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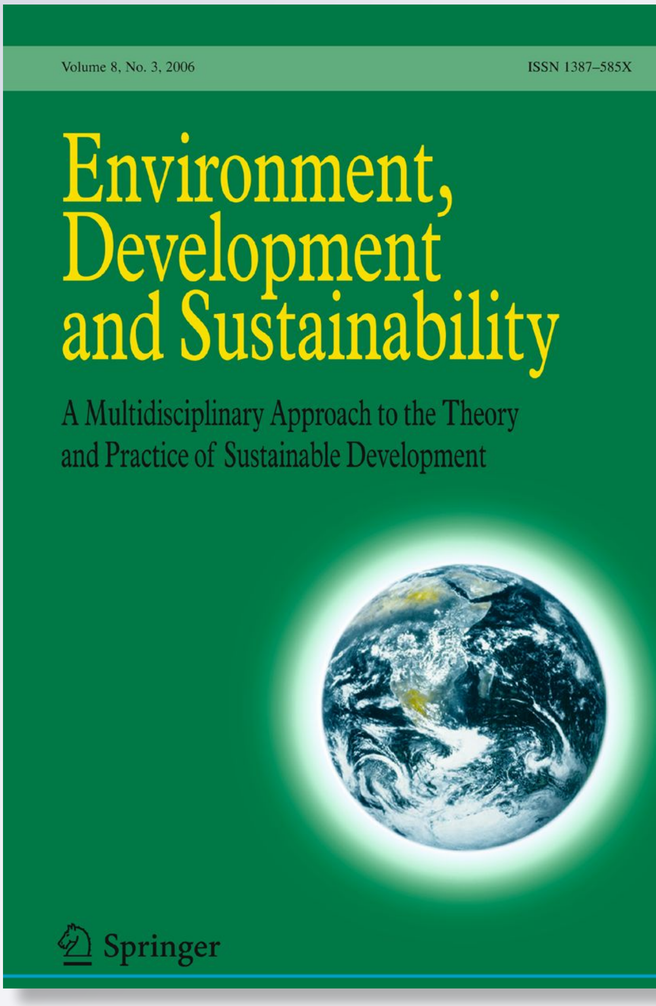

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CASE STUDY

Can the African food supply model learn from the Asian food supply model? Quantification with statistical methods

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Abstract This study seeks to verify the relationship or correlation between food supply and four variables that are fertilizers, machinery, permanent cropland and permanent pasture land in Africa and Asia. The data were obtained from FAOSTATS and the World Resource Institute. The data were analyzed using the SPSS version 19. Pearson's correlation statistical tool and the multiple linear regression methods were then used within the SPSS interface to analyze the data. The results show that the levels of fertilizer application and machinery use are more significant in affecting food supply in Asia than in Africa with respect to the four variables. In Africa, permanent cropland is of greater significance when food supply is concerned with respect to these four variables. The likely trend is for Africa to enact policies that will encourage investments in machines and organic fertilizers to be able to improve its food production and supply rather than merely increasing farm sizes.

Keywords Food supply · Machinery · Fertilizers · Permanent cropland · Permanent pasture land · Food policy

1 Introduction

Agriculture is of great importance to mankind for the simple reason that people in all parts of the world need to be fed. In Africa, the importance of agriculture goes beyond just being

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fed to the fact that it contributes about 50% of the GDP (FAO and UNIDO 2008). However, while regions like Asia have been able to transform their agricultural system to obtain 'increased food supply', Africa still lags behind and all we hear of Africa are reports of famine and food shortages (Yohanna 2007). The Millennium Development goals were drawn with set targets to reduce by half the number of people who suffer from hunger by the year 2015. Yet, it is likely that this deadline is likely going to be reached without attaining a reduction in hunger especially in developing countries (Rosegrant and Cline 2003; Matson et al. 1997). In areas like Asia, Europe and North America, national governments have been able to reduce the number of people who face problems of food supply through astronomical increases in food production (Li et al. 1997; FAO and UNIDO 2008).

Food supply and production have often been considered as variables that are dependent on climatic factors such as precipitation, temperature and humidity, physiographic factors such as soil type, soil texture and slope to name but these (Kepner et al. 1978; Van and Wold 1986; Stewart 1985; Bernstein and Pearson 1954). However, there are several other important variables that impact on food supply and food yields. Some of these include the level of mechanization of pre- and post-harvest agriculture, quantity of fertilizer used, sizes of permanent cropland and to a lesser extent pasture land (Rosegrant and Cline 2003; Bationo et al. 1993; Matson et al. 1997). Simply put, physiological factors that impact crop yields have historically been balkanized into climate and soils. It is therefore true that where the soils are rich in compost and moisture and there is adequate temperature and sufficient rainfall, crop yields are likely to be good (Van and Wold 1986; Stewart, 1985; Bernstein and Pearson 1954; Antle et al. 2004). This current study acknowledges the differences in the physiological factors that affect agricultural systems in both regions and the fact that they vary. For the purpose of avoiding ambiguity and due to a lack of reliable time series data on soils and climate for the entire Asian and African regions, all physiological factors are held constant or simply taken out of the analysis. This study seeks to verify the degree to which the use of fertilizers, machines, arable land and pasture land each correlates with food supply in Africa and Asia in an attempt to establish a clear picture of the current role of these variables in these regions and to specify how Africa can benefit from the Asian situation which as described in the literature is advanced (Bumb et al. 1996). This approach is important because despite mankind's great understanding of the role of the physical factors, food crises remain ever so present. A look into the nonphysical dimension will go a long way to show where there are gaps and what examples are to be copied by lagging regions. Caution should be taken to understand that this study is not a comparison of the two regions that are evidently different in terms of the variables under study, cultural and the physical factors. To our knowledge, this is the first broad-scale study that verifies the food supply situation in both Asia and Africa using essentially time series data.

