Socio-economic Factors That Influence Household Incomes in Artisanal Gold Mining Area of Tangandougou Commune, Mali

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Available Online: 31st October, 2018
URL: https://www.journals.adrri.org/


Abstract
Mining activities generate incomes through direct employment for households in developing countries. Despite this, it has negative impacts on economies and the environment. Like many developing nations, household incomes in Mali are mainly derived from crop and livestock production, agroforestry and fisheries. The objective of this study was to assess factors that impact on livelihoods and household incomes in artisanal gold mining area of Tangandougou commune, Sikasso region in Mali. The study site was located in Farabacoura artisanal gold-mining area, some 170 km from the capital Bamako. The study used an exploratory and descriptive research design with a random sample of 200 households. Research tools used included questionnaires, focus group discussion, key informant interviews. Data was analysed using descriptive and inferential statistics. The different sources of incomes were all negatively and significantly affected by profession but not the incomes from artisanal gold mining. The second factor which affected households’ incomes was nativity, followed by gender, age, education level and family size respectively. Therefore, the study recommends national and local government, and NGOs intervention, particularly on artisanal gold mining so as to develop agricultural production systems through the integrated sustainable agriculture. This system entails rainwater harvesting for irrigation, livestock and crop production. Such an integrated agricultural production system could incorporate agroforestry and aquaculture that could complement one another, thereby enhance food security, environmental health, nutrition and above all increase the households’ income levels.

Keywords: artisanal, gold-mining, households, incomes, agriculture
INTRODUCTION

Agriculture is the backbone of the country’s economy, especially cereals crops and livestock production. In Malian rural areas, the majority of households depend on agriculture for their livelihoods. Yet, food insecurity remains important in rural Mali, although agricultural development was promoted by national government and international donors since 2006 (LOA, 2006).

Mining activities generate incomes through direct employment for households in rural areas but it has also negative impacts on human societies and the environment (Zhang and Moffat, 2015). Apart from gold mining activities the communities in Tangandougou were usually based on such crops and livestock production, agroforestry and fisheries. These activities were characterized by research of incomes so as to cover households’ expenditure in Tangandougou community. In most of the cases for households, the incomes were done from these economic activities for substance food, health care and many others. Tenkorang and Osei-Kufuor, (2013) reported that most of these leases were for surface mining displacing the original owners from large arable land needed for their livelihoods. This situation makes the local people vulnerable to local economic shock which were undertaken in crops and livestock production, agroforestry and fisheries (Hilson, 2016).

The real benefits accruing to the ordinary local communities is simply taken, for granted as monetary compensation is paid to affected community members in case of industrial exploitation, but not for artisanal mining that may poses household incomes distribution from others activities (Adu et al., 2016; Tenkorang and Osei-Kufuor, 2013). Even though, such palliative payments to people displaced by mining activities do not address the existing vulnerabilities of these mining communities (Tenkorang and Osei-Kufuor, 2013). On both the mining and the non-mining sites, the sources of households’ incomes comprised of gold mining, crops and livestock production, agroforestry and fisheries in Tangandougou Commune. This fact of food insecurity motivates rural populations to be engaged in artisanal gold mining in Mali.

Cartier and Bürgé (2011) documented the case of Sierra Leone by “the ongoing lack of viable livelihood opportunities for rural populations is a serious issue in post-conflict Sierra Leone and this means that many individuals and communities have no choice but to turn to (informal) gold or diamond mining as a source of income in their efforts to combine food security and generate revenue”.
Impacts of artisanal gold mining was reported by Meisanti et al., (2012) to three principals’ parameters in Indonesia (social, economic and environmental), which were influenced farmers and communities surrounding mining in term of daily activities. As a matter of fact, the presence of the gold mining changed the social structure of the farming society and affected their social interactions. This kind of situation has made the local people vulnerable to economic uncertainties in Ghana (Tenkorang and Osei-Kufuor, 2013). The objective of this study was to assess factors that impact on livelihoods and household incomes in artisanal gold mining area of Tangandougou commune, Sikasso region in Mali.

