketing, the various channels identified were:

Channel I: Producer (NRs. 195) - Wholesaler/Processors (NRs. 220) - Industrial Consumer

Channel II: Producer (NRs. 190) – Collection at Co-operatives (NRs. 195.50) – Wholesaler/Processors (NRs. 220) - Industrial Consumer

Channel III: Producer (NRs 180) - Village traders (NRs. 198) – Wholesaler/Processors (NRs. 220) - Industrial Consumer

The percentage of farmers following the Channel I, Channel II and Channel III were 54.28%, 14.29% and 31.43% respectively (Table 9).

Marketing of rubber encompasses all the activities performed in moving the rubber sheet/latex from the point of production to the industrial consumer. Marketing system creates time, space and form utilities. The producers, cooperatives, traders, wholesalers and retailers are the main marketing actors. In the channel I, the producer receives NRs. 195, they sell their produce to the wholesaler directly. This channel has the least price spread of NRs. 25 and the producer’s share in the consumer price is 88.64%. Similarly, in channel II, The producer receives NRs. 190. They collect their produce in the co-operatives and includes only marketing cost. Then they sell their products to the wholesaler at NRs. 220. They have a price spread of NRs. 30 and have the producer’s share of 86.36%. In channel III, the producer receives NRs. 180. The village trader collects and sells to the wholesaler at NRs. 198. The wholesaler sold to the industrial consumer at NRs. 220/kg. This channel has the highest price spread of NRs. 40 and the producers’ share in the consumer price is 81.82%. as shown in Table 10 and Figure 5. A similar type of marketing channel was identified by Adikari and Sharma (2018) in Tripura, India. The marketing efficiency of the 3 different channels was calculated. The marketing efficiency of channel I, channel II and channel III was calculated as 10.30, 7.81 and 7.05 respectively (Table 11). Large companies follow the channel I, which was found more effective. Anuja et al. (2012) found a similar marketing channel. Betty et al. (2018) encouraged backwards to produce the budded stumps by themselves and process the latex to produce the maximum profit.
Table 10. Price spread of rubber plantation through different marketing channels.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Particulars</th>
<th>Channel I</th>
<th>Channel II</th>
<th>Channel III</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gross price received by the producer</td>
<td>195</td>
<td>190</td>
<td>180</td>
</tr>
<tr>
<td>2</td>
<td>Marketing cost of co-operatives</td>
<td>-</td>
<td>5.50</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Price received by the cooperatives</td>
<td>-</td>
<td>195.50</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Marketing cost trader</td>
<td>-</td>
<td>-</td>
<td>7.88</td>
</tr>
<tr>
<td>5</td>
<td>Profit of trader</td>
<td>-</td>
<td>-</td>
<td>10.12</td>
</tr>
<tr>
<td>6</td>
<td>Wholesaler’s purchase price</td>
<td>195</td>
<td>195.50</td>
<td>198</td>
</tr>
<tr>
<td>7</td>
<td>Marketing cost of wholesalers</td>
<td>19.46</td>
<td>19.46</td>
<td>19.46</td>
</tr>
<tr>
<td>8</td>
<td>Profit of wholesalers</td>
<td>5.54</td>
<td>5.04</td>
<td>2.54</td>
</tr>
<tr>
<td>9</td>
<td>Industrial consumers’ purchase price</td>
<td>220</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>10</td>
<td>Price spread</td>
<td>25</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>11</td>
<td>Producers’ share in consumer’s price (%)</td>
<td>88.64</td>
<td>86.36</td>
<td>81.82</td>
</tr>
</tbody>
</table>

Table 11. Marketing efficiency of different marketing channel.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Particulars</th>
<th>Channel I</th>
<th>Channel II</th>
<th>Channel III</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Industrial consumer price</td>
<td>220</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>2</td>
<td>Total marketing cost</td>
<td>19.46</td>
<td>24.96</td>
<td>27.34</td>
</tr>
<tr>
<td>3</td>
<td>Marketing efficiency</td>
<td>10.30</td>
<td>7.81</td>
<td>7.05</td>
</tr>
</tbody>
</table>

Conclusion

The average yield in the study area was found more than that of the national average. Rubber plantations were found to be a profitable farm enterprise and it takes about three years after the production phase to cover the investment. The selling price of latex and sheet was found higher in 2015 and 2016 with the reduction of price in 2017. The price increased in the year 2018 and 2019. The producers following the market channel I was more profitable than the producers following other marketing channels.

ACKNOWLEDGEMENTS

We want to express our special thanks to Agriculture and Forestry University, Rampur, Chitwan and PMAMP, Project Implementation Unit, Rubber zone, Jhapa for this opportunity. We want to acknowledge Mr. Shesh Raj Poudel, Senior Agricultural Officer, PMAMP, Rubber zone for his guidance and support in the entire research period. We want to express our special thank to National Youth Council (NYC) for providing fund to complete this research.

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Assessment of fish pond sediments for growth, yield and nutritional quality of Indian spinach (*Basella alba* L.)

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ABSTRACT

Integrated farming system is a very effective tool for improving rural economy. Our present study was carried out in different pond dykes of Dumuria upazila of Khulna district, Bangladesh to investigate the effect of different fish pond sediments on growth, yield and subsequently analyze the nutritional quality of Indian spinach. The experiment consisted of two factors viz., pond types (P) (three different ponds growing different fish species: P₁ = prawn and carp, P₂ = prawn and mola, and P₃ = prawn, mola and carp) and each pond was cultivated with different fish species with different population densities; and pond sediments (M) (three levels: M₁ = pond dyke soil, M₂ =50% pond mud and 50% pond dyke soil, and M₃ =100% pond mud). Physical and chemical properties of three ponds dyke soil as well as sediments were analyzed. Parameters studied on Indian spinach were growth, yield and nutritional qualities. Pond sediments were better quality due to well decomposition and microbial activity of sediments compared to dyke soil of ponds. Organic matter of pond sediment was 2.79 (P₃) and EC was 790 (µc/cm). Plant height was varied from 10 to 19% due to the ponds type and sediment effects. Mostly, the plant growth was found better under the supplement of 100% pond sediments compared to dyke soil (M₁) and mixed soil (M₂). The highest yield was found in P₃M₃ and it was varied from 20 to 25%. Minerals like Ca (%), P (%), and S (mg/100g) were found statistically significantly higher in P₂M₃ compared to other treatments combinations. Nutrition like Vit A and Vit C were the highest (81.33 µg/100 g and 106.14 mg/100 g, respectively) found significantly higher in P₂M₃. Therefore, the pond mud (50% and 100%) can be used to increase the yield and nutrient uptake by the crop which can facilitate to reduce eutrophication and fertilizer for the better environment.

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INTRODUCTION

Integrated farming is becoming important for the sustainable production of diversified product which are cost effective and friendly environment. Such integration may be observed in the combination of fish farming and crop husbandry. Since, successful management of tropical fish ponds in a balanced manner through fertilizer application and supplementary feed addition is a basic need for the biological optimal fish growth while the sediment of pond can be a good source of organic matter to improve the soil health as well as for the crop growth and yield (Ihejirika *et al*., 2012; Li and Yakupitiyage, 2003). Fish feed and fertilization in fish ponds result to accumulation of organic matter (Rahman *et al*., 2004). Moreover, higher amount nitrogen, higher fractions of phosphate compounds and organic matter are deposited in the sediments of fish ponds; which facilitate to improve the soil condition and reduce the cost through less amount inorganic fertilizer application in the crop land (Olah *et al*., 1994;
People are suffering from malnutrition due to lack of balanced diet devoid of nutrient rich vegetables and fruits, good protein sources in the food menu. Yet millions of people who depend on fish to live every day, faced by the fear of food shortage (World Fish Centre, 2002). This leading to a range of negative health outcomes, including anemia, poor growth, rickets, impaired cognitive performance, blindness and neuromuscular deficits (Murphy et al., 2003).

Bangladesh is a land hungry country and its southern part land is mostly converted gher for fish culture especially prawn (Mollusca rosenbergii) cultivation. Integration of prawn farming in seasonal rice/paddy fields (ghers) has been successfully implemented and served as a significant source of income to coastal families of southwest Bangladesh. Farmers typically sell the prawns to fetch higher prices in overseas markets; meanwhile family members remain malnourished due to lack of complete protein, vitamins and other minerals in their diet (Milstein et al., 2006). In these areas the land is occupied with crops for eight months, while the rest of the year pond dyke is mostly remained fallow. In areas, some negligible amount vegetables are grown without any nursing. Therefore, integration of pond dyke vegetable culture with fish culture can give the opportunity to avail the diversification of food and help changing the food habit of the local people.

Integration of fish farming and use of effective pond mud for the vegetable cultivation is a new approach for the sustainable environment in Bangladesh. Indian spinach (Basella alba L.) is a very popular nutrient rich leafy vegetable under the family Basellaceae. It is widely grown not only in Bangladesh but also in tropical Asia and Africa (Bose et al., 2008). There is an increasing trend in Bangladesh to use inorganic fertilizer for the crop production and the country faces a large fertilizer deficit. Consequently, the share of imported urea increased from 30% in 2005–2006 and 69% in 2010–2011, and the country is almost completely dependent on imports of triple super phosphate (TSP) and muriate of potash (MoP) (Ahmed, 2011). High application rates of inorganic fertilizers have the disadvantage of surface runoff of nutrients to water bodies causing eutrophication which leading to anoxia and even toxic or harmful impacts on fisheries resources, ecosystems, and human health (Bijay et al., 1995; Anderson et al., 2002). Pond sediment is enriched with organic matter, nitrogen, phosphorus, and macro and micronutrients and hence, it can be a potential fertilizer supplement and soil conditioner. Therefore, the aim of the study was to investigate the performance of pond sediments from different fish cultures on the growth, yield and nutritional quality of Indian spinach.

**MATERIALS AND METHODS**

**Location of the experiment**

The experiment was conducted during the period from January to May, 2015 to examine the growth, yield and afterwards analyzed the nutritional quality of Indian spinach as influenced by different fish pond sediments. All the experimental units were selected in the areas where freshwater prawn culture is practicing for several years. The experiment was conducted at the different ponds dyke at Dumuria upazila under Khulna district, Southwest part of Bangladesh (Figure 1) to observe proper utilization of sediments of pond on the growth, yield and nutritional quality of Indian Spinach.

![Figure 1. Map of Bangladesh showing Khulna district (Southwest part of Bangladesh) and the Dumuria upazila where the research was conducted (Source: Google).](image-url)
Experimental design
Two factors experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications and total experimental plots were 27. Factor A was types of pond where number of fishes and species were different in each pond and factor B was the ratio of ponds sediment and dyke soil for the cultivation of Indian Spinach. The treatment combinations for two factors of the experiment are given in Table 1. The size of unit plot was 1.5 m² (1m × 1.5m). Sediments from different ponds and the dyke soil of the respected ponds have been carried to the Soil Science Laboratory of Bangladesh Agricultural University, Mymensingh for chemical analysis. The initial soil properties are presented in Table 2.

Cultivation practices
Selected pond dyke was opened using spade on 25 January 2015 and the soil was mixed with sediments of pond according to the design of the experiment. Indian spinach seeds (green variety) were collected from the seed market and dibbling (3 seeds per pit) was done on 12 February 2015 maintaining the producers recommended spacing (25 cm × 25 cm). Extra seedlings in the same pit were uprooted and used in case of gap filling. Irrigation was given regularly for the germination of seeds as well as for the establishment. Other intercultural operations such as weeding, frequent irrigation, etc. were given at interval according to necessary. Manure or fertilizer was not used in the experiment. Only dyke soil and pond mud/sediments were used to see the effect of dyke soil and mud on vegetable production.

Plant growth and yield analysis of Indian spinach
Plants were randomly selected and tagged as samples for collection of data from the middle of the rows of each unit plot for avoiding border effect. Plant height (cm) was taken from the base to the tip of plant using a meter scale and numbers of leaves were counted during the first harvest of Indian spinach. First harvest (from 10 cm above of plant was considered as edible part) was done after 45 days of seed planting. Length and breadth of largest leaves were measured using meter scale. Fresh weight (g) of each harvested plant (harvesting for consumption after 45 and 60 days after planting) were weighed and calculated per plot (kg) as well as to the unit area. Twig of 10 cm length from selected plants were separated as leaves and stem. Each sample were cut into pieces and was dried in air for 7 days and then kept in an oven at 70°C for 72 hours before taking the dry weight till it was constant. The dry weight was converted in dry matter percentage by the following the formula.

\[
\text{Moisture content} = \frac{\text{FW} - \text{DW}}{\text{FW}} \times 100
\]

\[
\text{Dry matter} = \frac{\text{FW} - \text{MC}}{\text{FW}} \times 100
\]

Where,
FW= Fresh weight
DW= Dry weight
MC= Moisture content

Table 1. Treatment combination of the experiment.

<table>
<thead>
<tr>
<th>Factors A (Ponds mud under different species combinations*)</th>
<th>Factor B: Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (P₁)</td>
<td>Fish</td>
</tr>
<tr>
<td>Prawn</td>
<td>80.84 nos/decimal</td>
</tr>
<tr>
<td>Mola</td>
<td>0 nos/decimal</td>
</tr>
<tr>
<td>Carp (Rohu)</td>
<td>4 nos/decimal</td>
</tr>
<tr>
<td>Prawn</td>
<td>80.84 nos/decimal</td>
</tr>
<tr>
<td>Mola</td>
<td>80.84 nos/decimal</td>
</tr>
<tr>
<td>Carp (Rohu)</td>
<td>0 nos/decimal</td>
</tr>
<tr>
<td>Prawn</td>
<td>80.84 nos/decimal</td>
</tr>
<tr>
<td>Mola</td>
<td>80.84 nos/decimal</td>
</tr>
<tr>
<td>Carp (Rohu)</td>
<td>0 nos/decimal</td>
</tr>
</tbody>
</table>

Table 2. Physical and chemical properties of dyke soil and pond sediments.

<table>
<thead>
<tr>
<th>Pond type</th>
<th>Types of soil</th>
<th>pH</th>
<th>EC (µc/cm)</th>
<th>Org M (%)</th>
<th>Total N (%)</th>
<th>P (ppm)</th>
<th>K (ppm)</th>
<th>S (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P₁</td>
<td>Pond sediments</td>
<td>6.23</td>
<td>601</td>
<td>1.79</td>
<td>0.09</td>
<td>19.13</td>
<td>114.07</td>
<td>233.2</td>
</tr>
<tr>
<td>Dyke soil</td>
<td>5.98</td>
<td>657</td>
<td>1.59</td>
<td>0.08</td>
<td>12.25</td>
<td>97.27</td>
<td>385.0</td>
<td></td>
</tr>
<tr>
<td>P₂</td>
<td>Pond sediments</td>
<td>6.32</td>
<td>618</td>
<td>1.72</td>
<td>0.08</td>
<td>42.63</td>
<td>150.74</td>
<td>297.8</td>
</tr>
<tr>
<td>Dyke soil</td>
<td>6.78</td>
<td>517</td>
<td>1.57</td>
<td>0.08</td>
<td>36.08</td>
<td>110.8</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>P₃</td>
<td>Pond sediments</td>
<td>6.60</td>
<td>790</td>
<td>1.92</td>
<td>0.10</td>
<td>50.52</td>
<td>175.18</td>
<td>327.14</td>
</tr>
<tr>
<td>Dyke soil</td>
<td>6.60</td>
<td>494</td>
<td>2.79</td>
<td>0.14</td>
<td>33.23</td>
<td>101.85</td>
<td>113.21</td>
<td></td>
</tr>
</tbody>
</table>
**Nutritional quality analysis of Indian spinach**

Twigs (twig consisted of leaves and stem) were used for the nutritional quality analysis. Vitamin C was determined by the indophenols dye extraction method. This procedure was based upon the quantitative discoloration of 2, 6-dichlorophenol indophenols by ascorbic acid. Vitamin A was calculated using following formula:

$$\text{Beta carotene} = \frac{(3.984 \times \text{OD} \times \text{volume})}{(100 \times \text{W sample volume})}$$

Phosphorus content of Indian spinach was determined by colorimetric method, following the procedure as mentioned by Jackson (1973). Calcium concentration was determined by EDTA titrimetric method using Na$_2$EDTA as a complexing agent at pH 12 in presence of calcion indicator (Page et al., 1982). Sulphur concentration was determined turbidimetrically with the help of a digital spectrophotometer (Model: Labtronics LT31) as outlined by Tandon (1995). The iron content was determined by atomic absorption spectrophotometer (Model PG 990) at the wave length of 248.3 nm.