Looking at the variables, it can be said that mechanization, for example, has been described as a very important component of agro-industrial development and its use varies from one landscape to another. It covers various farm equipments, irrigation and food processing techniques with the aim of increasing agriculture as a means of enhancing the productivity of human labor and to achieve results beyond the capacity of human labor (Yohanna et al. 2011; FAO and UNIDO 2008; Matson et al. 1997; Matson et al. 1998; Antle et al. 2004). In addition to the low productivity of essentially human labor–driven farms, about 30-40 percent of crops are lost today in Africa due mainly to post-harvest problems such as lack of storage and processing facilities (FAO and UNIDO 2008; De Datta 1986; De Lima 1987). It is for this reason that this study is focused on food supply in kilocalories per capita per day and not just the raw yields because emphasis so far has been on the raw yields with little attention at what happens after harvest. As such, this study has defined food supply as the total amount of food that is available to the population from actual or raw yields and after subtracting food lost due to poor storage and inadequate processing. Therefore, food supply in the context of this study encompasses the actual or raw yields and the yields lost due to inadequate storage and processing. This can be summarized in the following food supply model: $FS = Y - YLS$, where FS is food supply, Y refers to actual yields before decomposition, and YLS refers to yields lost due to poor storage and processing.

The application of fertilizers is another factor that has impacted agriculture in most developed and developing countries. Its importance in these study sites will be of great importance, and its correlation with food supply will also be verified (Hossain and Singh 2000; Buresh et al. 1988; Matson et al. 1998). The common types of fertilizers under consideration here are both organic (compost manure) and inorganic chemical fertilizers dominated by those of the nitrogen, phosphorous and potassium categories. Generally, the application of inorganic fertilizers should be done with caution, and it is the place of governments to regulate this without which there will be long-run environmental degradation due to seepage of pollutants in water systems, and general flora, fauna and soil degradation. (Maeda et al. 2003). This study therefore advocates a possible emphasis on compost fertilizers and a use of environmentally acceptable quantities of inorganic fertilizers to avoid the dangers of pollution. Finally, permanent croplands as well as pasture land are of pertinence. It is held that when crop and pasture land sizes increase, food production and supply will increase since more hectares will come under cultivation. Here, this study will verify the correlation that this has to food supply in both regions (FAO and UNIDO 2008; FAOSTATS 2011).

2 Study areas and methodology

The study area covers the entire Asian and African regions (Fig. 1a, b) with no exceptions of countries as it is specified on the websites of the World Resource Institute (www.wri.org) and the Food and Agricultural Organization (www.faostats.org). Therefore, to obtain the data, we access the websites above and simply click on Asia or Africa, select the number of years for which data on the variable are available and select the variable; this way, the data are populated on an excel sheet directly. The data included variables such as food supply, machinery use, fertilizer use, permanent cropland and permanent pasture land. The time period covered by the data ranged from 1961 to 2000. It should be noted that all the data used were time series data for all the five variables, and they were obtained from FAOSTATS (2011) and World Resource Institute (WRI) (2011).

The data were analyzed with the aid of the statistical package for the social sciences (SPSS) version 19. Two main methods of analysis were applied. The first method of analysis was the use of the Pearson's correlation statistical tool as specified in the study by Motulsky (1999). The independent variables are machinery, fertilizers, permanent cropland and permanent pasture land, while the dependent variable is food supply. The equation used to run a Pearson's correlation is given as follows:

$$r = \sum(x - \mu)(y - \mu) / \sqrt{\sum(x - \mu)^2 \sum(y - \mu)^2}$$

where r is the Pearson's correlation coefficient, x is the independent variable, y is the dependent variable, μ is the mean of both variables, r ranges from -1.0 to $+1.0$ where -1.0 to -0.7 indicates strong negative associations, -0.7 to -0.3 weak negative

Fig. 1 **a** Asia and **b** Africa, culled from www.googlemaps.ca

associations, −0.3 to +0.3 little or no association, +0.3 to +0.7 weak positive association and +0.7 to +1.0 strong positive association.