MATERIALS AND METHODS

Description of Study Area

Sikasso region is located in Southern part of Mali and it is also the third administrative region of country. It neighbors Segou region to the Northern, Republic of Cote d’Ivoire to the Southern, Republic of Guinea to the Western, Burkina Faso to the Eastern and the region of Koulikoro to the North-west. The region covers 71.790 km$^2$ which represents 3.8% of national territory of Mali. It has 7 districts that include Sikasso, Bougouni, Kadiolo, Kolondièba, Koutiala, Yanfolila and Yorosso. In Sikasso region, there are 3 urban communes, 144 rural communes and 1,831 villages (ARS, 2011).

Farabacoura and Tiéguècourouni are villages in Tangandougou commune, district of Yanfolila in Sikasso region. The commune is some 170 km from Bamako the capital of Mali. The study site, Farabacoura is about 10 km from Selingué Dam which is on Sankarani River while Tiéguècourouni is 75 km away from Selingué. The population of the commune is about 5,775 inhabitants (RGPH, 2009). The major ethnic groups of native population are composed of Bambara, Senufo, Manliké, Bozo and Peulh.

The main economic activities of the community include cereals and vegetables crop farming, livestock production, fisheries, agroforestry, commerce and gold-mining. These production systems are characterized by small-scale farming with low yield in agricultural production. In term of cereals production, these small-scale farmers are dealing with maize, sorghum and millet for subsistence purposes. The commercial crops are mainly rice, cotton, groundnut, sweet-potatoes, cassava and tomatoes.
The livestock production methods comprise of extensive system and traditional practices of households to supply crop production with composting manure from livestock and other activities in the farm. The main type of livestock reared includes cows, goats, sheep, donkeys and chicken. The livestock are mostly reared for domestic consumption and in addressing minor household expenditures health care, ceremonies like marriage and burials among others. Agroforestry activities are focused on both indigenous and exotic plants. They exploit indigenous plants such as Vitellaria paradoxa, Parkia biglobosa, Adansonia digitata, Afzelia africana, Khaya senegalensis and Prosopis africana for food production, precious wood and medicinal needs. In addition, they also grow Citrus sinensis, Citrus aurantium, Mangifera indica, Carica papaya and Tereticornis globulus fruits and wood production.

**Data Collection Tools and Methods**

Structured questionnaires were used to gather information from the household head or his/her representative. The questionnaires were structured on professions (gold mining, crop, livestock, agroforestry, fisheries, age, gender, origin, marital status, education level, etc.). In addition, three focus group discussions were held with local government, miners and non-miners in Tangandougou Commune plus key informant interviews and observation check-list. The collected data was analysed using the Statistic Package for Social Sciences (SPSS) while ArcGIS was used for geographical information to come up with study area Map.

Figure 1: Map of Study Area (Map of Mali Inset)
The sampling technique that was employed in this study considered artisanal gold mining as a factor that caused impacts on social economic functions of the natives of Sikasso region. Data was collected by the use of structured questionnaire which were administered through interviewing the households’ heads. In each case one representative of the household who was 18 years old was interviewed. The sample size was 200 households consisting of respondents drawn from the study area and had some information about artisanal gold mining and impacts on the social economic systems. The questionnaires were administered in Farabacoura and Tieguecourouni villages both in Tangandougou Commune, of Yanfolila district. The respondents were drawn from the two villages equally as follows:

The **mining site**: Farabacoura village respondents represented the mining site. These respondents were involved in either mining and/or agricultural activities. The information on these activities was collected from an area of approximately 20 km².

The **non-mining site**: as a nearby site of Tieguecourouni village, the study interviewed 100 households by soliciting information about mining and agricultural activities based on the study objectives. The distance between the two study villages was approximately 45 km but within the same commune.