**Statistical analysis**

Effects of treatments on growth, physiological yield and nutritional quality data were analyzed using analysis of variance (General Linear Model procedure) and Tukey's pair wise comparison test (P< 0.05) using Minitab Version 16 (Minitab Inc., State College, PA, USA).

**RESULTS AND DISCUSSION**

Pond sediments/muds of pond and fish species in ponds effect on plant growth and yield of Indian spinach

The present study was an integrated work of aquaculture and horticulture. Fish number and species were different in different ponds which were conducted by the aquaculture group. This experiment was conducted in pond dyke using the sediments/muds of considering the work of aquaculture. So, output of fish cultivation (May - December of last year) was harvested. Already, the feed of fish and fertilizers given to the pond (the different number of fish species in different ponds) was decomposed. The physical and chemical properties of sediments and dyke soil is shown in Table 2. Muds/sediments of different ponds were used in the dyke of respected pond for the Indian spinach cultivation. Ihejirika et al. (2012) determined the pond sediments quality and used it as supplement of chemical fertilizer for crop production. In our study, statistically significant variation was recorded on growth and yield contributing characters of Indian spinach (Table 3). The longest plant height was found 29.80 cm in P$_3$M$_3$ and the lowest plant height obtained in P$_3$M$_1$. The similar range of plant height was found in the plot of different ponds dyke where 100% pond sediments were used. Although, no significant difference was found in plant height where as other growth parameters like leaf numbers/plant, leaf length and breadth were shown significant different among the treatment combinations (P≤0.05). The highest number of leaves, leaf length and breadth were 21.6, 17.2 cm and 12.2 cm, respectively in P$_3$M$_3$. It indicates that plant leaf parameters influenced the yield of this crop, because yield per plot was found significantly different (Figure 2). The highest (9.4 %) dry matter accumulation was found from P$_3$M$_3$ while the lowest was found in P$_3$M$_1$ and P$_3$M$_2$ (Table 3). Higher dry matter accumulation utilized the nutrient input for plant production and nutrient uptake by plants.

In case of yield, significant variation was recorded due to different level of muids presented in Figure 2. Ponds mud/sediment gave the better growth of plant as well as the yield because of high nutrient are available in the muids compared to the dyke soil. Fish feed decomposed and contain the higher nutritional status for the plant growth like N, P and another macro and micro nutrients (Ihejirika et al., 2012; Rahman et al., 2004). Also, it is reported that this sediment is a good source of nutrient for the crop production and friendly for the environment and soil where crop nutrients are readily available due to well decomposition. Actually, sediments can work as a potential source of fertilizer supplement for the crop product and a new dimension for the sustainable aquaculture-agriculture integrated farming system. In the experiment of aquaculture, farmers were used the fish feed and fertilizers like urea and TSP in the ponds. Those products and phytoplanktons are decomposed which increased the organic matter and other minerals in the muids of pond. The reuse of pond-mud for the cultivation of vegetables and the aquaculture is a good tool considering the cost-effective methods as well as the supplement of diversified food for the rural poor people considering the nutritional aspects. Applying a high level of both feed and fertilizer gave high positive nutrient balances for the pond and sediments become a good source of nutrients for crop production. It is reported that farmer used 74.69 tonnes feed per hectare of pond assuming that 30% of the nitrogen in the feed is converted into fish flesh and the remainder are deposited as bottom sediments in the pond (Ali and Haque, 2011; Rahman et al., 2004). The bottom sediment is enriched with organic matter, nitrogen, phosphorous, and macro and micronutrients (Rahman et al, 2004) and the value of these nutrients for crop production is potentially high (Voss et al., 1999). In our experiment, pond mud application has given better result for the Indian spinach production compared to the only dyke soil. The similar findings have been found by the work of Verdegem, 2005. He has reported that using pond sediments on the dyke resulted in higher plant yields and improved some of the soil fertility characteristics. Thus, this integrated agriculture–aquaculture (IAA) system has the great potentiality throughout the country (Pervin et al., 2012). Besides, Uwimana et al. (2018) encouraged to promote the use of water and pond sediments as fertilizer for crop production which can be reflected as environmental restoration and sustainable agriculture. Ultimately, this practice could maximize nutrient utilization and decrease the potential for harmful phytoplankton blooms, reduce the dissolved oxygen level and less environmental impacts (Wahab et al., 2008).
Table 3. Combined effect of pond types and pond sediments on growth parameters and dry matter content of Indian spinach.

<table>
<thead>
<tr>
<th>Treatment combination</th>
<th>Plant height (cm)</th>
<th>Leaf number/plant</th>
<th>Leaf length (cm)</th>
<th>Leaf breadth (cm)</th>
<th>% Dry matter of twig</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1M1</td>
<td>24.70</td>
<td>12.60</td>
<td>11.60</td>
<td>7.60</td>
<td>8.10</td>
</tr>
<tr>
<td>P1M2</td>
<td>26.20</td>
<td>15.10</td>
<td>12.90</td>
<td>7.90</td>
<td>8.20</td>
</tr>
<tr>
<td>P1M3</td>
<td>29.30</td>
<td>18.60</td>
<td>13.10</td>
<td>8.20</td>
<td>8.40</td>
</tr>
<tr>
<td>P2M1</td>
<td>21.10</td>
<td>12.50</td>
<td>10.60</td>
<td>6.30</td>
<td>8.00</td>
</tr>
<tr>
<td>P2M2</td>
<td>21.30</td>
<td>14.60</td>
<td>11.70</td>
<td>6.70</td>
<td>8.30</td>
</tr>
<tr>
<td>P2M3</td>
<td>29.80</td>
<td>20.30</td>
<td>12.00</td>
<td>7.00</td>
<td>9.40</td>
</tr>
<tr>
<td>P3M1</td>
<td>23.80</td>
<td>14.70</td>
<td>11.20</td>
<td>8.10</td>
<td>7.80</td>
</tr>
<tr>
<td>P3M2</td>
<td>25.10</td>
<td>18.30</td>
<td>14.60</td>
<td>11.70</td>
<td>7.80</td>
</tr>
<tr>
<td>P3M3</td>
<td>29.80</td>
<td>21.60</td>
<td>17.20</td>
<td>12.60</td>
<td>8.50</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>9.11</td>
<td>7.32</td>
<td>2.69</td>
<td>2.25</td>
<td>0.212</td>
</tr>
</tbody>
</table>

Level of significance

* = Significant at 5% level of probability, NS = Not significant.

Table 4. Combined effect of pond types and pond sediments on the mineral contents of edible part of Indian spinach.

<table>
<thead>
<tr>
<th>Treatment combinations</th>
<th>Ca (%)</th>
<th>P (%)</th>
<th>S (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1M1</td>
<td>0.56</td>
<td>0.02</td>
<td>2.14</td>
</tr>
<tr>
<td>P1M2</td>
<td>0.70</td>
<td>0.06</td>
<td>2.25</td>
</tr>
<tr>
<td>P1M3</td>
<td>1.36</td>
<td>0.10</td>
<td>2.67</td>
</tr>
<tr>
<td>P2M1</td>
<td>0.69</td>
<td>0.04</td>
<td>1.06</td>
</tr>
<tr>
<td>P2M2</td>
<td>0.82</td>
<td>0.05</td>
<td>1.83</td>
</tr>
<tr>
<td>P2M3</td>
<td>1.74</td>
<td>0.13</td>
<td>2.78</td>
</tr>
<tr>
<td>P3M1</td>
<td>1.07</td>
<td>0.07</td>
<td>1.78</td>
</tr>
<tr>
<td>P3M2</td>
<td>1.12</td>
<td>0.13</td>
<td>1.99</td>
</tr>
<tr>
<td>P3M3</td>
<td>1.40</td>
<td>0.15</td>
<td>2.35</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>0.08</td>
<td>0.02</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Level of significance

* = Significant at 5% level of probability, NS = Not significant.

P1 = Pond type A, P2 = Pond type B and P3 = Pond type C; M1 = dyke soil, M2 = 50% pond mud and 50% dyke soil, M3 = 100% pond mud.
The scenario of the research site (Dumuria Upazila under Khulna district is the Southwest part of Bangladesh) is to cultivate fish in pond during the July to December in some extension to February. But the rice is cultivated in the pond when pond is becoming dry or less water. In the winter season, farmers are used to grow vegetables without caring to the crops. But, farmers give too much concentration to rice cultivation, also the scarcity of water does not encourage to farmers to grow vegetables after January to April. After May, rainy season is a natural disaster and not convenient for the crop cultivation that is up to September–October. The research site is climate vulnerable area and its cropping pattern was found through visiting the research site and interviewing farmers (Figure 3). So, different fish species cultivation in the same pond and vegetable cultivation introduction can uphold the national security through reducing the use of fertilizer and eutrophication. Because, it is assumed that diversification of fish is decomposing pond sediments/muds of pond and fish species in ponds effect on the nutritional quality of Indian spinach

Plants grown under different treatments were harvested analyzed the mineral and nutritional status from the edible parts of Indian spinach. There are some works conducted to grow vegetables in the dyke area utilizing the pond sediments but no work is found on the nutritional status of crops influenced by pond sediments. In our experiment, minerals like Ca, P and S were analyzed which were found significantly different among the treatment’s combinations (P≤0.05) (Table 4). Edible parts of Indian spinach like leaves and stems were analyzed together and

![Figure 3. Cropping pattern in the South-western part of Bangladesh.](image)

![Figure 4. Combined effect of pond types and pond sediments on the Vitamin C content of edible part of Indian spinach. P₁ = Pond type A, P₂ = Pond type B and P₃ = Pond type C M₁ = dyke soil, M₂ = 50% pond mud and 50% dyke soil, M₃ = 100% pond mud.](image)

![Figure 5. Combined effect of pond types and pond sediments on the Vitamin A content of edible part of Indian spinach. P₁ = Pond type A, P₂ = Pond type B and P₃ = Pond type C M₁ = dyke soil, M₂ = 50% pond mud and 50% dyke soil, M₃ = 100% pond mud.](image)
the highest amount of calcium (Ca), phosphorous (P) and sulphur (S) were found 1.74%, 0.13% and 2.78 (mg/100 g), respectively in P₂M₂ and the lowest Ca and P was found in P₃M₃. This result is consistent with the dry matter accumulation in plant parts. On the other hand, 100% pond sediments showed the highest amount of nutrient content compared to the dyke soil.

In case of nutritional analysis, the highest content of Vit A and Vit C of Indian spinach was found 81.33 (µg/100 g) and 106.14 (mg/100 g) in P₂M₂ (Figures 4 and 5). On the other hand, the lowest Vit A was in P₂M₁ and Vit C was P₂M₂. Both of the lowest value was found in the different pond dyke where the soil media was only dyke soil (M₁), no addendum of pond sediments. This highest amount nutrition is consistency the other mineral contents, as well as the growth and nutrient supply to the soil.

Conclusion

Sediments/muds of each pond contain the higher of organic matter and mineral compared to the respected dyke soil. Supply of nutrients to the soil through 100% pond sediments gave the better result on growth and yield of Indian spinach in pond type 3 (P₃) where three type fish species combination were cultivated. On the other hand, higher amount of minerals and vitamins were found in the pond dyke where 100% pond sediments were used. Findings from this experiment indicate that pond sediments application from the pond of different types fish species combination can be useful for increased crop production and nutritional quality of the crop through improved soil quality. On the other hand, these findings can be an exemplary to continue the further work of integrated aquaculture and horticulture to improve the soil health and environment, reduced eutrophication and less chemical fertilizer application for crop production.

ACKNOWLEDGEMENTS

The authors would like to thank USAID-AquaFish Innovation lab to support the work. Also, greatly acknowledge to South-western part household families who allow this work and support to collect data.

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World Fish Centre (2003). Fish an issue for every one: A concept paper for fish for all Summit, pp.10.
Impact of forest land cover on runoff, erosion and sedimentation in the Karai Watershed, Simalungun Regency, North Sumatra Province, Indonesia

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Development activities in the Karai Watershed, in upstream area, are intensive. The activities tend to decrease the land abilities in absorbing water and protecting surface soil for erosion, which finally affect the rise of surface run-off and erosion (Wasis, 2012 Wasis et al., 2018. Wasis et al., 2019). Population growth is identified as the cause of water quality decreases in Karai river. With the population growth, road construction, land clearance, and ecology pressure for the river decreases water quality of the river and rises sedimentation (sand). Landslide occurance, sedimentation at Pembangkit Listrik Tenaga Mikrohidro (PLTM) or Micro-hydro Electric Power (Karai 7 and Karai 13), and the decrease of water quality in the river are the evidence of failure indication in managing resources (forest and land resources).

Issues of environment quality decrease in watershed management, especiallly landslide issue, erosion, sedimentation, is a dispute that has to be solved quickly, for this issue has caused faster sedimentation process. At PLTM Karai 7, sedimentary trap management is maintained per two days, thus...
this activity decreases the ability of PLTM to produce electricity. Damage Forest (Illegal logging) had a significant effects toward the bulk density increase, as well as C-organic decrease. In other hand Illegal logging had a significant effects on sand fraction, total microorganisms, and soil respiration (Wasis, 2019). Landslide process, erosion, sedimentation are caused of the conversion of forest coverage, the change of natural forest converted into garden, dwellings, mine site, and road construction. For that reason, analysis of biophysics condition, analysis of forest coverage, and rehabilitation effort is needed. To solve this environmental problem at this catchment area, it needs to include all stakeholders (local citizen, local companies, and government). Therefore, The plan of Karai Watershed has to be created to increase the integrity among local stakeholders included in the management of catchment area resources by coordinating, integrating, synchronizing some aspects (policies, management activities, and development of effective and efficient catchment area). Based on those management, all stakeholders has some agreements and commitment to construct program and also do some efforts to achieve those purposes that has been agreed together. This study aimed to collect forest coverage data at Karai Catchment Area, to analyse the cause of damaged soil and damaged environment which are the rise of soil sedimentation at Karai river and to assemble program and activity guidance in managing the increase and rehabilitation of natural resources and land at the Karai Watershed.

MATERIALS AND METHODS

Research place and time
These activities will be conducted at the Karai Watershed (PLTM Karai 7 and Karai 13) Kahean Sub-district, Simalungun District, in various types of land coverage (tropical rain forest, agroforestry, local garden, road, damage soil, etc.). This research is conducted at January 16th January 18th 2017.

