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PRODUCTIVITY OF LABOUR AND CAPITAL IN GUM GARDENS IN WESTERN SUDAN

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Abstract. This study aimed to assess the labour and capital productivity of Gum Arabic Producers Associations (GAPAs) based on the performance of GAPAs in North and West Kordofan States, where 14 GAPAs were selected for a case study. More specifically, the study aimed to: i) estimate the productivity of gum gardens per hour worked (hrs/ha/yr) and per dollar invested ($/ha/yr), as well as their capital productivity ($/$), and ii) analyze the relationship between productivity and gum arabic revenue and gum production. To achieve these specific objectives, the following questions were highlighted: i) What is the productivity of gum gardens and how can it be estimated? ii) How can productivity influence gum arabic revenue and gum production? Primary and secondary quantitative and qualitative data were collected to answer these questions. The primary data were collected using face-to-face interviews with a random sample of 338 household heads, group discussions, and 38 interviews with key informants. Data analysis relied on mathematical equations for labour and capital productivity, and regression analyses of the relationship between productivity and gum revenue were employed. The results revealed that capital productivity is low in Alkhowi (9.3) compared to Shiekan (18.5) and Umrawaba (24.1) Localities. Labour productivity per hour worked and labour productivity per dollar were low in Shiekan compared to the other localities. The regression findings show that labour productivity per working hour and per dollar significantly influenced gum revenue. The main conclusion is that labour and capital productivity play an essential role in assessing the performance of GAPAs and are influenced by many factors. The study recommends that government and NGOs provide production inputs and ease marketing services to enhance capital and labour productivity.

Keywords: productivity measures, labour, capital, gum garden, Sudan

INTRODUCTION

Based on the literature reviewed by Francesconi and Heerink (2011), Abebaw and Haile (2013), Abate et al. (2014), and Francesconi and Ruben (2012), agricultural cooperatives play an essential role in improving farm productivity by influencing the adoption of technologies that enhance productivity. In the general sense, productivity is the level of utilization of all types of resources that contribute to raising a firm's profits and profitability (Vodyannikov and Subaeva, 2018). Agricultural cooperatives can contribute to the provision of credit facilities and resolve production constraints (Tefera et al., 2017). Organizations can improve their productivity by increasing outputs or decreasing inputs. An economic measure of enterprise efficiency, productivity

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can be measured as value added per worker, value added per hour worked, or value added per unit of investment. Productivity is considered a vital concept because it is seen as one of the main indicators that reflects the performance of an organization, or of a production unit in particular (Hoehn, 2003; Helo, 2005; Phusavat and Photaranon, 2006).

Labour productivity, the most common indicator used to measure productivity, is defined as the output corresponding to the input obtained from the workforce, or as value added per hour worked (Lieberman and Kang, 2008). According to Ovidiu et al. (2011), labour productivity is the amount of product obtained per unit of labour represented in the number of hours worked, the number of employees per employee or the number of employed persons (employees and other categories). However, the number of working hours is the most common indicator. Labour productivity rises with increased labour per working hour and decreases if the same output is produced with fewer hours worked (Hinterberger et al., 2011). In the agricultural sector, labour productivity can be enhanced through investments in human capital, research and development, and the extensive utilization of other production inputs (Goldin, 2016). In the case of gum gardens, capital productivity is measured based on the capital and credit used annually to tap a gum garden and the total production revenue. This quantity indicates how well capital is used to provide goods and services. Any increment in capital productivity means less capital is needed to generate the same level of output. Capital investment plays a significant role in reducing labour and materials productivity costs. Thus capital productivity is a critical issue, especially for eco-investments and investments in natural capital; in these investments, the ratios and periods of return are less productive in conventional terms (Jackson, 2009).