The sample for this study was calculated using the Nassiuma (2000) formula indicated below. The study used this formula, because the population of Tangandougou commune is already known.

\[
n = \frac{NC^2}{[C^2 + (N-1)e^2]^{\frac{1}{2}}} \tag{1}
\]

Where:

\[n = \text{the sample size}\]
\[N = \text{the known population of Tangandougou commune}\]
\[e = \text{the error margin of (3%)}\]
\[C = \text{the coefficient of variation (30%)}\]

The sample size based on this formula was:

\[
n = \frac{5775 \times 0.3^2}{[0.3^2 + (5775-1) \times 0.03^2]} = 100 \tag{2}
\]

The result was multiplied by two giving a total of 200 households distributed as 50% between the two villages for data collection in Tangandougou commune. Data was analyzed using descriptive and inferential statistics such as correlation and multiple linear Regressions.
In contrast to linear simple regression which uses a simple predictor variable \( x \) to explain the response variable \( y \), the multiple linear regression describes how a dependent variable \( y \) is explained by more than one explanatory variables \( x \) (Liebscher, 2012).

A MLR model with \( n \) explanatory variables \( X_1, X_2, \ldots, X_n \) and a dependent variable \( Y \), can be written as follows:

\[
y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + u = \left[ \beta_0 + \sum_{n=1}^{n} \beta_n x_n + u_n \right]
\]  

(3)

Whereas \( y \) is dependent variables; \( x \) is the independent variables; \( \beta_0 \) is the intercept; and \( \beta_1, \beta_2, \ldots, \beta_n \) are coefficient of regression.

The MLR may consist of exponential of one or more explanatory variables as:

\[
y = \beta_0 + \beta_1 x_1 + \beta_2 x^2 + \cdots + \beta_n x_n + u
\]  

(4)

The MLR can also have within the equation the interaction effects among two or more variables as:

\[
y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_1 x_1 x_2 + \beta_n x_n + u
\]  

(5)

The study assumes neither interaction effects nor exponential ones among variables, thus the choice of equation (a) for further analysis. This equation is specified as follows:

\[
y = \beta_0 + \beta_{\text{var1}} \text{var1} + \beta_{\text{var2}} \text{var2} + \cdots + \beta_{\text{var n}} \text{var n} + u_n
\]

In this equation, the regression curve is not in a line, hence the preference of names “Non-Linear Regression Model” or “Polynomial Regression Model”. The model requires the number of observations be bigger than the number of variables in the equation (Bremer, 2012). The maximum likelihood estimation of MLR is similar to as the same as in simple linear regression model:

\[
y = X \beta + u
\]

Where the error term \( (u) \) is independent and identically distributed, \( N(0, \sigma^2) \). The decision to be made in MLR is about the good fitness of the model for the data and whether all the explanatory variables are needed in the model. To handle the first issue, Quick (2013) suggested a test of relationship among variables and its significance. In MLR, the interpretation of \( R^2 \) which is a simple square of the correlation between dependent variables and independent variables is no longer valid since the more the variables the higher the \( R \) (Bremer, 2012). Therefore, the second issue is handling by using the adjusted \( R^2 \) because it is not automatically proportional to the increase of in number of variable and it higher value shows the model better fitness (Bremer, 2012).
RESULTS

Incomes from Artisanal Gold Mining in Tangandougou

Results showed that 61 households represented by 30.5% of study population were not gaining from artisanal gold mining. Among this population, 52 respondents’ households were from the non-mining site and 9 from the mining site. The households which were gaining 100 Dollars per year from artisanal gold mining were 100 represented by 50% of study population (comprising of 33 households from non-mining site and 67 from the mining area). Within the study area, it is only 33 respondents’ households (13 from the non-mining area and 20 households from the mining site) represented by 16.5% who were earning above 200 Dollars annually. The largest amount of 300 Dollars per annum as an earning from artisanal gold mining was observed in 6 respondents’ households represented by 3% of the study population and the distribution was 2 respondents’ households from the non-mining site and 4 from the mining area of Farabacoura village.