Tools and materials
Research tools used are differentiated into two categories, which are data collecting tools on site and nutrient analysis tools at laboratories. Data collecting tools on site are complete sample collecting tools (ring sample), to take the composite soil samples by hoe, knife, ruler, plastic bag and marker. The details of those seven locations:

GKE 1 : Closed Natural Forest Site (N 03°03’ 30,6” E 098°47’ 51,7”)
GKE 2 : Cleared land for road construction (N 03°03’ 43,0” E 098°47’ 51,9”)
GKE 3 : Cleared land for road construction (N 03°03’ 35,7” E 098°47’ 56,2”)
GKE 4 : Cleared land for dam construction (N 03°02’ 50,4” E 098°47’ 01,4”)
GKE 5 : Cleared land for dam construction (N 03°02’ 44,9” E 098°46’ 54,9”)
GKE 6 : Gardening Site (N 03°03’ 26,3” E 098°48’ 01,2”)
GKE 7 : Gardening Site (N 03°03’ 03,3” E 098°48’ 27,2”)

Research procedures

Structure analysis and vegetation ingredient: Monitoring square establishment is choosed by purposive sampling at Karai Catchment Area. To assess the effect of changing land usage for triggered erosion, damaged soil, and damaged plants, sampling on various land (7 locations which each sample is 20 m × 20 m) is conducted (Soerianegara dan Indrawan, 2005; Wasis, 2012).

Collecting soil samples: Soil sampling is done by purposive sampling on tropical rain forest, garden and damage soil. The study was conducted on three plots on tropical rain forest and damage forest of 20 m × 20 m (0.04 ha) each. Within the mine, tropical rain forest and damage forest, three subplots of 1m × 1m were placed randomly for ground sampling. Then the soil sample is composited. Soil sampling for the chemical properties and biological properties of soil is taken evenly on the soil surface of 0-20 cm deep. Soil taking is done by composite as much as 1 kg. Soil sampling for soil physical properties was done at ground level of 0 - 20 cm depth (Figure 1). Intake of soil is done intact by using ring sample diameter of 7 cm with height of 5 cm (Wasis, 2012).

Soil analysis: Soil that has been take from the field are the analyzed at Forestry Influence Laboratory, Silviculture Department, Faculty of Forestry IPB. Soil analysis for physics properties are bulk density, porosity, available water, and permeability, for chemistry properties are soil pH and c-organic, and for biology properties is total microorganism, total fungi, and respiration.

Data analysis
Site monitoring data and soil analysis result are then analyzed based on current related rules (PP No.150, 2000) to know the damage that has been made (PLTM Karai 7). Coefficients for soil properties is bulk density, porosity, available water, permeability, pH, total microorganism, and total fungi.

RESULTS AND DISCUSSION

The calculated result predicts the broad of The Karai watershed is 462 km², in which the wide of forest coverage is 115.5 km² (25%) and the wide of non-forest coverage (garden, dwelling sites, road, etc.) is 346.5 km² (75%). This non-forest land coverage will trigger the increase of landslide, erosion, and runoff. It is proved by the high of sediment trap at PLTM Karai 7. The observation result illustrates that land clearance has caused damaged land by triggering erosion, the lost of soil nutrient and the increase of rock coverage at the soil surfaces. Damage at those things will surely increase sand sedimentation at Karai Watershed (PP No.150, 2000). For more detailed result, it is shown at Table 1.
Figure 1. Soil sampling at Karai catchment area.

Figure 2. Landslide caused by road construction at Karai watershed.

Figure 3. Eroded land at Karai watershed.

Figure 4. The loss of soil materials at Karai watershed.
Converting natural forest to gardening site, road and damaged soil are located at coordinate of N 03°03’ 43.0” E 098°47’ 51.9”, and N 03°03’ 35.7” E 098°47’ 56.2”, in which cleared podsol land, caused by road construction and soil erosion accounting for 20-150 cm/s found on site. (Figure 2). Most of erosion materials enter Karai riverbank. This occurrence has constituted enormous sediment materials inside the river. On the site, landslide is also found.

**Water system of Karai watershed**

Laboratory analysis result shows that land clearing has damaged water system function, which are the decreasing Available water the decreases infiltration, damage of water sistem will certainly increase sand sedimentation and will decrease water quality in Karai River (PP Number 150, 2000). For further detail, it can be seen in the Tables 2 and 3.

Other effects of damaged natural forest changing to open land and gardening site are the available water decreases in conservating water. It can be seen in the decrease of available water to infiltrate water, which is indicated by the decrease of permeability accounting for 1.98 - 8.12 cm/hour and the decrease of available water amounting to 0.01% - 43.43%. Those effects tend to run off the water dropped to the ground because of disability of land to absorb in into the soil. Big effects of this occurrence will bring soil textures (sand, dust, and clay) into the Karai river. Soil damage caused by logging activities, land clearing and soil processing has decreased soil infiltration ability amounting to 564 - 2.314 cm/hour. It can be caused by damaged soil structure and the decrease of organic materials on soil surfaces. Soil structure damage will decrease drainage pore. As a result, rain water will mostly fall and become run off. This run off level will tend to increase the level of eroded land in Karai Watershed (Figure 3 and 4).

**Soil physical properties**

Laboratory analysis result show that land clearing has affected in land physical damage which are the increase of bulk density, and the decrease of soil porosity. The damage of physical soil property will certainly decrease of soil infiltration levels and will increase surface runoff in Karai River (Nomor, 2000). For further details, it is illustrated in the Tables 4 and 5.

**Table 1. Soil damage for natural forest conversion into cleared land.**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Parameter (PP No 150 Th 2000)</th>
<th>GKE 2</th>
<th>GKE3</th>
<th>GKE4</th>
<th>GKE5</th>
<th>GKE6</th>
<th>GKE7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Erosion (cm)</td>
<td>20-30</td>
<td>50-150</td>
<td>10-20</td>
<td>10-20</td>
<td>5-10</td>
<td>1-2 cm</td>
</tr>
<tr>
<td>2</td>
<td>Solum (cm)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20-30</td>
<td>20-30</td>
</tr>
<tr>
<td>3</td>
<td>Surface rock (%)</td>
<td>60-80</td>
<td>60-80</td>
<td>60-80</td>
<td>60-80</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 2. Water system analysis in Karai watershed.**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Parameter (PP No 150 Th 2000)</th>
<th>GKE 1</th>
<th>GKE 2</th>
<th>GKE 3</th>
<th>GKE 4</th>
<th>GKE 5</th>
<th>GKE 6</th>
<th>GKE 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Available water (%)</td>
<td>46.78</td>
<td>3.35</td>
<td>14.61</td>
<td>18.74</td>
<td>29.28</td>
<td>30.62</td>
<td>46.77</td>
</tr>
<tr>
<td>2</td>
<td>Permeability (cm/jam)</td>
<td>9.35</td>
<td>1.23</td>
<td>1.58</td>
<td>4.68</td>
<td>3.69</td>
<td>2.53</td>
<td>7.37</td>
</tr>
<tr>
<td>3</td>
<td>Infiltration (cm/jam)</td>
<td>2.664</td>
<td>350</td>
<td>450</td>
<td>1332</td>
<td>1050</td>
<td>720</td>
<td>2100</td>
</tr>
</tbody>
</table>

**Table 3. The change of water system due to converting natural forest to damaged land and gardening site.**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Parameter (PP No 150 Th 2000)</th>
<th>GKE 2</th>
<th>GKE 3</th>
<th>GKE 4</th>
<th>GKE 5</th>
<th>GKE 6</th>
<th>GKE 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Available water (%)</td>
<td>-43.43</td>
<td>-32.17</td>
<td>-28.04</td>
<td>-17.50</td>
<td>-16.16</td>
<td>-0.01</td>
</tr>
<tr>
<td>2</td>
<td>Permeability (cm/hour)</td>
<td>-8.12</td>
<td>-7.77</td>
<td>-4.67</td>
<td>-5.67</td>
<td>-6.82</td>
<td>-1.98</td>
</tr>
<tr>
<td>3</td>
<td>Infiltration (cm/hour)</td>
<td>-2.314</td>
<td>-2.214</td>
<td>-1.332</td>
<td>-1.614</td>
<td>-1.944</td>
<td>-564</td>
</tr>
</tbody>
</table>

**Table 4. Soil physical property analysis at Karai watershed.**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Parameter</th>
<th>GKE 1</th>
<th>GKE 2</th>
<th>GKE 3</th>
<th>GKE 4</th>
<th>GKE 5</th>
<th>GKE 6</th>
<th>GKE 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bulk density (g/cm³)</td>
<td>0.64</td>
<td>1.73</td>
<td>1.40</td>
<td>1.54</td>
<td>1.34</td>
<td>0.97</td>
<td>0.78</td>
</tr>
<tr>
<td>2</td>
<td>Porosity (%)</td>
<td>75.95</td>
<td>34.88</td>
<td>47.05</td>
<td>41.77</td>
<td>49.50</td>
<td>63.46</td>
<td>70.74</td>
</tr>
</tbody>
</table>

**Table 5. Soil physical property changes due to converting natural forest to damaged land and gardening site.**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Parameter</th>
<th>GKE 2</th>
<th>GKE 3</th>
<th>GKE 4</th>
<th>GKE 5</th>
<th>GKE 6</th>
<th>GKE 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bulk density (g/cm³)</td>
<td>+1.09</td>
<td>+0.76</td>
<td>+0.90</td>
<td>+0.70</td>
<td>+0.33</td>
<td>+0.14</td>
</tr>
<tr>
<td>2</td>
<td>Porosity (%)</td>
<td>-41.07</td>
<td>-28.92</td>
<td>-34.18</td>
<td>-26.45</td>
<td>-12.49</td>
<td>-5.21</td>
</tr>
</tbody>
</table>

Explanation: (-) (decrease); (+) (increase).
Damaging natural forest (tropical rain forest) to agricultural land has affected the rise of bulk density amounting to 0.14–1.09 cm$^2$/g. The rise of this bulk density is caused by land clearing using heavy equipment such as tractors, causing soil structure damage. On the other hand, the effect of compressing land will damage the pore of soil. This research result has proven that in this research site has soil pore damaged, which is land porosity decreases accounting for 5.21–41.07%. This research result demonstrates that logging natural forest and land clearing with heavy equipment causes damage in soil physical property. This property is important to natural forest specifically for available water, permeability, porosity, drainage, and soil infiltration in which uncovered soil will cause the available water will run off on the soil and will eradicate soil structure increasing bulk density. Soil structure damage will decrease soil porosity, permeability and soil infiltration. As a result soil damage to soil physical property will completely cause the decrease of hydrology function (water system) of Karai Watershed. This research is the same as the result of Hendrayanto et al. (2001) stating that surface run off of flood (water system decreases) could happened due to the decrease of soil infiltration capability and the lowered quality of covered land vegetation. It is also the same as the research of Aminudin (2012) stating that logging natural forest to cultivation line has caused the decrease of permeability accounting for 2.92 cm/hour, the decrease of porosity amounting to 2.93%, the decrease of available water amounting to 3.22% and the increase of bulk density accounting for 0.08 g/cm$^3$.

Vegetation effects on eroded land show differently regarding the type of those plants, crown, growth level and climate. The effects of climate is probably close to the forest management and plants (Hardjowigeno, 2005; Rahim, 2006). The existence of good covering vegetation such as grass and thicked density forest could eradicate topography effects for erosion. Thigtc covering vegetation slows down run off and also prevents loss of soil particles. Type of vegetation cultivated plays important role in preventing erosion (Arsyad, 2006). Rootage of plants tends to be closure of soil aggregate and increase soil porosity. Root also could grab the soil mass for affecting shear strength value. Therefore, soil that has plant roots has high permeability. Different plants suprisingly has different characteristics in affecting soil. Plants that has big leaves will be easy to break down to vertile the soil, thus reducing the soil sensitivity to erosion (Rahim, 2006). Overall erosion in thich natural forest will have low erosion levels called geology erosion (Arsyad, 2006; Wasis, 2012; Wasis et al., 2019). Forest conversion was carried out to land of rubber and palm oil farming with some actual agro technologies. Land of monoculture rubber I resold the highest run off and soil erosion more than the other land use type and showed different of run off and soil erosion on land of secondary forest (Sunarti et al., 2008).

**Soil chemical properties**

Laboratory analysis result illustrates that land clearing causes the damage of function of soil chemical property such as the decrease of C organic. The damage of soil chemical property will decrease the ability of soil in providing nutrition for the plants and decrease soil aggregate stability (PP Number 150 2000). For further detail, it is shown in Tables 6 and 7.

Demolishing forest and land causes the decrease of soil chemical analysis such as C Organic. The decrease of soil C organic accounting for 9.03% - 19.98% (93%). The biggest decrease of C organic occurs in open land, thus land coverage with vegetation is the most effective way to maintain soil fertility. Destroying natural forest has caused the loss of natural forest biomass. The loss of biomass tend to downgrade the ecosystem. In addition, destroying natura forest causes damage in soil chemical property such as the activities of logging and land clearing. Cutting trees in natural forest causes the loss of nutrition cycle in ecosystem. The loss of natural forest will affect the loss of branch, leaves, and nutrient, the decrease of organic materials on the forest ground will surely decrease the level of nutrients (N, P, Ca, Mg, K, and other soil materials). Those organic materials will decompose into simpler compound. In addition, those organic materials will get into mineralisation process. Decomposed organic materials will assemble resistant organic compound for the next decomposition (humat compound) and part of that will be released as useful nutrients. Therefore, final decomposition process of those chemical materials could be (directly or indirectly) affected. For the importance of organic material functions, the decrease of organic material levels should be notified fastly (Tables 6 and 7).

**Table 6.** Soil chemical properties at Karai watershed.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Parameter (PP No 150 Th 2000)</th>
<th>GKE 1</th>
<th>GKE 2</th>
<th>GKE 3</th>
<th>GKE 4</th>
<th>GKE 5</th>
<th>GKE 6</th>
<th>GKE 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>4.5</td>
<td>5.6</td>
<td>4.3</td>
<td>5.2</td>
<td>4.1</td>
<td>4.0</td>
<td>4.1</td>
</tr>
<tr>
<td>2</td>
<td>C-organic (%)</td>
<td>22.74</td>
<td>8.82</td>
<td>11.92</td>
<td>11.57</td>
<td>2.76</td>
<td>3.90</td>
<td>13.71</td>
</tr>
</tbody>
</table>

**Table 7.** The change of soil chemical property due to natural forest conversion to damaged land and gardening site.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Parameter (PP No 150 Th 2000)</th>
<th>GKE 2</th>
<th>GKE 3</th>
<th>GKE 4</th>
<th>GKE 5</th>
<th>GKE 6</th>
<th>GKE 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>+1.1</td>
<td>-0.2</td>
<td>+0.7</td>
<td>-0.4</td>
<td>-0.5</td>
<td>-0.4</td>
</tr>
</tbody>
</table>

* (decrease); + (increase).
Cultivating natural forest vegetation will cause the loss of biomass (log). In natural forest, log or biomass is the biggest component compared to other plant structures (such as branch and leaves). Consequently, natural forest cultivation indirectly tend to be the primary cause of the decrease of soil nutrients (Binkley, 1987; Evan, 2000; Wasis, 2006; Aminudin, 2012). The damage of soil chemical property due to logging in natural forest will break nutrient cycle in the forest. The result of Indrawan’s research (2003) shows that structures and composition of primary forest will decide the level of toughness of forest cultivation. It is predicted that the higher the density of commercial forest cultivation then the higher the damage is. The destruction effects in cultivated forest site will affects a) the availability of primary vegetation and their brood b) the availability of nutrients and c) other environment components such as temperature, humidity and other aspects. Reparation of soil chemical property could be done by giving them natural manure or green manure originated from Leuser Mountain Nation Park. The process of giving unorganic manure (chemical manure) is not recommended because it will cause pollution. In addition, seed used for reboisation have to use endemic vegetation (Wasis and Noviani, 2010; Wasis and Fathia, 2011, Wasis, 2012).