Gum arabic not only provides income and compensates farmers against seasonal fluctuations in agricultural product prices but is also considered an essential source of foreign exchange for Sudan. The income earned from gum arabic production is important because the collection process is carried out during the dry season, after other agricultural crops have been harvested. Gum arabic production is more economical, more efficient and less labour intensive than the production of other cash crops. In addition, it employs all family members for four to six months per year and provides seasonal labour for people from other parts of the country. Despite the importance of gum arabic, few studies have been conducted to assess the productivity of gum arabic producers. The present study was conducted to assess the labour and capital productivity of Gum Arabic Producers Associations (GAPAs) in Umrawaba and Shiekan localities (North Kordofan State) and Alkhowi locality (West Kordofan State), where 14 GAPAs were selected for analysis. More specifically, the study aimed to i) estimate the productivity of gum gardens per hour worked (hrs/ha/yr) and per dollar ($/ha/yr), as well as their capital productivity ($/$), and ii) to analyze the relationship between productivity and gum arabic revenue and gum production. To achieve these specific objectives, the following questions were highlighted: i) What is the productivity of gum gardens and how can it be estimated? ii) How can productivity influence gum arabic revenue and gum production?

MATERIAL AND METHODS

Study area

This research was conducted in North and West Kordofan States, Sudan (Fig. 1), where 14 GAPAs were analyzed. The two states are located in the gum arabic belt in the semi-arid zone of Sudan, which has a good reputation for gum arabic production worldwide (Tieguhong and Ndoye, 2004). The area of North Kordofan State is 190,840 km^2, and the population was estimated at 2.92 million in the national population census of 2008 (SCBS, 2008). The average annual rainfall (mm per annum) ranges from 100 mm in the northern part to 250 mm in the southern region and up to 450 mm per annum in the far southernmost part of the state (IFAD, 2003; Meteorological Station – Elobied, 2014). The area of West Kordofan State is 144,00 km^2 (LGC, 2015), with low rainfall savanna to high rainfall. The average rainfall in the northern part is 300mm, and the far southmost part of the state is characterized by high annual rainfall of up to 400 mm (Meteorological Station – ElNuhud, 2014). The primary sources of income are an integrated farming system of rain-fed crop cultivation, gum arabic production and raising livestock (Taha, 2006; Ramly, 2011).

Data collection and analysis methods

Qualitative and quantitative data were collected to measure the productivity of the gum arabic system of GAPAs. The primary data were collected via face-to-face