Table 1: Incomes from Artisanal Gold Mining by Frequency, Percentage on Sites

<table>
<thead>
<tr>
<th>Incomes in $</th>
<th>Freq.</th>
<th>%</th>
<th>Non-Mining</th>
<th>Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>61</td>
<td>30.5</td>
<td>52</td>
<td>9</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>50</td>
<td>33</td>
<td>67</td>
</tr>
<tr>
<td>200</td>
<td>33</td>
<td>16.5</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>300</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>47.486</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors

Incomes from Crops Production in Tangandougou

The households which were not gaining any amount from crops production were 51 respondents represented by 25.5% of the total study population in the area. The distribution was for 10 respondents’ households from the non-mining site and 41 from the mining site of Farabacoura village. There were 58 household who earning about 100 Dollars per year from crops production which represented by 29% of total households interviewed in the study area (17 households from the non-mining site and 41 from the mining site). The agricultural crop production income of 200 Dollars per annum was earned by 53 households (36 from the non-mining site and 17 from the mining area) which represented by 26.5% of total interviewed households in the study area. Additionally, those who earned about 300 Dollars per annum were 36 respondents’ households represented by 18% of interviewed households with a distribution of 35 from the non-mining site and 1 household from the mining area. The highest earners of 400 Dollars per year were 2...
respondents’ households from the non-mining site representing 1% of total representation in study area.

Table 2: Incomes from Crops Production by Frequency, Percentage on Sites

<table>
<thead>
<tr>
<th>Incomes in $</th>
<th>Freq.</th>
<th>%</th>
<th>Non-Mining</th>
<th>Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>51</td>
<td>25.5</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td>100</td>
<td>58</td>
<td>29</td>
<td>17</td>
<td>41</td>
</tr>
<tr>
<td>200</td>
<td>53</td>
<td>26.5</td>
<td>36</td>
<td>17</td>
</tr>
<tr>
<td>300</td>
<td>36</td>
<td>18</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>400</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Likelihood Ratio 80.961 0.000

Source: Authors

Incomes from Livestock Production in Tangandougou

The incomes from livestock production were null in 66 interviewed households represented by 33% of the study population. These were was 8 interviewed households from the non-mining site and 58 from the artisanal gold mining area of Farabacoura village. The households which were gaining about 100 Dollars from livestock production were 37 (12 from the non-mining area of Tieguecourouni village and 25 from the mining area of Farabacoura village) represented by 18.5% of total interviewed household in the study area. The income of about 200 Dollars per annum from livestock production was realized by 40 interviewed households represented by 20% of total respondents’ population in the study area. The 40 households comprised of 33 from the non-mining site and 7 from the mining area. Those households which earned about 300 Dollars annually from livestock production were 47 (38 households from the non-mining area and 9 from the mining site) which was represented by 23.5% of the total households interviewed in the study area. The highest earners received about 400 Dollars annually. However, they were only represented by 10 interviewed households whereby 9 were from the non-mining area and 1 from the mining site representing 5% of the total household interviewed in the study area.

Table 3: Incomes from Livestock Production by Frequency, Percentage on Sites

<table>
<thead>
<tr>
<th>Incomes in $</th>
<th>Freq.</th>
<th>%</th>
<th>Non-Mining</th>
<th>Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>66</td>
<td>33</td>
<td>8</td>
<td>58</td>
</tr>
<tr>
<td>100</td>
<td>37</td>
<td>18.5</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>200</td>
<td>40</td>
<td>20</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>300</td>
<td>47</td>
<td>23.5</td>
<td>38</td>
<td>9</td>
</tr>
<tr>
<td>400</td>
<td>10</td>
<td>5</td>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>