**Soil biological properties**

Laboratory analysis result show that land clearing has caused the damage of soil biological function which has triggered the decrease of total microorganism, total fungi and respiration (PP Number 150 2000). For further detail, it is shown in the Tables 8 and 9.

Deforestation has degraded the total microorganism, total fungi, and respiration. In addition, the detail or total decrease of total microorganism $5.0 \times 10^6$ cpu - $11.0 \times 10^6$ cpu, the decrease of total fungi $1 \times 10^8$ spk and soil respiration accounting for $12.16 - 23.08$ mgC-CO$_2$/kg soil/day. The result of this research has proven that converting natural forest to open land and gardening site causes the damage of soil biological property. Deforestation in Karai Watershed has caused the decrease of soil microorganism. The activity of deforestation should not be done because there are genetic sources and high diversities of microorganism. The existence of microorganism fuctions as soil fertility maintainance. According to Subba Rao (1986), soil microorganism is needed to maintain soil fertility and could be the important factor for nutrient cycle. The restoration forest soil doule be made by giving inoculation VA-mikoriza and incubation Rhizobium to catalyze the growth (Rumondang and Setiadi, 2011; Tuheteru and Husna, 2011). Restoration of existed damaged land near Catchment Area could be done by giving compostite manure or other natural manure, inoculating microorganism (mikoriza) and replanting endemic vegetation (Wasis et al., 2018). According to Nguyen and Klinnert (2001), giving organic manure is recommended to maintain plant productivity and soil fertility. Giving organic manure into soil is the potential source of N, P, and S elements for vegetation growth (Evans, 2000). Decomposition of organic materials for microbiology is one of the most important steps to release nutrient bond to become simple form (Kumada, 1987). Giving inoculation mikoriza is needed to increase the growth rate of plants and to conserve nutrient.

**Vegetation analysis**

Conversion of natural forest converage into garden, road, and dwelling sites is found. The result of vegetation analysis using plot ($20 \times 20$ m), at garden land closure and damaged soil is shown at Table 10.

### Table 8. Soil biological properties analysis at Karai watershed.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Parameter (PP No 150 Th 2000)</th>
<th>GKE 1</th>
<th>GKE 2</th>
<th>GKE3</th>
<th>GKE4</th>
<th>GKE5</th>
<th>GKE6</th>
<th>GKE7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total microorganism ($10^6$ cpu)</td>
<td>12.0</td>
<td>4.0</td>
<td>1.0</td>
<td>7.0</td>
<td>5.0</td>
<td>1.0</td>
<td>5.0</td>
</tr>
<tr>
<td>2</td>
<td>Total fungi ($10^5$ cpu)</td>
<td>1.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>Respiration (mgC-CO$_2$/kg soil/day)</td>
<td>26.68</td>
<td>3.60</td>
<td>5.88</td>
<td>9.72</td>
<td>5.84</td>
<td>6.28</td>
<td>14.52</td>
</tr>
</tbody>
</table>

### Table 9. The change of soil biological property due to converting natural forest to damaged land and gardening site.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Parameter (PP No 150 Th 2000)</th>
<th>GKE 2</th>
<th>GKE3</th>
<th>GKE4</th>
<th>GKE5</th>
<th>GKE6</th>
<th>GKE7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total microorganism ($10^6$ cpu)</td>
<td>-8.0</td>
<td>-11.0</td>
<td>-5.0</td>
<td>-7.0</td>
<td>-11.0</td>
<td>-7.0</td>
</tr>
<tr>
<td>2</td>
<td>Total fungi ($10^5$ cpu)</td>
<td>-1.0</td>
<td>-1.0</td>
<td>-1.0</td>
<td>-1.0</td>
<td>-1.0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Respiration (mgC-CO$_2$/kg soil/day)</td>
<td>-23.08</td>
<td>-20.8</td>
<td>-16.96</td>
<td>-20.84</td>
<td>-20.40</td>
<td>-12.16</td>
</tr>
</tbody>
</table>

* (decrease) ; + (increase).

### Table 10. Result analysis of vegetation on plots ($20 \times 20$ m) in natural forest and damaged soil at Karai watershed.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Growth level/Potential level</th>
<th>Natural forest (GKE 1)</th>
<th>Damaged soil (GKE 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Undergrowth</td>
<td>Types: 10 plants</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Seedlings</td>
<td>Types: 5 plants</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Saplings</td>
<td>Total: 6 plants; Volume: 0.15 m$^3$</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Poles</td>
<td>Total: 3 plants; Volume: 0.83 m$^3$</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Trees</td>
<td>Total: 10 Trees; Volume: 15.09 m$^3$</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Total volume</td>
<td>Volume: 16.7 m$^3$(417.5 m$^3$/ha)</td>
<td>Volume: 0 m$^3$</td>
</tr>
</tbody>
</table>
Inside complete natural forest, there are vegetation stratifications vertically (canopy/crown) and completely horizontally. Inside natural forest, there are also undergrowth plants, seedlings, saplings, poles and trees. Total volume of well-conserved natural forest is 417.5 m³/ha. However, on the damaged soil there is no stratification of trees vertically and horizontally. On the other hand, on the cleared land there is no vegetation with total volume of 0 m³. Those observation results shows that on cleared land occured damaged vegetation of natural forest, which means the ability of land in absorbing carbon dioxide (CO₂) tend to decrease or dissapear. Besides that fact, soil become unprotected. Therefore, soil aggregate are eradicated triggering soil bulk density increases and run-off increases (Figures 5-7).

Type of endemic trees of natural forest in Karai catchment area:
- Shorea (Shorea sp.)
- Cat Eyed Shorea (Shorea javanica)
- Rengas (Glutha rengas)
- Cengal (Hopea sangal)
- Iron wood (Eusideroxylon zwageri)

Type of trees planted:
- Sengon (Paraserianthes falcataria)

The type of undergrowth that is:
- Palm (Cyrtostachys renda)
- Calliandra (Calliandra calothyrsus)
- Bamboo (Bambusa sp.)
- Rotan (Daemonorops sp.)

Figure 5. Natural forest areas encroached upon society at Karai watershed.
Figure 6. Natural forest (tropical rain forest) area in Karai watershed.
Figure 7. Comparison of water quality (a) water from natural forest, (b) water from Karai river.
Damaged soil and the lost of permanent vegetation (forest) is the reason why Karai Watershed area has low water quality and high dissolved sedimentation. In the sedimentation process, the presence of forest land cover on a wide watershed is sufficient to reduce sediment flowing into the river (Junaidi and Tarigan, 2011).

According to observation and laboratory analysis could be discovered that damage on land and forest has occurred in forest area, protection area and non forest area. As a result to menage Karai catchment area has to notice technical factors and social economic aspects for local citizen. Therefore, to solve the exist problems integrated catchment area management should be implemented. This research shows that the wider the natural forest cover, the lower surface runoff and erosion. Salim et al. (2019) stated that the simulation from several scenarios shows that a decreasing in forest area can increase discharge and surface runoff, whereas an increase in forest area will increase soil infiltration and evapotranspiration. Decreasing forest area by 10% from existing conditions caused 58% of rain water to become surface runoff. The large number of discrepancies between the existing conditions and the directions in the RTRWP will require a long time and large costs to adjust so that the short-term alternative that can be done is to convert dryland agricultural cover to the forest to reach forest cover of at least 45% of the land area in the upstream area and can optimize the hydrological function of the watershed.

**Integrated management of Karai watershed**

Karai Catchment area is one of the biggest catchment area in which located in Northern Sumatera Province. It has the wide of 462 km² with non forest coverage amounting to 75%. To answer the problem, integrated management of Karai catchment area is necessary. To increase coordination and to continue communication processes among stakeholders to solve the problem, it needed to be insprative from those stakeholders. To make integrated program, activities and fundraising, it needs Integrated Management of Karai Watershed catalyzed participationly by including stakeholders (government, business community, academision and each individual). The reason is to achieve common mutual goals arranged together based on characteristic of natural capital such as upper are (atmosphere), soil and its component, vegetation, fauna, human capital including its intitutional (formal and informal), social capital and man made capital. With those plan in Karai Watershed, hopefully there are improvements among stakeholders in the resource management by coordinating, integrating and synchronizing policies with management and development of effective and efficient Watershed. Therefore, stakeholders construct programs and also do the activities for achieving common mutual arrangements.

Cases of land use changes in some areas in Indonesia will be presented with discussion on the causes and effects of watershed hydrology, especially in relation to carrying capacity and sensitivity of the watersheds and flood frequency. Hydrologic and discharge characteristics of some major rivers in Indonesia (especially in Java) will be given in relation to the status of watershed development. It was concluded that land use changes have occurred at large scale, especially in Java, and significant impacts on water yields of the river basins were observed, with increased frequencies of extreme events such as floods and droughts. Also of importance is the drop of present mean annual rainfall compared to earlier time of this century in Java and some other regions in Indonesia, which is believed to be related to the disappearance of proper forest land covers (Pawitan, 2014).

**Logical framework for planning integrated management of Karai watershed**

Logical framework of this management should be built based on the results of meeting with other stakeholders. For further details, logical framework was illustrated in Table 11.

**Table 11. Logical Framework for Karai watershed management.**

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objective</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing contribution of Karai Watershed for sedimentation, flood, and increasing water quality to fulfil the standard for certain purposes.</td>
<td>Increasing the function of absorbing area</td>
<td>Improve the function of water absorption. The wide of covered land increases. Government: Protected land (Open green land, Protected land, Conservation area, etc) including mixed forest, monoculture forest, enriching resources in conservation area. Local citizen: Owned land by local citizen is agroforestry, plants rotation Company: Owned land for private sectors. Adopted technology of soil and water conservation by stakeholders increases. Government: Control channel, dam checking, cross drainage on road and crops area. Citizen: Absorbing pit, crops area, cross drainage. Company: Rorak, Cross drainage on road, rorak, dam checking, crops area and free area to choose.</td>
</tr>
<tr>
<td>Increasing water quality</td>
<td></td>
<td>Increasing water quality of Karai river Infrastructure disposal and waste management increases (government). Management of household waste by citizen increases. Adopting environmentally friendly technology by industries increases.</td>
</tr>
<tr>
<td>Asumsi</td>
<td>Government policies and cities support the management of this Watershed</td>
<td></td>
</tr>
</tbody>
</table>
Program recommendation for integrated management of Karai watershed

Based on logical framework that has been made with technical biophysics condition, management and social economy that has been implemented, stakeholders can arrange alternative activities that could be done in each sub-district. Related to goals that has been approved to increase absorb function and water quality of the river, surface run off condition, sedimentation, and revenue level of citizen are factors to be considered in deciding activities that should be done. The success of this program highly depends on citizens’ support in local area. The support are measured by the level of revenue to land rehabilitation activities. Field observation result for land management could be recieved by citizen and environment do not destruct development soil in mixed gardening site and agroforestry. In addition, type of fruit cultivation period that has occurred is banana, talas, rice, sweet, corn and ginger. On the other hand, cultivated trees in local communities are rubber, coffee, pinang, durian, bamboo, and kallandra.

Conclusion

Land Cover for non forest area is the biggest sediment source in Karai Catchment Area. Based on observation on field and labotatory analysis, it shows that conservation activities in natural forest to garden, road, and dwelling site have caused damages to soil (parameter bulk density and total fungal) and environment with indicators of erosion, sediment materials in Karai River and Karai 7 Project location. Observation result shows that program to reduce erosion and sedimentation could be implemented by integrated management program of Karai Watershed with priorities to develop mixed garden and agroforestry.

REFERENCES


A case study of medicinal plants and their usage by the local community of Dilasaini Gaunpalika, Baitadi district, Nepal

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ABSTRACT
An Ethnomedicinal survey study was conducted to get information about the usage of medicinal plants and the diversity of species found around the village. The main objective of the study was to document the plants for their medicinal and other uses. Ethnomedicinal plants are locally available used by tribal communities and local inhabitants for various medicinal purposes. Random sampling survey was conducted by selecting 50 households to access the medicinal plants and document their usage in Gokuleshwor, Baitadi. A total of 33 species of medicinal plants to treat 40 ailments was reported with their multipurpose use. During the survey, an equal proportion of males and females aged 14 to 78 were selected randomly. The literacy rate of the study area was 80% and 94% of the people were found to be involved in the collection of medicinal plants. The majority of the respondents (92%) used medicinal plants for minor diseases like cuts, wounds whereas few were found to use the medicinal plant for a long time to treat major diseases like cancer, tumor. The use of medicinal plants for skin infections, cuts and wounds, fever was found to be high followed by diarrhea, common cold, ulcer, asthma, jaundice, burns, piles, and eye inflammation. Most of the plants were found to be used for more than one disease. The conservation of Indigenous knowledge on the Ethnomedicinal plant should be promoted as most of the respondents were unaware of the conservation of medicinal plants.

INTRODUCTION
Nepal is naturally and biologically enriched with diversification. Nepal is ranked 25th and 11th position in biodiversity richness in the world and Asia respectively. Nepal occupies about 0.1% of the global area, but harbor 3.2% and 1.1% of the world’s known flora and fauna. A total of 118 different ecosystems have been identified in Nepal (MoAD, 2017). From Nepal over 300 taxa of MAPs are traded with a total amount of 10,770 tonnes value worth of USD 60.09 million (Ghimire et al., 2016). The geographically important areas of Nepal include Nawalparasi, Chitwan, Bardiya, Kaski, Syangja, Illam, Lamjung, Humla, Jumla, Manang, Mustang, Solukhumbu, Nuwakot (MoAD, 2017).

The use of medicinal plants for the purpose of curing human diseases and disorders has had a long history. Popular observation on the use and efficiency of medicinal plants significantly contribute to the disclosure of their therapeutic properties, so that they are frequently prescribed, even if their chemical constituents are not always completely known (Maciel et al., 2002). Various national, as well as international research organizations, are involved in order to evaluate and authenticate the medicinal and scientific value of plants (Manandhar, 2002). Over the centuries, the knowledge of their medicinal value and healing properties has been transmitted within and among human communities (Silva et al., 2010). The tribal communities, significantly the women are involved in the continuation, preservation as well as the promotion of the local crop species, collecting and using the forest-based plants in daily dietary and...
Medicinal plants available in different niches are reported by several researchers. Pandey (1961) reported 73 medicinal plants for the first time in Nepal. 143 species of commercial MAPS were assessed from the gradient of Himalayas (Bhattarai and Ghimire, 2006). 51 species were reported from Palpa district which was climbing plants (Singh and Kumar, 2017). Medicinal plant reported from different districts of Nepal; 161 species were reported to use by Tamang community in Makwanpur district (Luitel et al., 2014). Tharu community of Rupandehi district used 45 species of 32 families and 41 genera (Acharya and Acharya, 2009). Magar community of Gulmi district used 161 species of plant for medicinal purpose (Acharya, 2012). 64 plant species were reported from Jhapa district used by Meche people (Rai, 2004). 105 vascular plants of medicinal importance was reported from Terhathum district (Rai, 2003). Nepal is considered to be reservoirs of medicinal plants and trade history from 2005 to 2014 showed an increase of, 27.49 million in 2005 to USD 60.09 million in 2014 (mean for the last 10 years being USD 39.34 million (Ghimire et al., 2016). IUCN has banned 11 species of medicinal plants on their export, collection, and transportation as they are threatened species (IUCN, 2000). Baitadi district is one of the under-developed districts in province 7 as well in the country. Peoples are found to be highly dependent on traditional medicines. Thus, the plant species used by them and their usage in the daily life of people living there have been focused on the study. The main objective of the study is to study the attitude of people’s perception towards the medicinal plants and the diversity of species used by the peoples found locally in the home gardens and fields.