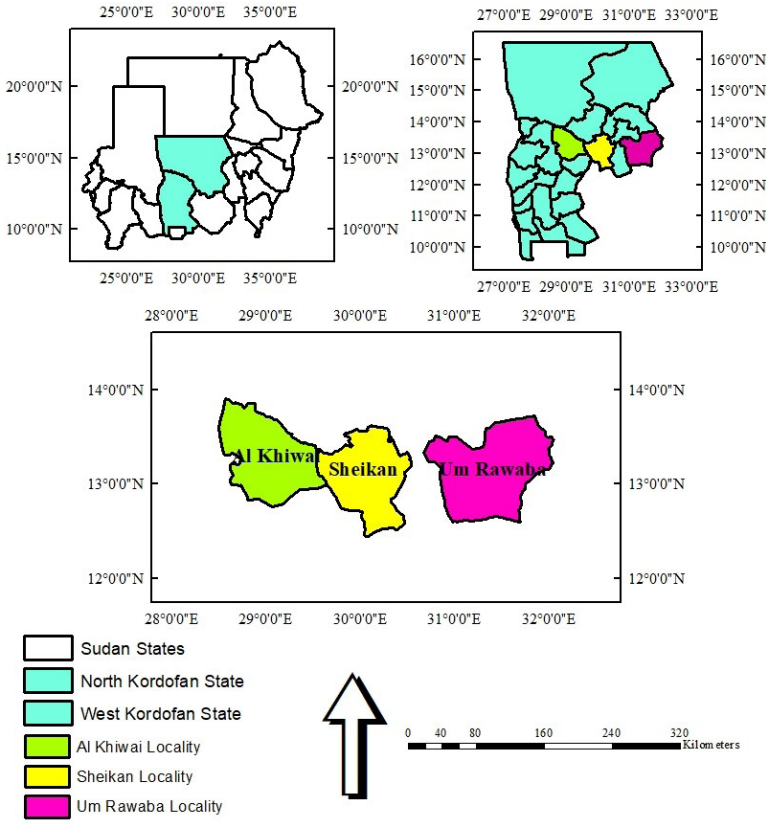

Fig. 1. Map of the study area
Source: GIS, 2020.

interviews, covering 338 households (HHHs) from 14 GAPAs in Sheikan and Umrawaba Localities (North Kordofan State) and Alkhowi Locality (Kordofan State). Moreover, 42 in-depth interviews with GAPA executive committees, group discussions at the village level and direct observation were used to collect the primary data. Furthermore, 38 key informants were interviewed for triangulation of the data collected via the in-depth interviews with the GAPA executive committees. Respondents were selected using random simple sampling, while for the supplementary data, prospective techniques were used. The secondary data were gathered from relevant documents of the archive of line ministries, NGOs and published papers.

The data were analyzed in three phases according to the following steps: i) The labour costs per working hour and per dollar paid were calculated using the wages and the number of hours required for gum production from a unit of area (ha). The physical and financial capital were calculated based on the financial capital invested in producing gum arabic per ha ($/ha). ii) Mathematical equations of labour productivity and capital productivity were used to estimate the productivity. iii) A regression analysis of productivity based on gum revenue and gum yield (production) was conducted using Statistical Package for Social Sciences (SPSS) software (version 25). The calculations are described below.

Estimation of labour and capital costs

For paid labour, the costs of different types of labour ($/person-day) were obtained from farmer interviews. The total labour cost of tapping (TLTC) per *Mokhamas* (1 *Mokhamas* = 0.735 ha) was calculated by multiplying the number of hours required to tap a *Mokhamas* (NH) by the average wage (TW /H), or the cost of one working hour, and the number of *Dahawyia* (morning

session) working hours needed to tap one *Mokhamas*. In the case of family labour (unpaid labour), the calculation was based on the alternative labour costs (LAC /WH) in $/hour. The cost for picking gum arabic from one *Mokhamas* (TLPC) was calculated in a similar way to the labour cost for tapping. The total gum picking cost was obtained by multiplying the average number of pickings during the production season (NP) by the mean cost of a single picking. Value-added costs were calculated in a similar way to the picking cost. For capital inputs, the financial capital was calculated directly based on the amount of money in the bank account. However, the physical capital of a used tractor was calculated based on the purchase price when new in the nearby market minus the cost of depreciation. The physical capital of a gum store was calculated based on the cost of building a store. However, in the case of unpaid physical capital, alternative costs were calculated either for renting a tractor and/or renting a store instead of using houses for gum storage. Moreover, total gum arabic revenues in different marketplaces (farm gate, village market, and city market) were calculated by multiplying the quantities sold by actual sale prices. All local units for measuring gum arabic labour and capital inputs, gum production units, and revenue units were converted into international units. For the regression analysis, the total gum arabic production (gum yield) was calculated by multiplying the quantity produced per tree (kg) in all pickings by the number of trees per *Mokhamas*. The labour and capital productivity calculations were as follows.

Labour productivity per working hour (LPWH)

Labour productivity per working hour was calculated to estimate labour efficiency. The calculation was based on Nezu (2001) and Hara and Ichiue (2011), as shown in equation (1) below:

$$LPWH = \frac{TQP}{NH} \quad (1)$$

Where: LPWH – labour productivity per working hour, TQP – total quantity of gum produced (Ton), and NH – actual person-hours required to produce that quality.