Likelihood Ratio 92.373 0.000

Source: Authors
Incomes from Agroforestry in Tangandougou

Out of the total study area respondents, 122 interviewed households with a distribution of 45 from the non-mining area of Tieguecourouni and 77 from the mining site of Farabacoura which is represented by 61% of total interviewed household in the study area earned no income from agroforestry. Those whose income was about 100 Dollars annually from agroforestry activities were 44 household (29 households from the non-mining area and 15 from the mining site) which represented 22% of the population observed in Tangandougou commune. Those who earned about 200 Dollars per year from agroforestry were 21 households distributed as 17 from the non-mining site and 4 from the mining site which represented 10.5% of interviewed households. For the income of 300 Dollars annually, there were 10 interviewed households with 6 from the non-mining area and 4 from the artisanal gold mining site which represented 5% of households interviewed in study area. The highest level of income of about 400 Dollars per annum was earned by 3 households from the non-mining area against represented by 1.5% of total respondents in the study area.

Table 4: Incomes from Agroforestry by Frequency, Percentage on Sites

<table>
<thead>
<tr>
<th>Incomes in $</th>
<th>Freq.</th>
<th>%</th>
<th>Non-Mining</th>
<th>Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>122</td>
<td>61</td>
<td>45</td>
<td>77</td>
</tr>
<tr>
<td>100</td>
<td>44</td>
<td>22</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>200</td>
<td>21</td>
<td>10.5</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>300</td>
<td>10</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>400</td>
<td>3</td>
<td>1.5</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><strong>Likelihood Ratio</strong></td>
<td><strong>26.249</strong></td>
<td><strong>0.000</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors

Incomes from Fisheries in Tangandougou

The incomes from the exploitation of fisheries were null in 159 interviewed households (70 from the non-mining area and 89 from the mining site) which represented 79.5% of total household interviewed in study area. However, there were 39 households which were earning about 100 Dollars per year from fisheries with a distribution of 28 from the non-mining site and 11 households from the mining area which represented 19.5% of study total population. Those who earned about 200 Dollars annually were 2 households both from the non-mining which represented 1% of total interviewed household.
Table 5: Incomes from fisheries by Frequency, Percentage on Sites

<table>
<thead>
<tr>
<th>Incomes in $</th>
<th>Freq.</th>
<th>%</th>
<th>Non-Mining</th>
<th>Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>159</td>
<td>79.5</td>
<td>70</td>
<td>89</td>
</tr>
<tr>
<td>100</td>
<td>39</td>
<td>19.5</td>
<td>28</td>
<td>11</td>
</tr>
<tr>
<td>200</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Likelihood Ratio 200 0.002

Source: Authors

Correlation Results on Households Incomes

The households’ sources of incomes included gold mining activity, crops and livestock production, agroforestry and fisheries production. There were significant negative relationships between locality and incomes from crops ($r = -0.573; p > 0.01$), incomes from livestock production ($r = -0.610; p > 0.01$), incomes from forests ($r = -0.302; p > 0.01$) and incomes from fisheries ($r = -0.242; p > 0.01$). There were also significant negative relationships between incomes from artisanal gold mining and incomes from crops ($r = -0.203; p > 0.01$), incomes from livestock production ($r = -0.243; p > 0.01$) and incomes from fisheries ($r = -0.144; p > 0.05$).

The results showed that there were significant positive relationship between locality and incomes from artisanal gold mining ($r = 0.353; p > 0.01$), incomes from crops and incomes from livestock production ($r = 0.549; p > 0.01$), incomes from crops production versus incomes from forest ($r = 0.322; p > 0.01$), between incomes from livestock production and incomes from forest ($r = 0.395; p > 0.01$), incomes from fisheries ($r = 0.292; p > 0.01$) and between incomes from forests and incomes from fisheries ($r = 0.330; p > 0.01$).
Table 6: Pearson’s Correlation of Income Sources in Tangandougou Commune