MATERIALS AND METHODS

Study area

Dilasaini gaunpalika, Baitadi is a hilly district, falls in the province no. 7 of Nepal touching Jhulaghat, India to its border of Nepal. Gokuleshwr village is at an altitude of 800-950 masl (Figure 1). Two wards were selected for study viz. Ward no. 5 and ward no. 6. Dilasaini gaunpalika consists of a diversity of plants and among them, the plants used for the medicinal purpose by the peoples are found to be very limited. Thus, the plants used by the peoples were surveyed along with primary information and other information associated with the use of medicinal plants.

Research design and data collection

The total number of households in Dilasaini VDC is 497 (Source: Dilasaini gaunpalika). Sample size of 50 Households were selected from Dilasaini VDC on simple random basis as sampling frame size was determined (497). The sample size was adjusted to 10% as suggested by Ajayi et al. (2005) in social sciences research. A questionnaire survey was conducted and a random sampling survey was conducted to collect the information on the use of medicinal plants in Dilasaini gaunpalika. A random sampling survey was conducted and household respondents were interviewed. Also, a group discussion was conducted to gather information about the plant species used by them for the medicinal purpose along with their other uses. For identification of species and medicinal uses literature was cited (Kunwar et al., 2009; Kunwar et al., 2010; Rajbhandari et al., 1995). Also, secondary information was obtained from the conference papers, bulletins and, websites.

Data analysis

MS Excel 2013 and IBM Statistical Package for the Social Sciences (SPSS) for descriptive analysis. Graphs are prepared through MS Excel 2013.

RESULTS AND DISCUSSION

Socio-economic characteristics

A total of 50 households were selected randomly for the study out of which 50% were males and 50% were females, aged between 14 to 78. The literacy rate of the area was 80% and 20% were found to be illiterate. Agriculture as the primary occupation is found to be of 86% respondents and 14% were found to be involved in agriculture as a part time job. None of the respondents were found to get training on the use and protection of medicinal plants (Field survey, 2019).

Usage of medicinal plants

All of the respondents were found to be involved in the use of medicinal plants. The easy availability of medicinal plants got an advantage for the use. 94% of the respondents were found to use medicinal plants occasionally whereas 6% were found to use it regularly. Not all of the respondents were found to have a positive response regarding satisfaction gained from it. About 92% of the respondents are satisfied by the use of it whereas 8% of them are not satisfied with the use of it, Figure 2 (Field survey, 2019).

Marketing and preference of medicinal plants

Only 2% of the respondent was found to be involved in the marketing of medicinal plants whereas 98% do not involve in it.
The response regarding the preference to medicinal plants over processed medicine was found to be 94% and 6% of them are attracted to processed medicine. A cross tab result regarding the preference to medicinal plants towards age showed a result which is presented in the Figure 3.

The respondents were found to use for major diseases only (Figure 4).

**Diversity of medicinal plants investigated with their related information**

Medicinal plants documented in the study were found to be used for curing of 40 ailments. The majority of the plant species were found to have a multipurpose use for both medicinal and other various culinary uses. The majority of plant species were found to be used for skin infection, diarrhea, fever, common cold, cough, cuts and burns, asthma. However, diseases like heart pain, spleen enlargement, tumor, cancer, ulcer, astringent, fungal infection, weakness, eye inflammation, dandruff, jaundice, piles, gastritis were found to be cured by a few species. The details of the medicinal plant with their medicinal uses documented from the study are as shown in Table 1.

Medicinal plants assessed in the study were found to have multipurpose use including ornamental and food value. About 34 species were reported which was continuously used from generation to generation for the curing of 41 ailments. A similar use of plants for the medicinal purpose was reported by Kunwar et al. (2010) in far-west Nepal. The author reported 48 species of medicinal plants used for curing various ailments like asthma, tumor, diabetes, cold and cough, joint pain, gastritis and many more. The multipurpose use of medicinal plants was reported by Rokaya et al. (2010) with their culinary and ornamental uses. The author also reported that the medicinal plants were used chiefly for ophthalmic and gastrointestinal ailments. Similarly, Joshi et al. (2019) reported 44 medicinal plants for treating 62 ailments from Gyaneshwor community forest of Chitwan, moreover, Uprety et al. (2010) documented 56 species used for 60 medicinal formulations.

Medicinal plants are widely used to cure minor diseases like common cold, cough, fever, cuts and burns, swelling. People's attitude towards medicinal plants is high because of the low availability to hospital services and their faith towards medicinal plants. In our study, we found that people used medicinal plants for diseases like common cold, cough, diarrhea, dysentery, cuts & burns, skin infections, fungal infections, gastritis, pneumonia, asthma, bleeding gums, kidney stone, sinusitis, ulcer, earache, bowel pain and uterine contraction, purgatives, tumor, piles, ophthalmic disorder, bronchitis heart pain, and jaundice. Their ancestral preaching towards the use of medicinal plants was limited among family members. The use of medicinal plants towards major diseases is found to be low because of slow healing but also few people are attracted to it because of low or no side effects as compared to allopathic medicine (Jawlal et al., 2009). The proportion of the collection of the medicinal plant was high in forests followed by gardens and few are locally available in the market. The low land use in far west Nepal makes more reliable to collect medicinal plant from the field whose use is known (Kunwar et al., 2015). People's high response for the use of the medicinal plant is also due to its easy availability and most of them are found around home gardens making them cost-effective (Joshi et al., 2019).
<table>
<thead>
<tr>
<th>S.N.</th>
<th>Local name</th>
<th>English name</th>
<th>Family</th>
<th>Plant species</th>
<th>Plant parts used</th>
<th>Medicinal uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Chiuri</td>
<td>Butter nut tree</td>
<td>Butyraceae</td>
<td>Diploknema butyraceous (Roxb.)</td>
<td>bark</td>
<td>diarrhea, ulcer</td>
</tr>
<tr>
<td>2.</td>
<td>Bael</td>
<td>Bengal quince</td>
<td>Rutaceae</td>
<td>Aegle marmelos (L.) Corrêa</td>
<td>bark, fruit</td>
<td>dyspepsia, fever, constipation</td>
</tr>
<tr>
<td>3.</td>
<td>Bhringraj</td>
<td>False daisy</td>
<td>Compositae</td>
<td>Edista prostrata (L.)</td>
<td>bark, leaves</td>
<td>fever, liver and urinary problem, wounds, skin diseases</td>
</tr>
<tr>
<td>4.</td>
<td>Bojho</td>
<td>Sweet flag</td>
<td>Acoraceae</td>
<td>Acorus calamus L.</td>
<td>root</td>
<td>sore throat, voice disorder, cough, carcinogenic</td>
</tr>
<tr>
<td>5.</td>
<td>Barro</td>
<td>Belleric myrobalon</td>
<td>Combretaceae</td>
<td>Terminalia bellirica-(Gaertn.) Roxb.</td>
<td>fruit</td>
<td>piles, astringent, laxative</td>
</tr>
<tr>
<td>6.</td>
<td>Ban lasun</td>
<td>Liliaceae</td>
<td>bark</td>
<td><em>Lilium</em> nepalense D.Don</td>
<td>Bulb</td>
<td>relieving pain in cardiac region</td>
</tr>
<tr>
<td>7.</td>
<td>Barro</td>
<td>Indian gooseberry</td>
<td>Phyllanthaceae</td>
<td>Phyllanthus emblica L.</td>
<td>root, seeds</td>
<td>jaundice, asthma, bronchitis, laxative</td>
</tr>
<tr>
<td>8.</td>
<td>Alainchi</td>
<td>False daisy</td>
<td>Compositae</td>
<td>Eclipta prostrata (L.) L.</td>
<td>bark, leaves</td>
<td>treat enlargement of spleen, wounds, tumor, ear diseases</td>
</tr>
<tr>
<td>9.</td>
<td>Bhang</td>
<td>Sweet flag</td>
<td>Acoraceae</td>
<td>Acorus calamus L.</td>
<td>root</td>
<td>rhizome, used as anthelmintic, vermifuge, used as tonics</td>
</tr>
<tr>
<td>10.</td>
<td>Sandesh Thapa</td>
<td>Hill cardamom</td>
<td>Liliaceae</td>
<td><em>Amomum</em> subulatum Roxb.</td>
<td>oil, rhizomes</td>
<td>lung diseases, reduce eye inflammation.</td>
</tr>
<tr>
<td>11.</td>
<td>Pahade amla</td>
<td>False daisy</td>
<td>Compositae</td>
<td><em>Eclipta</em> prostrata (L.) L.</td>
<td>bark, leaves</td>
<td>treat enlargement of spleen, wounds, tumor, ear diseases</td>
</tr>
<tr>
<td>12.</td>
<td>Indrayani</td>
<td>False daisy</td>
<td>Compositae</td>
<td><em>Eclipta</em> prostrata (L.) L.</td>
<td>stem</td>
<td>asthma, earache, seeds; emetic, purgative also cures hemicranias, weakness of limbs.</td>
</tr>
<tr>
<td>13.</td>
<td>Harro</td>
<td>False daisy</td>
<td>Compositae</td>
<td><em>Eclipta</em> prostrata (L.) L.</td>
<td>leaves, flowers, fruits</td>
<td>leaves; used in inflammation of smoke to cure asthma, flower juice; used to treat earache, fruit juice; curing dandruff, falling hairs.</td>
</tr>
<tr>
<td>14.</td>
<td>Kaphal</td>
<td>False daisy</td>
<td>Compositae</td>
<td><em>Eclipta</em> prostrata (L.) L.</td>
<td>leaves</td>
<td>treat enlargement of spleen, wounds, tumor, ear diseases</td>
</tr>
<tr>
<td>15.</td>
<td>Harro</td>
<td>Indian gooseberry</td>
<td>Phyllanthaceae</td>
<td><em>Phyllanthus</em> emblica L.</td>
<td>leaves</td>
<td>treat enlargement of spleen, wounds, tumor, ear diseases</td>
</tr>
<tr>
<td>16.</td>
<td>Panchaule</td>
<td>False daisy</td>
<td>Compositae</td>
<td><em>Eclipta</em> prostrata (L.) L.</td>
<td>leaves</td>
<td>treat enlargement of spleen, wounds, tumor, ear diseases</td>
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Conclusion

Medicinal plants are the basics for the household treatment of minor and some of the major diseases. The study showed the direct relationship of households with the use of medicinal plants. By the use of medicinal plants, 92% of the respondents were satisfied. 76% of the collected medicinal plants from gardens and 22% from forests and 2% from others like ayurveda. A total of 33 medicinal plants were documented to cure 40 ailments. The majority of the medicinal plants collected were found to be used for diseases like fever, diarrhea, cuts and burns, gastritis, heart pain, chest pain, a painkiller. Also, the uses of medicinal plants were reported against diseases like ulcer, diabetes, laxative, dyspepsia, anxiety, gum bleeding, jaundice, pneumonia, asthma, cancer and so on. The use of a single medicinal plant for multiple diseases increases the value of medicinal plants and an effective strategy should be adopted for exploring the use of it. Also, the lack of training related to medicinal plants in the study area showed less knowledge on the conservation of plants and their effective use and propagation. Thus, the concerned government/ non-government body should take effective action for exploring the use of medicinal plants.

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Analysis of agricultural growth and its determinant factors in Nepal

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ABSTRACT
This paper critically analyzes the trajectory of agricultural growth and its determinants in Nepal. Agricultural growth is vital for stimulating overall economic growth. The World Bank research shows strong statistical link between agricultural and overall economic growth in less developed countries. Economic growth and agricultural growth in Nepal also show strong correlation (r = 0.7501 **). Agricultural transformation is characterized by declining share of agriculture in national employment and GDP, and increasing share of secondary sectors like industry, service and manufacturing. However, this structural shift seems unplanned and ungoverned in case of Nepal. The contribution of agriculture to GDP is continuously declining, but, the growth of secondary sectors likes industry and manufacturing still looks stagnant. At this incipient stage of agricultural transformation, productivity growth in agriculture is both a necessary as well as sufficient condition for the development of economy as a whole. Agricultural growth depends on institutional (agricultural credit and land holdings), infrastructural (irrigated area, farm mechanization, electricity, storage, transportation, agricultural market), technological (high yielding varieties or improved seed, fertilizers and pesticides) and socioeconomic factors (population, poverty and literacy). Policies strengthening these determinants can help Nepal in achieving targeted sustained economic growth.

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INTRODUCTION
Nepal is one of the least developed and low income countries in the world. Nepal aims to graduate from least developed country to developing country by the year 2022 and low income to middle income country by 2030 (MoF, 2018). Out of the three criteria (i.e. Human Asset Index, Economic Vulnerability Index and Per Capita Income) set by UN to graduate to the league of developing nations, two of them have been met but Nepal lies far behind in the Per Capita Income (Shrestha, 2018). Low per capita income is attributed by the high agriculture dependent rural population. Agriculture is one of the powerhouses of Nepalese economy contributing 26.5 percent of total national gross domestic product (GDP) (MoF, 2018). It is both the source of food as well as the economic wealth of the nation. Majority of the population (65.6 percent) are involved in agriculture sector (MoAD, 2018). Major portion of total export depends on agriculture; large cardamom, ginger, lentil, tea, coffee being the major exportable commodities. The fate of development of Nepal is highly dependent upon the growth of Agri-GDP as the large proportion of population as well as industries and trade are agriculture dependent. Growth in agriculture sector is thus, the panacea for achieving economic development in Nepal which in turn depends on the several factors. Researchers have emphasized labor force growth, human capital, financing, capital accumulation in public infrastructures and research and technology as major determinants in examining agricultural growth (Thapa, 2011). This paper makes an attempt to critically analyze the sectoral structure of GDP, find the relation between economic
growth and agricultural growth and determine the factors affecting agricultural growth and thus find out where in Nepal lies in the path of agricultural transformation.

**METHODOLOGY**

This study is basically carried out using publicly available data sources, such as Economic Survey Reports (FY 2003/04, 2012/13 and 2018/19) and World Bank database. Relevant journal articles, reports and books were consulted for having detail insight on determinants of agricultural growth. Descriptive statistical tools such as pie-chart, bar-diagram was used to represent sectoral contribution to GDP, comparative study of productivity of major crop in South Asia. Trend line was used to study the trajectory of agricultural growth, pattern of contribution of agricultural and non-agricultural sector to GDP and growth of agricultural credit flow. Correlation analysis was employed to find out the relation between agricultural growth and economic growth in Nepal. MS-Excel and STATA (version 12) was used for this purpose.