Labour productivity per dollar paid (LPDP)

Labour productivity per dollar paid was calculated using equation 2, as suggested by Ahn and Abt (2006):

$$LPDP = \frac{TC}{Ms} \quad (2)$$

Where: *LPDP* – labour productivity per dollar paid, *TC* – total cost of output produced ($), and *MS* – amount of money spent on workers ($).

Capital productivity (CP)

Capital productivity for each GAPA was calculated based on the study of Lopez and Marcuello (2006), which used capital productivity to measure economic efficiency. Capital productivity was calculated using equation 3:

$$CP = \frac{TQP}{CE} \quad (3)$$

Where: *CP* – capital productivity, *TQP* – total quantity of gum produced (Ton), and *CE* – capital employed ($).

In the regression analysis, the outputs (gum production and gum revenue) were selected as independent variables, while labour and capital productivity were determined as dependent variables. The model relied on equation 4 below:

$$Y = a + bX \quad (4)$$

Y – the dependent variables (LPHW, LPMP and CP)
X – a vector of independent variables (gum production and gum revenue)
a and *b* are constant parameters that need to be estimated from data. Their roles in the straight-line formula are as follows:

a – the intercept (the value of *Y* when *x* = 0)
b – the slope of the line (gradient).

RESULTS AND DISCUSSION

Labour productivity per working hour (hrs/ha/yr) and per dollar paid ($/ha/yr)

Table 1 shows the labour productivity per working hour (hrs/ha/yr) and labour productivity per dollar paid ($/ha/yr) in the study area. The average highest labour productivity per hour worked was in Umrawaba Locality, followed by Alkhowi Locality, while Shiekan Locality showed the lowest labour productivity per working hour. The variation in the labour productivity ratio per working hour in the study areas is mainly due to differences

Table 1. Labour productivity per hour (hour/ ha) and per dollar ($/ ha)

Locality	Mean annual gum revenue ($/ha/yrs)	Average annual working hours (hr/ha)	LPWH (hrs/ha/yr)	Total annual labour costs ($)	LPDP ($/ha/yr)
Alkhowi	319.9	13	24.6	36.6	8.7
Shiekan	198.6	10.8	18.4	29.3	6.8
Umrawaba	355.9	13.8	25.8	35.5	10.0
Mean	291.4	12.5	23.3	33.8	8.6

Source: own elaboration.

in gum arabic revenue from the sale of stored gum or lower gum production (low tree density per ha in Sheikan because of the use of a tractor). The findings also show that there were more man-working hours (about 3 hours higher) in Umrawaba and Alkhowi Localities compared to Shiehan Locality. This result agrees with Popescu (2015), who pointed out that farmers' labour productivity can be increased by providing the necessary financial support to improve the endowment and modernize agricultural farms for modern technological practices, and to increase production quality and profitability.

Table 1 also presents the labour productivity per $/ha/yr paid at the GAPAs level in the study area. The highest labour productivity per dollar paid among the study areas was in Umrawaba Locality (10 $/ha/yr), with a total annual labour cost of 35.5 $/yr. Variations in the labour productivity ratio per dollar paid may be attributed to differences in stocking density and the number of taps per year, where farmers tap the same Hashab tree twice yearly in winter and summer. Therefore, the highest labour productivity per dollar was in GAPAs characterized by a high density of gum trees per ha (No./ha); this leads to an increase in gum arabic production per ha (Ton/ha) or the ability to sell gum arabic at a higher price. All gum producers in the study area suffer from a lack of availability of labour, which influences gum production due to low returns from gum arabic production. As a result, landowners migrated to the principal cities in search of alternative job opportunities or shifts from gum production to agricultural crop production and/or off-farm activities, such as hired labour and gold mining, as a primary source of income. This result is supported by a study by Asmamaw et al. (2014), who claimed that in Umrawaba and Elnehud, migratory labourers commonly practice off-farm activities by working as seasonal labourers in the nearby cities or in traditional gold mining.