<table>
<thead>
<tr>
<th>Incomes</th>
<th>gold</th>
<th>crops</th>
<th>livestock</th>
<th>agroforestry</th>
<th>fisheries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Incomes artisanal gold mining</td>
<td>0.353**</td>
<td>1</td>
<td></td>
<td>0.203**</td>
<td>1</td>
</tr>
<tr>
<td>Incomes crops production</td>
<td>-0.573**</td>
<td>-0.203**</td>
<td>0.349**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Incomes livestock production</td>
<td>-0.610**</td>
<td>-0.243**</td>
<td>0.549**</td>
<td>0.243**</td>
<td>1</td>
</tr>
<tr>
<td>Incomes agroforestry</td>
<td>-0.302**</td>
<td>-0.101</td>
<td>0.322**</td>
<td>0.395**</td>
<td>0.292**</td>
</tr>
<tr>
<td>Incomes fisheries</td>
<td>-0.242**</td>
<td>-0.144*</td>
<td>0.115</td>
<td>0.330**</td>
<td>0.330**</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Source: Authors
Multiple Linear Regressions of Households Incomes

The results showed that socio-economic parameters were influenced by different sources of households’ incomes in the study area of Tangandougou Commune in Sikasso region, Mali. The parameters considered were profession under agricultural productivity, nativity of respondents during household’s survey, gender of respondents, age of interviewees, education level, children presence on gold mining site and the size of the family in the study area of Tangandougou Commune.

**Profession under agricultural productivity:** results showed that profession influenced significantly and positively artisanal gold mining incomes (0.119). However, they significantly and negatively influenced crops production, livestock production, agroforestry and fisheries (-0.192, -0.237, -0.147, -0.045) respectively in study area.

**Nativity of respondents:** the result significantly and negatively influenced the nativity of the respondents in the study areas for artisanal gold mining incomes (-0.294) but significantly and positively influenced by incomes from crop production (0.807) and livestock production (1.086) as showed in (Table 7).

**Gender of interviewees:** the respondents gender influenced significantly and negatively the incomes from artisanal gold mining (-0.294) and it was influenced significantly and positively by incomes from agroforestry (0.369) and incomes from fisheries (0.145) (Table 7).

**Ages of respondents of households:** there were significant and positive influence in characters of age of the interviewees’ incomes from crops production (0.189) and incomes from livestock production (0.152) in study area as shown in Table 7.

**Education level of respondents:** the levels of none, primary, secondary, college or University influenced significantly and negatively the incomes from agroforestry production (-0.234) in study area of Tangandougou commune (Table 7).

**Children presence on gold mining:** household’s children involved in gold mining significantly and negatively influenced incomes from fisheries (-0.403) in study area.

**Family size of interviewees:** the number of people in family significantly and negatively influenced the incomes from artisanal gold mining (-0.215) (Table 7).
Table 7: Multiple Linear Regression Results of Households Incomes

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Incomes Gold Mining</th>
<th>Incomes Crops</th>
<th>Incomes Livestock</th>
<th>Incomes Agroforestry</th>
<th>Incomes Fisheries</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>0.982</td>
<td>0.320</td>
<td>0.700</td>
<td>0.389</td>
<td>1.171</td>
</tr>
<tr>
<td>Profession</td>
<td>0.119***</td>
<td>0.038</td>
<td>-0.192***</td>
<td>0.047</td>
<td>-0.237***</td>
</tr>
<tr>
<td>Nativity</td>
<td>-0.329**</td>
<td>0.117</td>
<td>0.807***</td>
<td>0.142</td>
<td>1.086***</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.294***</td>
<td>0.128</td>
<td>0.211</td>
<td>0.155</td>
<td>0.462</td>
</tr>
<tr>
<td>Age</td>
<td>0.068</td>
<td>0.066</td>
<td>0.189**</td>
<td>0.080</td>
<td>0.152**</td>
</tr>
<tr>
<td>Education Level</td>
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<td>-0.064</td>
<td>0.103</td>
<td>-0.067</td>
</tr>
<tr>
<td>Marital Status</td>
<td>0.365</td>
<td>0.282</td>
<td>0.228</td>
<td>0.343</td>
<td>-0.399</td>
</tr>
<tr>
<td>Children Presence</td>
<td>-0.004</td>
<td>0.305</td>
<td>0.049</td>
<td>0.371</td>
<td>-0.553</td>
</tr>
<tr>
<td>Family Size</td>
<td>-0.215**</td>
<td>0.096</td>
<td>-0.085</td>
<td>0.116</td>
<td>-0.063</td>
</tr>
<tr>
<td>Number</td>
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<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>R²</td>
<td>0.427</td>
<td>0.631</td>
<td>0.640</td>
<td>0.425</td>
<td>0.345</td>
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<td>P</td>
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<td>0.000</td>
<td>0.000</td>
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</table>