**RESULTS AND DISCUSSION**

**Sectoral contribution to GDP**

The contribution of agriculture sector to GDP is gradually decreasing annually while that of non agricultural sector is increasing. In the FY 2017-18 the contribution of agriculture and non agricultural sector to GDP was 28.1 percent and 71.9 percent respectively (Figure 1). The contribution of agriculture to GDP was projected to decline to 27 percent in the FY 2018-19 (MoF, 2018). Nepal has shown a drastic change in the structure of employment and GDP composition in last few years. According to World Bank, the share of agriculture in GDP has decreased drastically from around 69 percent (1966) to 26 percent (2016) whereas the contribution of service and industry to GDP shows the increasing trend which is believed as good indicator of an economy (World Bank, 2019).

Nepal’s economy is enjoying a solid expansion through the reconstruction activities after the devastating earthquake of 2015. The economic growth in the recent two-three years shows sustained growth around 6 percent. The preliminary draft of concept paper of 15th five year plan has set a target to achieve a minimum economic growth of 9.4 percent per annum next five year. Similarly, contribution of agriculture sector and industrial sector in national GDP is projected to reach 22.1 percent and 20.3 percent respectively (Himalayan Times, 2019). As an economy develops, the relative contribution of agriculture to output and employment must decline (Joshi, 2018). A declining share for agriculture in national employment and GDP is an inevitable consequence of economic progress (Cervantes-godoy and Dewbre, 2010). This is largely due to higher income elasticity of demand for non-agricultural goods and services. This process of agricultural transformation is usually accompanied by rising incomes and lower incidence of poverty of the agriculture dependent population. Per Capita Income (PCI) of Nepal has crossed 1,000 US dollar and poverty rate has sharply declined which is marked as a major boost to graduate from least developed to developing country.

The experiences of developed countries show the transfer of labor force from less productive agricultural sector to more productive non-agricultural sector. However, story of agricultural transformation is rather different in Nepal. The contribution of agriculture to GDP is continuously declining, but, the growth of secondary sectors like industry manufacturing etc. still seems stagnant. The service sector, on the other hand, is growing at faster rate. Agricultural labor force is in continuous decline due to heavy outmigration. The economy has become remittance dependant and agriculture still remains the less productive sector. Therefore, the structural shift in agriculture is found to be unsystematic. Without the sustainable development in other sectors like service and industry, such shift could be suicidal for a country like Nepal having deep rooted life style, culture, religion and knowledge based agriculture (Satyal, 2010). Under these circumstances, higher agricultural growth is vital for the sustainable economic development (Figure 2).

**Economic growth and agricultural growth**

The World Bank research shows strong statistical link between agricultural and overall economic growth in less developed countries. Countries with agricultural share of GDP greater than 20 percent in 1970s exceeded 3 percent a year in 17 of the 23 countries whose GDP growth rate was above 5 percent a year while 11 of the 17 countries with GDP growth below 3 percent a
year managed agricultural growth of only 1 percent or less (Timmer, 1988). Analyzing the relation between annual agricultural growth rate and GDP growth rate in Nepal shows a significant positive correlation ($r = 0.7501^{***}$) at 1 per cent level of significance. This indicates agriculture is a key sector for economic growth in Nepal.

The trend line in Figure 3 shows agricultural growth is increasing but the rate is not significant. In the fiscal year 2017/18, GDP at basic price increased by 6.3 percent which is expected to increase by 6.8 percent in the fiscal year 2018/19. Favorable weather conditions, increased access of irrigation facilities and easy availability of seeds and chemical fertilizer contributed to increase the production and productivity of agricultural sector in the same year. Gross Value Added (GVA) of agriculture and non-agricultural sector is estimated to grow by 5 percent and 7.5 percent respectively. Data of last decade shows the average annual economic growth rate of 4.6 percent with 3.1 percent and 5.3 percent average annual growth rate respectively in agricultural and non-agricultural sector (Figure 4). Nepalese economy was devastated by the earthquake and border blockade in the fiscal year 2015/16. Reformative works from that stage has made it possible to expand the economy with an annual average of 7.3 percent from the fiscal year 2017/18 (MoF, 2018).

**Determinants of agricultural growth**

Cereal crops, horticulture, livestock, fisheries and forestry are the major subsectors of agricultural sector of Nepal. Cereal crops contribute the highest (49.4 per cent) to the agri-GDP followed by livestock (25.8 per cent), horticulture (16.7 per cent) and forestry (8.1 percent) (Joshi, 2018). Growth of agriculture sector requires the increased productivity in all these subsectors. The productivity growth in agriculture is both a necessary and sufficient condition for the development of this sector as well as the economy. However, productivity of major subsector of Nepalese agriculture seems stagnant. Productivity of maize, in Nepal, is at the bottom in South Asia while that of rice is only higher than Afghanistan (Figure 5). Contraction of agricultural land due to escalating urbanization and plotting in one hand and declining of agricultural labor force on the other hand has exacerbated the situation of poor agricultural productivity in Nepal. We are facing a challenge to increase productivity from declining agricultural land and agricultural labor force. This requires a capital intensive technology driven agricultural sector.

Agricultural growth depends on institutional (agricultural credit and land holdings), infrastructural (irrigated area, farm mechanization, electricity, storage, transportation, agricultural market), technological (high yielding varieties or improved seed, fertilizers and pesticides) and socioeconomic factors (population, poverty and literacy). Thapa (2011) identified population growth rates, male literacy, improved seeds and chemical pesticides as important contributors in agricultural growth of Nepal. The contribution of female literacy, road density, irrigation coverage, agricultural credit and mineral fertilizer were also significant contributors to agricultural growth in Nepal. Awan and Mustafa (2013) found total cropped area, irrigation water; improved seed distribution and import of pesticide have significant impact on growth of agri-GDP. Major determinants of agricultural growth in Nepal are:

![Figure 3. Scatterplot matrix for correlation analysis of agricultural growth and economic growth.](image)

![Figure 4. Trend of agricultural growth in Nepal from the year.](image)
Agricultural credit
Least developed countries like Nepal needs improved technology for increasing agricultural productivity and sustained agricultural growth. These modern agricultural technologies (chemical fertilizer, improved seed, irrigation, farm machineries etc.) are capital intensive. Adoption of these technologies demands increased credit facilities to the resource poor farmers. Access to credit can promote the adoption of high yielding technologies in agriculture (Saboor et al., 2009). Easy and cheap credit is the quickest way for increasing the agricultural production (Abedullah et al., 2009). Total amount of Rs. 128.33 billion agricultural credit was mobilized up to mid-march of 2017/18 which increased by 40.6 per cent to Rs. 180.2 billion. This figure was only Rs. 50.91 billion. Since then, there had been about 167 per cent in last five years period and stood as Rs. 135.76 billion in the fiscal year 2017/18 (MoF, 2018). Disbursement of agricultural credit by commercial bank has increased drastically than earlier indicating good sign for agricultural growth (Figure 6).

Agricultural land
Increase in agricultural land has a positive relation with agricultural productivity. As the cultivated land increases, production also increases, then, it could be expected that agriculture sector contribute larger percentage of its output growth. Odhiambo and Nyangito (2004) and Teshome and Lupi (2018) found positive impact of agricultural land on agricultural growth respectively in Kenya and Ethiopia. Nepal has cultivated land of 30,91,000 ha and still 10,30,000 ha arable agricultural land is uncultivated (MoAD, 2018). Escalating urbanization has posed a huge threat on agricultural productivity in Nepal.

Agri-inputs
The growth of agricultural sector is largely dependent on the availability and use of the agri-inputs like chemical fertilizers, improved seeds, and chemical pesticides. Research shows that at least 30 to 50 per cent yield is attributable to commercial fertilizer nutrient input (Stewart et al., 2005). Use of high yielding varieties seed increases the yield by 45 per cent. Crop losses due to various pests is about 35 per cent (Kafle et al., 2014). Availability of safe and efficacious pesticides and their judicious use is critical for the sustainable increase in agricultural production. Nepal is far behind in using fertilizer per hectare of arable land. Potential demand for fertilizer in Nepal is about 7,00,000 MT of which actual supply was only 3,24,977 MT in the year 2016/17 (Panta, 2018). The average increase of fertilizer use per hectare in Nepal is 3.4 kg per annum. The sale of improved seed increased from 6911.604 MT in 2016/17 to 8143.958 MT in 2017/18 (MoAD, 2018). Subsidy program on chemical fertilizer and improved seed had impressive effect on their adoption (Bista et al., 2016).
Rural infrastructure

Rural infrastructure like road connectivity, transport facilities are the most crucial factors for sustained agricultural growth. Road networks and transport facilities helps in reduction of transportation cost and makes the agricultural products competitive in the market. It gives an encouragement to the farmers and thus helps in increasing agricultural productivity. There has been substantial increase in road network. All district headquarters have been linked to road networks except Humla (MoF, 2018). Linking all the agricultural areas of Nepal with road networks can boost up agricultural production creating favorable environment for rural farmers. Irrigation also plays crucial role in agricultural growth. Bhattarai and Narayananamoorthy (1994) found a strong inverse relationship between incidence of rural poverty and percentage of gross area irrigated in India. Therefore, it is thought as a critical factor for overall development of agricultural sector. Only 1.473 million hectare out of a total of 2.641 million hectares of agricultural land in Nepal had irrigation facility in the fiscal year 2017-18. However, due to lack of availability of sufficient amount of water in the source and delayed implementation of the projects of water transfer, only, 33 per cent areas of irrigated land has irrigation facility throughout 12 months of a year (MoF, 2018). Expansion of additional irrigated area and introduction of modern irrigation technology, in coming days, can enhance the agricultural productivity of Nepal.

Literacy rate

Adoption of high yielding modern technology is crucial for the increased productivity. Educated people readily adopt these technologies than the illiterate and uneducated one. Literature shows that education has high rates of return to investment, and higher contribution to economic growth rates by improving total factor productivity (Thapa, 2011). Education increases the decision making capacity of the farmers. Nepal has made a substantial improvement in social sector like education. Adult literacy rate increased from 20.57 percent in 1980 to 67.9 per cent in 2018 (World Bank, 2019). This improvement in literacy rate has played important role in human capital development and growth of agricultural productivity in Nepal.

Conclusion

It is evident from the research that agricultural growth is vital for the overall economic growth for the least developed countries like Nepal (as shown by the strong correlation between agricultural growth and economic growth in Nepal). The process of agricultural transformation is still at the incipient stage in Nepal. The contribution of agricultural sector to GDP is declining but the sectoral contribution of industry and service to GDP still looks stagnant. At this critical stage of agricultural transformation, agriculture driven growth is the current need for the overall economic growth of the nation. Agricultural growth depends on institutional (agricultural credit and land holdings), infrastructural (irrigated area, farm mechanization, electricity, storage, transportation, agricultural market), technological (high yielding varieties or improved seed, fertilizers and pesticides) and socioeconomic factors (population, poverty and literacy). Strengthening of all of these factors is crucial in achieving the targeted double figured economic growth. Declining of agricultural labor force and agricultural land demands the capital intensive technology driven agricultural sector. For this easy and cheap (low interest rate) agricultural credit should be encouraged with regular monitoring. Timely supply of the agricultural inputs as per the farmers’ demand should be ensured by the government. Both underground and above ground irrigation facility should be increased. Expansion of the road networks by government is a must to connect rural farmers with market. Policy discouraging conversion of agricultural land into other purpose should be formulated and implemented. Efficient extension services should be provided to increase adoption of high yielding agricultural technologies. It is, thus, imperative for the government to address all these sectors for agricultural as well as economic growth.

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This study delves into the issues related to remittance and its role in the Nepalese economy. Remittance is found to have positive association with human capital formation and financial development while negative impact on productivity and international trade in Nepal. Nepal is one of the leading nations of sending workers abroad received approximately US$ 6.29 billion of remittances, almost 25 per cent of its GDP in 2017/18. The investment of remitted amount in unproductive sectors like consumption expenses rather than in productive sectors has resulted in an increment in overall import. The remitted income has occupied a major position of financing which exceeds all the foreign aid and investment in recent years. Thus, the Government of Nepal should make an appropriate policy to maximize the benefit of remittance and retain the manpower to the sustainable economic growth and development sector of the country.

INTRODUCTION

Remittance refers to the money and goods that are transferred by the emigrants to their households, either from urban areas or abroad (Richard and Adams, 2011). Nepal represents the country with a small size economy of US$ 25 billion GDP with a share of remittance to its GDP is approximately 25 per cent in 2018 which was only 1.8 per cent in 1995 (MoF, 2018). This indicates that the Nepalese economy is becoming more remittance-dependent with the inflows of remittances that have been continually growing over recent decades. The share on the migrant population from Nepal is 3 million; approximately 10 per cent of the total population of the country (Sharma, 2019). The history of labour migration dates back to 300 years ago; in May 1815 agreement between the colonial British government in India and Nepal formally opened up the avenues for Nepalese to be employed overseas with the annual recruitment of Gorkha soldiers from Nepal for the British armed force. Since then, Nepalese have been migrating to North-East India in search of work in the coal mining and agriculture sectors (Kshetry, 2003). This century old tradition undergoes a transformation after the civil war of Maoist party which became one of the push factors for the youths to leave their villages. Especially gulf countries (Saudi Arabia, Qatar, UAE, Oman, and Kuwait), South Korea and Malaysia became the priority destination for them. The new destinations emerged because of the globalizing dynamics and the boom in the oil industry that started in the Middle East in the 1970s (DoFE, 2015). The liberalized economic policy adopted after 1992 helped to formalize labour migrations and opened doors for recruitment and remitting agencies to operate in the country and solicit workers for jobs in the other countries (Shrestha, 2016). Rai and Awale (2016) have reported that about 1500 Nepalese workers on average fly out from Kathmandu international airport to these countries every day. The survey carried out in 2010/11 revealed that approximately 56 per cent of the Nepalese households received remittances, both from internal and external sources. Different scholars have differently characterized the impact of remittance on economic growth in various countries. Remittance has been considered as a major source of financing in the Nepalese economy but there has been limited study carried out exploring the relationship between remittance and its impact on economic growth in Nepal. Therefore, the objective of the study is to analyze the remittance inflow and its impact in the Nepalese economy.
**METHODOLOGY**

The study is based on the secondary data obtained from the various issues of Economic Survey of Ministry of Finance (Fiscal years 2000/01, 2008/09 and 2018/19); World Bank, Quarterly Economic Bulletin and Economic reports of Nepal Rastra Bank (Central Bank). Different remittance related journal articles, reports and books were also reviewed. Descriptive statistical tools such as bar diagram, tables are used to represent the remittance status in developing countries and South Asia, a pie chart to show the foreign employment status in Nepal and line graph and trend line to discuss the remittance and national economy. Correlation relationship is carried out to show the relationship of remittance income with gross domestic product and gross capital formation and all of this is carried out using MS excel and STATA (version 12).