Capital productivity

Table 2 presents the capital productivity in the study area. Umrawaba Locality has the average highest capital productivity among the study areas, with an average working capital of 10,563 $/year. The average lowest capital productivity was in Alkhowi Locality (9.3 $/yr). The results also reveal that the highest capital productivity is found in GAPAs which invest a proportion of their capital to provide financial and physical services to their members. This result is attributed to external support. The finding agrees with Peng and Yuan (2014), who reported that the economic status of cooperatives becomes stronger with government support. In most GAPAs, members failed to play their roles in supporting GAPAs with financial and physical capital because gum arabic is produced by small producers who are poor and do not understand the importance of the collective action concept. This result concurs with the statement that smallholder farmers often fail to utilize agricultural inputs effectively, and consequently, productivity faces credit constraints (Akudugu et al., 2009, 2012).

Table 2. Capital productivity in the study area

Locality	Gum revenue ($)	Working capital ($)	CP ($ / $)
Alkhowi	319.9	3 287.3	9.3
Shiekan	198.6	3 073.5	18.5
Umrawaba	355.9	10 563.0	24.1
Mean	291.4	5 641.2	17.3

Source: own elaboration.

Regression analysis

Labour productivity

Table 3 shows the Multi Regression findings of labour productivity per working hour and per dollar paid for gum in the study area. The results show that the *multiple correlation coefficient* (*R*) is 0.995, indicating a high level of prediction. This finding means that 99.5% of the variation in the dependent variable (gum revenue) is related to the incorporated independent variable (labour productivity per hour). When gum production is used as the dependent variable, *R* is 0.113, indicating a low level of prediction (11.3% of the variation is related to the incorporated independent variable). Another notable result is that the *unstandardized coefficient* (*B1*) for labour productivity per hour in the study areas, which is 0.998. This means that each dollar increase in gum revenue leads to an increase of 0.998 in labour productivity per working hour. In the case of gum production, *B1* is 0.407, meaning that each 1kg increase in gum production leads to an increase of 0.407 in labour productivity per working hour. The same table also shows that in *Pearson's Correlation analysis*, there is a strong positive correlation between gum revenue and labour productivity per working hour, where $r = 0.998$ (p at 0.05 level (2-tailed) is 0.044 ($p > 0.001$)). While in the case of gum production, correlation is not significant at the 0.05 level, where $r = 0.336$.

The *multiple correlation coefficient* (*R*) of labour productivity per dollar for gum production in the study area in table 3 is 0.962, which means 96.2% of the variation in the dependent variable (gum revenue) is related to the incorporated independent variable (labour productivity per dollar). When gum production is used as a dependent variable, it is equal to *0.006*, which indicates a very low level of predictive power. This finding means that only 0.6% of the variation in the dependent variable (gum production) is related to the incorporated independent variable (labour productivity per dollar). The *unstandardized coefficient* (*B1*) for labour productivity per dollar in table 3 above is equal to 0.981. This finding means that each dollar increase in gum revenue leads to an increase of 0.981 in labour productivity per dollar. In the case of gum production, *B1* for labour productivity per dollar is very low, being equal to 0.038. This finding means that each 1 kg increase in gum production leads to an increase of 0.038 in labour productivity per dollar. According to Table 3, *Pearson's Correlation analysis* shows the correlations between gum revenue or gum production and labour productivity per dollar are not significant at the 0.05 level (2-tailed), where $r = 0.981$ and 0.078, respectively.