Note: ***; **; * Significant at 1%, 5% and 10% respectively

Source: Authors
DISCUSSIONS

Like many developing nations within the Sub-Saharan Africa region, Mali has limited arable land that faces a lot of pressure from the competing interests including subsistence crop production, livestock production and mining (Djibril, et al., 2017; Papworth, et al., 2017).

The distribution of amount of income from artisanal gold mining was not adequate to support the connected families on mining site over the year. Furthermore, the workforce used in the mining activities limits the available manpower to support agricultural production back in their family at home (Bryceson and Geenen, 2016). Therefore, food insecurity is currently impacting Malian rural populations in mining areas, which necessarily has to be eradicated through the intensification of crops production as a function of sustainable food security (Friedrich and Kassam, 2016).

The importance of mining is generally local and regional as longer it is not sustainable to replace the basically incomes from crops, livestock, agroforestry and fisheries (Aroca, 2001).

Profession, nativity, gender and family size influenced households’ participation in artisanal gold mining activities in Tangandougou commune. The parameter of profession was the only positive one, which means that individuals who are professional earn more income artisanal gold mining and the associated commercial activities. In contrast, nativity, gender and family size negatively and significantly influenced households’ incomes from artisanal gold mining in Tangandougou commune. The non-local people face more expenses arising from taxes, rents, land lease housing among others as compared with the locals in these mining communities of Tangandougou. Concerning gender, artisanal gold mining demands more physical energy, a situation which locks out most of the female gender from being engaged equally as males in artisanal gold mining. Family size was negatively significant, because of the characteristics of artisanal gold mining which forces the miners to keep migrating to new sites in search of the gold due to its rarity, hence a challenge to moving large families (Tenkorang and Osei-Kufuor, 2013).

The study revealed that crops production in mining areas were not possible as evidenced in the above (Table 2). The community had concentrated its energy and workforce to mining and other associated production activities such as business. For households in non-mining area, the major sources of income were from crops production which denoted that crops production and artisanal gold mining are not compatible. Consequently, crops production was influenced by artisanal gold mining
and its associated activities as depicted by the poor incomes from crops production. The same analysis was done by George-Laurentiuia et al. (2016) in Romania, which was confirmed that at present the agriculture is limited by the degraded lands in Ciudanovita mining area. This situation was as a result of limited workforce geared towards crops production by the populations in the study area, especially in the artisanal gold mining one (Bryceson and Geenen, 2016).

Crops production was influenced by profession, nativity and age in Tangandougou commune. The profession negatively and significantly affected incomes from crops due to the non-specialization of the community in substance crops production system. The nativity positively and significantly affected incomes from crops production as the households were primarily engaged in crops production for subsistence purposes. The priority of these households is for domestic consumption leading to the declined crops production and deviation from crops productions as the principal income generating activity for them (Danquah et al., 2017). Age also positively and significantly affected incomes from crops production due to the high demand of the energetic workforces for production (Hilson, 2016). Crops production was mainly dominated by women and youth and usually reflected the production capacity of households in this area.