**Empirical findings**

**Remittance and economic growth**

Researchers throughout the world have conducted several studies to investigate the impact of remittance on economic growth. There are different conflicting perspectives regarding the impact of remittance on economic growth (Turnell et al., 2008). The optimist argued that the remittances have a positive effect on economic growth as it increases in investment and human capital while pessimists’ remittances negatively affect economic growth through inflation and moral hazards resulting from reduced labor supply (De Haas, 2007). Difficulty of disentangling the links between remittance and economic growth might be the cause of this controversy. The study conducted by Tolcha and Rao (2016) in Ethiopia over 1981-2012 found that remittance has a significant impact on economic growth in the short run whereas it has adverse effect in the long run. Cooray (2012) found that remittance has a significant positive effect on economic growth considering education level and financial sector development in South Asia. Similar, a study carried out in Bangladesh over 1975-2013 concluded that the remittance has positive association only in the long run with economic growth (Majumder and Donghui, 2016). Lokshin, Bontch-Osmolovski and Glinskaya (2010) found that the remittance reduces poverty by one fifth between 1995 and 2004 in Nepal. Similarly, Adams (2006) in Ghana and Taylor, Mora, Adams and Lopez-Feldman (2005) in Mexico also concluded that international remittances reduce poverty. Chami et al. (2005) carried out the study covering 113 countries over 1970 to 1980 showed that the remittances serve negatively and have a significant effect on per capita GDP growth for different groups of the country. A similar study carried out in 100 countries for the period 1975 to 2002 by Giuliano and Ruiz-Arranz (2009) suggested that remittance enhances GDP growth in less developed countries by serving as the alternative to finance development. Richard and Adams (2011) reviewed that international remittances, however, creates a negative impact on labour supply, education, and economic growth, it usually has a positive effect on poverty and health in the developing countries. Fajnzylber and Lopez (2007) concluded the positive but relatively small impact of remittance on growth and investment. The study on the impact of remittances on economic growth in Nepal showed that remittance has positive relationships with financial development and human capital accumulation while a negative association with productivity and international trade signifies the mixed impact of remittance flows on the economic growth (Dahal, 2014). Likewise, remittance has contributed to create human capital through investment in education and health and lift up people from the extreme poverty group in Nepal (Sharma, 2019). Remittance may deteriorate economic growth as it led to moral hazard and the Dutch disease (real appreciation and loss of competitiveness in tradable goods) by hollowing out of adult members and creating inefficiency in farm production due to shortage of labor and income substitution effect (Sharma, 2019; Richard and Adams, 2011).

**The remittance and economy of developing nations and south Asia**

More than 247 million people or 3.4 percent of the world population, live outside their countries of birth. United States, followed by Saudi Arabia, Germany, the Russian Federation, the United Arab Emirates, the United Kingdom, France, Canada, Spain, and Australia are the top migrant destination country in the world (World Bank, 2016). Countries having higher income are the largest sender of the remittance where the United States (US$68 billion) followed by the United Arab Emirates (US$44 billion) and Saudi Arabia (US$36 billion) (World Bank, 2019). In 2018, the top recipient countries recorded were India, China, Mexico, the Philippines and the Arab Republic of Egypt. As a share of GDP, however, smaller countries such as Tonga (35.2 per cent), the Kyrgyz Republic (33.6 per cent), Tajikistan (31 per cent), Haiti (30.7 per cent), Nepal (28 per cent), and El Salvador (21.1 per cent), were the largest recipients in 2018 (Figure 1).

**South Asia**

Remittances to South Asia upsurge by an estimated 12.3 per cent in 2018, faster than the 5.7 per cent observed in 2017. In India growth of remittance is 14 per cent which remained moderate (6.7 percent) in Pakistan whereas Bangladesh, remittances showed a brisk uptick of 14.8 per cent and Sri Lanka witnessed remittance growth of 3.8 percent in 2018 (World Bank, 2019). India is the highest remittance (US$78.6 billion) recipient country in South Asia followed by Pakistan (US$21 billion) and Bangladesh (US$15.5 billion). In terms of gross domestic product (GDP) Nepal secured the highest position among all in 2018, having 28 per cent. This implies that the Nepalese economy is highly dependent on the remittance (Table 1).

**Foreign employment in Nepal**

According to the population of Nepal, about 500 thousand people entered the labour market every year creates a big challenge to provide employment opportunities. The nation is unable to extend the employment market as expected. Labor force survey 2017, showed that unemployment rate in Nepal is 11.4 per cent.
The increase in the unemployment rate in the country compel millions of youth to fly overseas for foreign employment. About 4.30 million youths have gone abroad in foreign employment through formal and informal way. However, more than 167 countries have been opened for foreign employment by personal initiatives; only 110 countries have been institutionally opened for foreign employment (MoF, 2018).

Of the total 4,365415 licensed migrant workers, 4167310 were male and 198105 were female till FY 2017/18. Malaysia is the first destination providing foreign employment to 1313658 (30.1 per cent) of Nepalese workers followed by Qatar 1196168 (27.4 per cent), Saudi Arab 880951 (20.2 per cent), UAE 572470 (13.1 per cent) and 402468 (9.2 per cent) in other countries (Figure 2). In Nepal, lack of employment opportunities, political instability, the low salary structure, government liberal policy within the nation and higher demand for the labour in the industrialized Asian and middle-east countries are major causal factors of foreign employment. Similarly, the majority of Nepalese students who have gone abroad (United States, United Kingdom, and Australia, etc.) for higher studies have decided not to return to because of a lack of opportunities in the nation (Dhungana, 2012).

The remittance and Nepalese economy
The increasing number of emigrants every year for employment raises the amount of remittance substantially. Remittances have become one of the major factors to contribute to household income and GDP of the nation (DoFE, 2014). As shown in Figure 3, the remittance income in Nepal was about NRs.10 billion in 1998 was drastically increased from NRs.65 billion in 2004 to NRs.209 billion in 2008. In FY 2017/18, the remittance income in Nepal is approximately NRs.755 billion (MoF, 2018). The trend of remittance income of Nepal has depicted through the figure below revealed that the share of the remittance to GDP has been dramatically increased over the recent decades. Similarly, the relation between remittance income and GDP is found to be highly correlated (0.9914) at 0.01 level of significance with about NRs.1074 billion of average GDP.

The contribution of the remittance on the national economy can be computed with remittance to GDP ratio which is shown in the figure below. Even in the presence of the wide trade deficit and rising burden of debt servicing, the surplus in current account and balance of payment is due to elevated levels of remittance inflows in recent years (Shrestha, 2008). Chami, Hakura and Montiel (2009) also discussed that growth volatility could be stabilized through remittance flows as raise in migrant’s remittance to GDP ratio by one per cent reduces the standard deviation of GDP growth by 0.16. The remittance to GDP ratio is relatively higher compared to other South Asian countries. The annual remittance contribution to GDP has been increasing since FY 2000/01 and decrease in FY 2009/10 and again raised to 29 per cent in FY 2014/15 which is 24.9 per cent in FY 2017/18 (Figure 4).

The remittance income and gross capital formation has been depicted through the Figure 5. Sapkota (2013) discussed that only 2.4 per cent of remittance is used in capital formation and rest are spent on day to day expenditure of households in Nepal. Similarly, (Dhungana, 2012) evoked about the dearth of the resource for investment due to consumption-oriented pattern of remittance utilization in Nepal. The average gross capital formation is found to be NRs. 405 billion. The relation between remittance income and gross capital formation is found to be highly correlated (0.9766). Similarly, the relation between GDP and gross capital formation is also highly significant and positive.
Remittance has become a major source of foreign currency reserves which have now sufficient for mechanizing and service imports of more than a year. It has increased the liquidity in the banking system and the lack of other investment opportunities in the nation leads the investment into the unproductive sectors (consumption growth) that results in increment in overall import in recent years (Dhungana, 2012). Similarly, the study carried out by Dhungel (2014) also disclosed that the remittance contributes just 0.07 percent in gross domestic product implies that international remittance is spend mostly on consumption expenditures rather than investing on the productive sector. Damber (2017) suggested that a substantial increase in remittance results in lower domestic production due to the emigration of youths and dependency on imports rather than investment has deteriorate GDP per capita of Nepal. Sharma (2019) revealed that remittance results in an increase in import of luxurious goods as well as eroded the competitive advantage of the country by debilitating the export sector which leads to the trade deficit. The import of goods has been inclined from about NRs. 284 billion to NRs. 1242 billion over FY 2008/09 and FY 2017/18 respectively. The rapidly increasing imports are highly financed by remittance, while the export worth about NRs. 67 billion during FY 2008/09 was approximately NRs.81 billion only at FY 2017/18 represents the trade deficit scenario of the nation (Figure 6).

The foreign aid is received in the form of grants and loans from bilateral and multilateral sources. As per the Ahamada and Coulibaly (2013) and Giuliano and Arranz (2005) remittance represents the major part of external finance exceeding export revenues, foreign direct investment (FDI) and aid for most of the developing countries. In the case of Nepal, the flow of foreign aid which has been remained nearby the remittance income during FY 2001/02 has consistently become lower than remittance income. Remittance has drastically increased from FY 2005/06, an occupied position as a major source of financing to the foreign aid in FY 2017/18 as shown in Figure 7.

**Policy and legal frameworks**
The liberalized economic policy adopted after 1992 helped to formalize labour migrations and opened doors for recruitment and remitting agencies to operate in the country and solicit workers for jobs in the other countries (Shrestha, 2016). In past, the government of Nepal responded with the promulgation of Foreign Employment Act, 1985 to regulate foreign employment but failure of this act gives rise to new Foreign Employment Act 2007 for dignified, organized and reliable foreign employment.
The government introduced National Labour Policy 1999 and Foreign Employment Policy 2012 to provide a safety and accessible migration process and to protect the rights of Nepali workers involving in foreign employment. Foreign Employment Act (2007) has removed all gender-based discriminatory clauses and made provision that only license holder manpower agencies can deal with foreign employment (Shrestha, 2008). The Three-Year Interim Plan had adopted the policies and strategies for providing pre-departure training, life and accidental insurance for the contract period, the establishment of labor commission and labor tribunal. Recently, the Constitution of Nepal has secured the right to employment and right to labor as basic rights. The Act on Right to Employment-2018 obliged all local levels to have Employment Service Center (ESC) to list out unemployed people, to provide at least 100 days of employment during a fiscal year under the Prime Minister Employment Programme. The government of Nepal has brought ‘National Employment Policy 2016’ and Foreign Employment Policy 2012 into implementation as per the commitment for sustainable development goals to ensure safe and secure employment through International Labour Organization (ILO) Convention. The Fifteenth Plan also aims to make foreign employment safe and secure, dignified and organized. Similarly, more than 167 countries have been opened for foreign employment by personal initiatives but only 110 countries have been institutionally opened for foreign employment by the government of Nepal (MoF, 2018).

The role of remittance for a nation is very significant because the investment of government is very low in this sector; the remittance inflow rescued the economy during ten years of insurgency period and the worldwide financial crisis during 2007 or 2009. On this dilemma of remittance inflow of Nepal, the government should make proper policy to maximize the benefit of remittance and retain the manpower to the sustainable economic growth and development sector. Similarly, to minimize the sapping effects of the remittance at the societal level, policymakers could come up with the idea of capacity building activities (Sharma, 2019). Government could formulate policies like sending the remittance only through official channel, encouraging migrants to keep their savings in financial assets in the country rather than holding in abroad to increase the levels of remittance and creating environment for migrants to invest in productive assets within the country (Pant, 2011).

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Conclusion

This study attempted to analyze the relationship between remittance and economic growth in Nepal through the study of different empirical articles. It concludes that many economists are optimistic that the remittance can be a major contributor to economic growth while some of them found remittance to have a negative impact on it. This review shows that more work is needed to be carried out with appropriate methodology to resolve the controversy regarding the impact of remittance on economic growth and other areas. Nepal is one of the leading nations of sending workers abroad, it ranks the fifth largest recipient of remittance in term of GDP in the world and first among South Asian countries in the year 2018. Various study showed that remittance has a positive association with financial development and human capital formation while the negative impact on productivity and international trade in Nepal. The remittance being invested in the unproductive sector leads to an increase in the overall import of goods which creates dependency and slows down the economic growth in the long run. Remittance has been an important avenue for assisting family members to lift their livelihoods but couldn’t be the best way for development without its investment in productive sectors. Therefore, the government should make appropriate policies to maximize the profit of remittance and retain the manpower to the sustainable economic growth and development sector of the country.
REFERENCES


Preliminary toxicity assessment of chromium (Cr) and lead (Pb) on terrestrial snail (Helix aspersa)

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E-mail: varundhiman79@gmail.com

ABSTRACT

Chromium and lead are among the major toxicants that have their own environmental concerns and are very harmful for living organisms even in small concentrations. The present study is performed to evaluate the acute toxicity potential of chromium and lead on terrestrial garden snail (Helix aspersa) at different concentration ranges from 1.0 mg/L to 20 mg/L at different exposure time. In determining acute toxicity, LC$_{50}$ values after 24, 48, 72 and 96 h for both the metals were determined by probit statistical analysis method. Graphs also plotted between percent mortality and used concentrations to obtain regression equation and R$^2$ values. The obtained median lethal concentration (LC$_{50}$) for chromium were 15.13 mg/L, 12.88 mg/L, 6.76 mg/L and 4.027 mg/L for 24, 48, 72 and 96 h period of exposure, respectively. Similarly, for lead obtained LC$_{50}$ values were 15.282 mg/L, 6.095 mg/L, 2.094 mg/L and 1.352 mg/L for 24, 48, 72 and 96 h period of exposure, respectively. The study signifies the role of these metals in causing metal stress which leads to variation in electrolytes and A/G (Albumin to Globulin) ratio. The analysis of obtained results revealed that chromium is less toxic to H. aspersa in comparison to lead at similar concentrations and exposure time. It is concluded that the present study is one of its own kind of approach which may contribute in developing standard protocols for determining preliminary toxicity assessment of different heavy metals.

INTRODUCTION

Majority of the known heavy metals and their metalloids are found to be highly toxic to the living organisms (Singh et al., 2011). Exposure to minute concentration causes anomalies in the normal metabolic functioning of the animals and plants. Chromium (Cr) and lead (Pb) are one of the known toxic metals existed in various forms in the terrestrial and aquatic ecosystem influences the local flora and fauna (Wilbur, 2000; Ab Latif Wani and Usmani, 2015). Studies signifies the role of chromium in maintaining the carbohydrate and enzymatic metabolism in animal bodies (Havel, 2004) while lead is highly toxic in even parts per billion level of concentration therefore considered as non-essential metal (Ab Latif Wani and Usmani, 2015). These metals are comparatively highly toxic as compared to the essential metals that positively bind with number of enzymes as their co-factors. Besides their natural origin, heavy metals are always remains a matter of serious concern due to their toxic actions on our environment (Jaishankar et al., 2014). Terrestrial ecosystem is facing huge concern of heavy metal contamination (Tovar-Sánchez et al., 2018). Anthropogenic activities such as mineral mining, electronic waste dumping and use of plastics, releases the heavy metals in the terrestrial environment involve the phenomenon of leaching (Tchounwou et al., 2012). This directly contaminates the terrestrial ecosystem. Non-biodegradable nature of these metals is the main issue associated with them (Igiri et al., 2018). By following different exposure routes like inhalation, ingestion and dermal absorption, they find their place...
in the soft tissues of the organisms and initiate the process of bio magnification (Jakimska et al., 2011). Through food chain they enter in the trophic levels. The risk assessment of these heavy metals is basically analyzed on the basis of dose-response relationship (Zhang et al., 2007). Body of living organisms is unable to metabolize these metals which ultimately causes toxicity in them and finally leads to death (Jan et al., 2015). Therefore, toxicity test and assays have been conducted to explore the toxic effects of these metals. Garden snail, Helix aspersa is among the terrestrial biotic community which is very useful for pollution biomonitoring (Berger and Dallinger, 1993). Their soft tissues and shells are highly susceptible towards any kind of contamination. They have the capability to bio accumulate these metal contaminants (Rać, Stachowska and Machoy, 2005). Moreover, Biochemical examinations prove them as potential bio monitoring agents for heavy metals at particular site. Terrestrial garden snail, H. aspersa is used in the toxicity assay during the present study. This research aims to study the preliminary toxic effects of chromium and lead on adult garden snail, Helix aspersa to determine the electrolyte variations, changes in A/G protein ratio and mortality rate for each metal exposure at different concentrations.