Capital productivity

Table 4 presents the Multi Regression findings on capital productivity in the study area. The results show that the *multiple correlation coefficient* (*R*) is 0.879, which means 87.9% of the variation in the dependent variable (gum production) is related to the incorporated independent variable (capital productivity), while the *unstandardized coefficient* (*B1*) for capital productivity is 2.135. This result means that each 1kg increase in gum production leads to a decrease of 2.135 in capital productivity. In the case of gum revenue, the *R* is 0.006, which means only 0.6% of the variation in the dependent variable (gum revenue) is related to the incorporated independent variable (capital productivity). While *B1* is 0.081, each dollar increase in gum revenue leads to an increase of 0.081 in capital productivity. *Pearson's*

Table 3. Regression analysis of labour productivity per working hour and per dollar paid on gum revenue in the study area

Independent variables	Dependent variables	"R Square"	Adjusted R Square	Unstandardized coefficient	Sig (2-tailed)	Pearson Correlation
Gum revenue	LP WH	0.995	0.991	0.998	0.044*	0.998
	LPDP	0.962	0.924	0.981	0.125	0.981
Gum production	LP W	0.113	–0.774	0.407	0.782	0.336
	LPDP	0.006	–0.988	0.038	0.950	0.078

Correlation is not significant at the 0.01 and 0.05 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Source: own elaboration.

Table 4. Regression analysis of capital productivity on gum revenue in the study area

Independent variables	Dependent variables	"R Square"	Adjusted R Square	Unstandardized coefficient	Sig (2-tailed)	Pearson Correlation
Gum revenue	CP	0.006	–0.987	0.081	0.949	0.081
Gum production	CP	0.879	0.759	–2.135	0.226	–0.938
Correlation is not significant at the 0.01 and 0.05 level (2-tailed).						

Source: own elaboration.

Correlation analysis shows labour productivity per dollar has a positive relationship with gum revenue and a negative relationship with gum production. However, the correlations are not significant at the 0.05 level (2-tailed), where $r = 0.081$ and 0.938, respectively.

SUMMARY OF LABOUR AND CAPITAL PRODUCTIVITIES

Figure 2 illustrates that labour productivity per working hour and labour productivity per dollar paid reveal similar trends across the three localities; however, the latter is comparatively low. This is because most gum producers rely on family labour for gum production, which is considered unpaid labour. A low level of performance characterizes the capital productivity of GAPAs, and most loans are consumed by daily life expenses and the harvest of crops. However, a little of the money is invested in tapping gum trees. Although in Alkhowi locality GAPAs suffer from a lack of financial and physical capital, the capital productivity is higher due to the high gum arabic production per hectare (natural capital). Capital productivity is higher in GAPAs that have invested a portion of their capital in assets or in credit to finance their members during the gum production season.

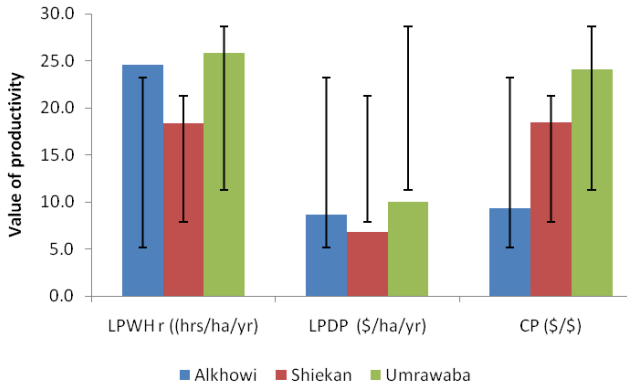

Fig. 2. Labour and capital productivity in the study area
Source: own elaboration.

CONCLUSION AND RECOMMENDATIONS

There is variation in labour productivity between Shiekan and Umrawaba Localities and in capital productivity between Alkhowi Locality and the other two localities. The regression findings reveal that labour productivity per working hour and dollar positively impact gum revenue, while capital productivity has no significant impact. These comparisons between different types of productivity provide information about the performance level of gum production systems. The findings also reveal that many factors influence the level of labour and capital productivity in the study area, such as labour availability, the gum price, other sources of income and external interventions. The study recommends that government and NGOs should provide production inputs and marketing services to enhance capital and labour productivity. Moreover, gum producers' awareness of new technologies needs to be raised to enhance productivity and to improve gum arabic production.

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