Those who were gaining more than 100 Dollars per year in mining area kept cattle, goats and sheep for business. In contrast, households in non-mining area were practicing substance livestock production so as to supplement household diet from crops production and to cover different domestic needs which include ceremonial and cultural aspects of family. Danquah et al. (2017) reported that livelihood resources in Amansie West, Ghana were exposed to the detrimental impact of mining and its activities, hence making it difficult for livelihood outcomes to be achieved by rural households. “The resulting illegality, along with the sector’s numerous social ills and environmental impacts, has overshadowed its importance, in particular how many subsistence farmers now rely on ASM for their disposable incomes” (Hilson, 2016).

The incomes from livestock production were affected by profession, nativity and age in Tangandougou commune. Profession negatively and significantly affected the incomes from livestock hence the need for the households to integrate livestock production in their agricultural production system (Sîrbu, 2014). Nativity positively and significantly affected incomes from livestock production a situation which gives them an advantage over the non-locals in livestock production. The age positively and significantly affected incomes from livestock production in the sense that energy
production is necessary to realize this agricultural activity. The nature of livestock production was mainly extension system which implicates youth intervention in most of the cases in livestock production in this area of study.

Trees production was limited to fruit tree production in Tangandougou commune. The goods and services from trees were sourced from the natural forests exploitation such as charcoal production, timber wood, construction wood, hunting and honey production. The pressure on natural forests has made them less dependable by the communities in study area. The two major goods from forests include charcoal and fire wood production for commercial and domestic consumption within the study area. The overexploitation of the forests to get the aforementioned goods has made the natural forests surrounding artisanal gold mining area to be vulnerable from the shock. Broadly, populations in gold mining areas usually exploit forests without replacement which posed the issues of vegetation regeneration (Moyo, 2017).

The incomes from agroforestry were affected by profession, gender and education level in Tangandougou commune. The profession affected negatively and significantly incomes from agroforestry which denotes the insufficiency of specialization in this area of agricultural production system. The different products from forests were naturally exploited without households' intervention in terms of agroforestry production system. The gender positively and significantly affected incomes from agroforestry, because of female gender intervention in this agricultural activity. Women were the dominant in agroforestry system through the supply of food products, earning from fire wood and charcoal. There were a few men who produced fruits such as mango, banana, papaya and many others under the agroforestry production systems. The education level affected negatively and significantly the incomes from agroforestry which was characterized the literacy in most of the households (Moyo, 2017).

The explanation of low incomes from fisheries was due to the rarity of fish and fisheries resources in the rivers and backwaters in study area. Furthermore, rivers were contaminated by chemical products in form of effluents from the artisanal gold mining activities (Rasheed and Amuda, 2014).

The incomes from fisheries were affected by profession, gender and children presence on site in Tangandougou commune. The profession negatively and significantly affected fisheries due to the limited specialized production methods and capacities in these areas. The female gender affected positively and significantly fisheries which was attributed to women intervention in fishing and aquaculture
supported by association and NGOs. For instance, children presence in study areas affected negatively and significantly fisheries, denoting that fisheries requires adults’ intervention than children for its development.

CONCLUSIONS AND RECOMMENDATIONS

The different sources of incomes were all negatively and significantly affected by profession but not the incomes from artisanal gold mining. The second factor which affected households’ incomes was nativity followed by gender, age, education level and family size respectively. Therefore, the study recommends national and local government, and NGOs intervention, particularly on artisanal gold mining so as to develop agricultural production systems through the integrated sustainable agriculture. This system entails rainwater harvesting for irrigation, livestock and crop production. Such an integrated agricultural production system could incorporate agroforestry and aquaculture that could complement one another, thereby enhance food security, environmental health, nutrition and above all increase the households’ income levels.

Acknowledgements

This material is based upon work supported by the United States Agency for International Development, as part of the Feed the Future initiative, under the CGIAR Fund, award number BFS-G-11-00002, and the predecessor fund the Fond Security and Crisis Mitigation II grant, award number EEM-G-00-04-00013.

Conflict of Interests

The authors declare they have no actual or potential competing financial interests.
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