MATERIALS AND METHODS

Samples collection
Adult snails were collected from the surrounding area and within the campus of central university of Himachal Pradesh, Dharamshala during rainy season in the month of September. Animals were transported to the lab in plastic boxes to the laboratory and placed in glass chambers (20×20×20cm) containing moistened soil, organic matter from the same habitat. These snails were acclimatized to laboratory conditions by providing suitable habitat to them for fifteen days under room temperature with 12 hours light and 12 hours of dark period using fluorescent lamps.

Sample preparation and metal concentration
Crude extract is prepared by the physical sonication of snails (Figure 1) viscera for the absolute homogenization of the extract. Both snails from metals treated and control chamber are being used in preparation of homogenized crude samples for further biochemical analysis. Before physical sonication, visceral parts are treated with 4N H₂SO₄. The prepared extract is filtered out using Whatman filter paper no. 42. The samples were stored in 50 ml glass vials at -20°C in a deep freezer until further analysis. Chromium and Lead salts used are of AR grade. Test concentrations were prepared from the stock solutions of both the heavy metals using calibrated pipettes and graduated cylinders. In this experiment, the used Chromium concentrations were control, 1.0, 5.0, 10.0 and 20.0 mg/L that was sprinkled on per 100 g of littering soil where snails are placed. In case of Lead, used concentrations were similar to Chromium. These concentration ranges were chosen on the basis of previous hit and trial studies.

Figure 1. Flow chart of sample preparation.
Toxicity assay
In this preliminary study, two toxicity experiments were carried out in the departmental laboratory for determining toxic effects of Chromium and Lead on the terrestrial garden snail, *H. aspersa*. The snails for experiment are transferred to glass chambers. Each chamber contains suitable moisture level which is maintained by using wet cotton cloth. Twenty snails were put per container with two replicates including the control chamber. All the toxicity assay procedures are carried out in controlled conditions under room temperature of 28± 2°C with photoperiods of 12 hour’s light and 12 hours dark. For carrying out the experiment, equal sized snails are preferred and exposed to the given concentrations. Counting of snails is carried out at every 12 hours and mortalities were recorded during the whole procedure (Tables 2 and 3). The alive and dead snails from control and treated glass chambers are taken away for further biochemical analysis.

Biochemical analysis
Biochemical analysis of crude extract of the snail’s viscera involves the determination of biochemical changes in the electrolytes (Potassium and Lithium), variation in A/G protein ratio after metal exposure (Figure 2).

Flame photometer analysis
Crude extract is taken in four different beakers and mixed with 4N H₂SO₄ solution in equal proportion. Magnetic stirrer is used to mix the solution properly. The prepared solution is transferred to water bath until water has been evaporated from the solution and charred mass remains. After this process, remaining mass is transferred into muffle furnace at a temperature of 500 °C for the preparation of ash. The ash formed is diluted to 100 cc of distilled water and formed solutions are filtered out to carry out flame photometer analysis. The main purpose of ash preparation is to remove ron salts from the crude extract as they interfere with sodium ions during flame photometer analysis (Figure 2).

Percent mortality conversion and probit regression analysis for LC₅₀ estimation
Probit method is useful in analyzing binomial response variables which involves regression analysis. Present study uses this approach to identify the dose-response relationship. For this purpose, the used concentrations of metals in the experiment were converted into log concentration values. Specially designated "Finney's table" is used for obtaining probit values of percent mortality of snails used in the experiment (Vincent, 2008; Finney and Stevens, 1948). For the calculation of LC₅₀ values of different metals used in various concentrations, following mathematical equation is used:

\[ y = ax + b \]

Where \( a \) is variable; \( y \) is dependent variable; \( x \) is independent variable and \( b \) is intercept. In regression analysis, \( x \) variable and intercept are substituted in the above formula and \( y \) probit value of 50 using Finney’s table is substituted in the same equation. Here is the calculation procedure:

\[ y = ax + b \]
\[ y = \text{variable } x \pm (\text{intercept}) \]
\[ 5 = \text{variable } x \pm (\text{intercept}) \]
\[ 5 \pm \text{intercept} = \text{variable } x \]
\[ x = (5 \pm \text{intercept}) / \text{variable } x \]
\[ x = \text{obtained value} \]

\[ \text{LC}_{50} = \text{antilog of value of } x \]
\[ \text{LC}_{50} = 10^x \]

LC₅₀ = Required result
Before the determination of probit values, the mortality rate of snails is calculated using the Abotte’s formula (Rosenheim and Hoy, 1989). The LC₅₀ values for different time intervals were taken from 5 probit value mentioned in Finney’s table because this value corresponds to 50% of the mortality. The actual LC₅₀ was calculated by taking inverse log of the used concentrations.
### Table 1. Variations in i) Total protein; ii) Albumen level and iii) A/G ratio in metal (Pb, Cr) stress in comparison to control.

<table>
<thead>
<tr>
<th>Glass Chambers</th>
<th>Total Protein (g/dL)</th>
<th>Albumen Level (g/dL)</th>
<th>A/G Ratio (g/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Chamber</td>
<td>&lt;3.00</td>
<td>0.02</td>
<td>-1.00</td>
</tr>
<tr>
<td>Pb Treated</td>
<td>&lt;3.00</td>
<td>0.01</td>
<td>0.11</td>
</tr>
<tr>
<td>Cr Treated</td>
<td>&lt;3.00</td>
<td>0.01</td>
<td>0.11</td>
</tr>
</tbody>
</table>

### Table 2. Mortality recorded in snails at different Cr concentrations (different time intervals).

<table>
<thead>
<tr>
<th>Exposure hours</th>
<th>No. of snails Per chamber</th>
<th>Cr concentrations (mg/L) in 100 g soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control 1.0 5.0 10.0 20.0</td>
</tr>
<tr>
<td>24 hr</td>
<td></td>
<td>0 0 03 06 09</td>
</tr>
<tr>
<td>48 hr</td>
<td></td>
<td>0 02 06 09 12</td>
</tr>
<tr>
<td>72 hr</td>
<td></td>
<td>0 02 09 12 15</td>
</tr>
<tr>
<td>96 hr</td>
<td></td>
<td>0 04 11 14 17</td>
</tr>
</tbody>
</table>

### Table 3. Mortality recorded in snails at different Pb concentrations (different time intervals).

<table>
<thead>
<tr>
<th>Exposure hours</th>
<th>No. of snails Per chamber</th>
<th>Pb concentrations (mg/L) in 100 g soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control 1.0 5.0 10.0 20.0</td>
</tr>
<tr>
<td>24 hr</td>
<td></td>
<td>0 02 05 08 12</td>
</tr>
<tr>
<td>48 hr</td>
<td></td>
<td>0 05 08 11 15</td>
</tr>
<tr>
<td>72 hr</td>
<td></td>
<td>0 08 12 15 18</td>
</tr>
<tr>
<td>96 hr</td>
<td></td>
<td>0 10 13 17 19</td>
</tr>
</tbody>
</table>

### Table 4. Log concentrations and probit values when exposed to Chromium after 24 and 48 h.

<table>
<thead>
<tr>
<th>Cr concentration (mg/L)</th>
<th>Log concentration</th>
<th>Number of snails used per chamber</th>
<th>% Mortality</th>
<th>Probit</th>
<th>% Mortality</th>
<th>Probit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>3.72</td>
</tr>
<tr>
<td>5.0</td>
<td>0.698970004</td>
<td>20</td>
<td>15</td>
<td>3.96</td>
<td>30</td>
<td>4.48</td>
</tr>
<tr>
<td>10.0</td>
<td>1</td>
<td>45</td>
<td>30</td>
<td>4.48</td>
<td>45</td>
<td>4.87</td>
</tr>
<tr>
<td>20.0</td>
<td>1.301029996</td>
<td>45</td>
<td>45</td>
<td>4.87</td>
<td>60</td>
<td>5.25</td>
</tr>
</tbody>
</table>

### Table 5. Log concentrations and probit values when exposed to Chromium after 72 and 96 h.

<table>
<thead>
<tr>
<th>Cr concentration (mg/L)</th>
<th>Log concentration</th>
<th>Number of snails used per chamber</th>
<th>% Mortality</th>
<th>Probit</th>
<th>% Mortality</th>
<th>Probit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
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<td>10</td>
<td>10</td>
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<td>4.87</td>
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<td>5.13</td>
</tr>
<tr>
<td>10.0</td>
<td>1</td>
<td>60</td>
<td>60</td>
<td>5.25</td>
<td>70</td>
<td>5.52</td>
</tr>
<tr>
<td>20.0</td>
<td>1.301029996</td>
<td>75</td>
<td>75</td>
<td>5.67</td>
<td>85</td>
<td>6.04</td>
</tr>
</tbody>
</table>

### Table 6. Log concentrations and probit values when exposed to Lead after 24 and 48 h.

<table>
<thead>
<tr>
<th>Pb concentration (mg/L)</th>
<th>Log concentration</th>
<th>Number of snails used per chamber</th>
<th>% Mortality</th>
<th>Probit</th>
<th>% Mortality</th>
<th>Probit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>3.72</td>
<td>25</td>
<td>4.33</td>
</tr>
<tr>
<td>5.0</td>
<td>0.698970004</td>
<td>25</td>
<td>25</td>
<td>4.33</td>
<td>40</td>
<td>4.75</td>
</tr>
<tr>
<td>10.0</td>
<td>1</td>
<td>40</td>
<td>40</td>
<td>4.75</td>
<td>55</td>
<td>5.13</td>
</tr>
<tr>
<td>20.0</td>
<td>1.301029996</td>
<td>60</td>
<td>60</td>
<td>5.25</td>
<td>75</td>
<td>5.67</td>
</tr>
</tbody>
</table>

### Table 7. Log concentrations and probit values when exposed to Lead after 72 and 96 h.

<table>
<thead>
<tr>
<th>Pb concentration (mg/L)</th>
<th>Log concentration</th>
<th>Number of snails used per chamber</th>
<th>% Mortality</th>
<th>Probit</th>
<th>% Mortality</th>
<th>Probit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0</td>
<td>40</td>
<td>40</td>
<td>4.75</td>
<td>50</td>
<td>5.00</td>
</tr>
<tr>
<td>5.0</td>
<td>0.698970004</td>
<td>60</td>
<td>60</td>
<td>5.25</td>
<td>65</td>
<td>6.30</td>
</tr>
<tr>
<td>10.0</td>
<td>1</td>
<td>75</td>
<td>75</td>
<td>5.67</td>
<td>85</td>
<td>6.04</td>
</tr>
<tr>
<td>20.0</td>
<td>1.301029996</td>
<td>90</td>
<td>90</td>
<td>6.28</td>
<td>95</td>
<td>6.64</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

Anthropogenic activities such as high rate of urbanization and industrialization are responsible for environmental pollution. Mainly release of heavy metals in the environment is a serious threat. By determining the changes in A/G protein ratio and electrolyte disturbance in the crude extract of Helix aspersa, we can easily predict the toxic potential of heavy metals and their harmful effects on the environment. Studies have been made to access changes in the protein content on exposure to different heavy metals which reveals the disturbed protein metabolism in different snail species (Waykar and Petare, 2018). Similarly, A study in year 2018 assess impacts of heavy metals in marine mollusk Mytilus galloprovincialis, reveals the typical fluctuations in its body electrolytes (Capillo et al., 2018). On comparison to other studies, the results of present study reveals the similar trend in changes in the A/G ratio and electrolytes of the target snail on exposure to different concentrations of chromium and lead. The obtained results discussed below:

A/G Protein ratio

On analyzing the total protein ratio of untreated and metal treated snails, it was found that the total protein content in all the snails was less than <3.00 g/dL while the albumen level decreases from 0.02 (control chamber) to 0.01 g/dL in both lead and chromium treated snails. A huge difference is recorded in A/G ratio in metal treated snails as compared to control. The A/G ratio is increases from 1.00 g/dL to 0.11 g/dL in both lead and chromium treated snails (Table 1) which highlighted that the rate of proteins in the snail's body increases in a manner in the presence of heavy metals. These results go in the same direction with a study carried out by Masaya and his associates in year 2000 which highlighted a significant increase in the protein rate under the effect of a chemical stress at different biological models (Masaya et al., 2002).

Electrolytes disturbance

Flame photometer analysis shows significant variation in the electrolyte balance in the extract of snails in control and others facing metal stress. The analysis of lead and chromium treated snails extract shows decline in K+ and Li+ ions level.

LC50 and snail’s mortality rate

In this experiment four concentrations of chromium and lead viz. 0.1 mg/L, 5.00 mg/L, 10.00 mg/L and 20.00 mg/L were taken and mortality rate was observed after 24, 48, 72 and 96 h exposure respectively (Tables 2 and 3). It was observed that, on increasing dose and exposure time, mortality rate was significantly increased. Lowest mortality was observed at 1.0 mg/L exposure for 24 hours while 85% mortality rate (Table 4 and Table 5) was observed in the snails for 96 hours for chromium exposure of varied concentrations. Similarly, in case of lead exposure, higher mortality rate was observed as compared to chromium at similar concentrations. 60% and 95% of mortality was observed in 24 and 96 hours at 20 mg/L concentration exposure respectively (Table 6 and Table 7). The concentrations taken in the whole experiment were converted into log concentrations and their corresponding probit values.

By taking antilog, actual LC50 values obtained for chromium were 15.13 mg/L, 12.88 mg/L, 6.76 mg/L and 4.027 mg/L for 24, 48, 72 and 96 h period of exposure respectively. Similarly, for lead obtained LC50 values were 15.282 mg/L, 6.095 mg/L, 2.094 mg/L and 1.352 mg/L for 24, 48, 72 and 96 h period of exposure, respectively. Some physical and behavioral changes were also observed during the experiment. Avoiding behavior, random movements, mucus secretion from the body, Color of snails appeared dark brown, stop feeding and restlessness before death were some of the major observations. These changes can
be attributed to an increase in physiological stress due to metal intoxication. The Figure 3 and 4 shows the graphical representation of metal concentrations versus snail’s mortality. By plotting the graph, regression and $R^2$ values were obtained for both the metals at different time intervals.

**Conclusion**

The present investigation is an attempt to measure variable toxic effects of chromium and lead on the garden snail, *Helix aspersa*. The mortality rate increases with the increase of metal concentrations in the soil and also with increasing the duration of exposure. General observation was made that, the Helix aspersa become more susceptible to the toxic effects of both metals by increasing their ambient concentrations. *H. aspersa* could be used as cheap living model bio indicator for heavy metals biomonitoring in terrestrial ecosystem by observing physiological and chemical changes occurred due to metal stress. Flame photometer analysis shows the deviation in normal trend of electrolytes concentration as compared to control. Also, changes have been observed in A/G ratio of the protein content due to these metals exposure. Regarding metal toxicity, chromium was found less toxic than lead to this snail species. This study is valuable and highly important for the determination of $LC_{50}$ concentration and total mortality dose to terrestrial living communities. This study also proves to be fruitful in developing future understanding of ecological and environmental concerns associated with chromium and lead.

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