The second method of analysis was the use of the multiple linear regression tool as specified in the method by Motulsky (1999). This method was employed to verify which of the independent factors were more responsible for the behavior of the dependent variable. The equation used to fit the model is as follows:

$$y = \beta_{0+}\ \beta_{1x1+}\ \beta_{2x2+}\ \beta_{3x3+}\ \beta_{4x4} + \acute{\epsilon}$$

where y is the dependent variable, β_0 is the intercept, $\beta_{1+}\ \beta_{2+}\ \beta_{3+}\ \beta_4$ are partial regression coefficients, x1 + x2 + x3 + x4 are dependent variables and $\acute{\varepsilon}$ is error term.

Based on the above methodology and background, this study seeks to answer the question, among the following variables (fertilizer use, use of machines, permanent crop land, permanent pasture land) which are more influential in explaining food supply for both Asia and Africa and which can we recommend African countries to invest in order to raise their food production?

3 Results

In Asia, this study has observed that of the four variables under study, the quantity of fertilizers used remains the most important factor with respect to the variables included in this study affecting the food supply (Figs. 2, 7; Tables 1, 2). This is because it has a t value of 12.461, which is by far higher than that for the other variables. In the same way, the coefficient of determination (r^2) and Pearson's correlation (r) for this same variable stands at 0.96 and 0.98, respectively. This not only is higher than the values obtained for the other variables but depicts a perfect positive correlation, showing that as the quantity of fertilizers increases, so does the food supply (Fig. 2). We can say that the quantity of fertilizers used aptly explains the behavior of food supply in Asia. The rest of the variables in order of importance are permanent crop land (t value, −4.045; r^2, 0.87; and r, 0.93) (Fig. 3), agricultural machinery (t value, 2.046; r^2, 0.86; and r, 0.93) (Fig. 4) and permanent pasture

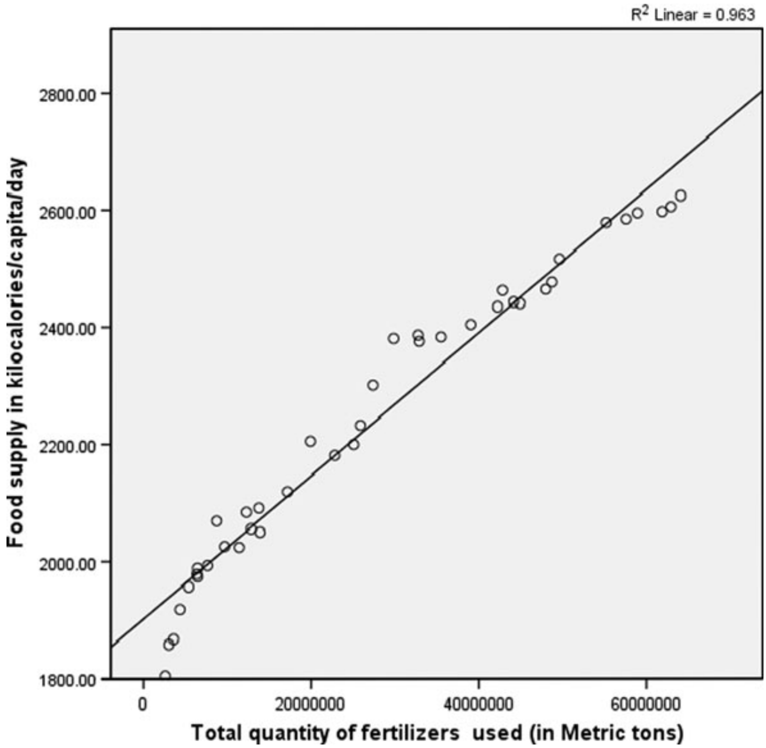

Fig. 2 Shows a close relationship between fertilizers and food supply in Asia. Points very close to the linear line depict that fertilizer use aptly explains the behavior of food supply. When compared to Africa (Fig. 7), it is observed that Africa has a weaker correlation with food supply

Table 1 Correlation results for Asia

Independent variables	Dependent variable	Pearson's r	Level of significance
Permanent crop land	Food supply	0.93	0.01
Agricultural machinery	Food supply	0.93	0.01
Total quantity of fertilizers used	Food supply	0.98	0.01
Permanent pasture land	Food supply	0.86	0.01

Permanent crop land and permanent pasture are expressed in thousand hectares and represent the area occupied by crops and agricultural animals. Agricultural machineries are expressed in thousand dollars of imports. Total quantity of fertilizers used is expressed in metric tons. Food supply is expressed in kilograms of calories per capita per day (Kcal/capita/day)

Table 2 Results of multiple linear regressions, r^2 and r for Asia

Independent variables	Standardized coefficients	Standard error	*t* value	Rank of *t* value	r^2	Ranks of r^2
Agricultural machinery	0.136	0.01	2.046	3	0.86	3
Quantity of fertilizers	1.443	0.01	12.461	1	0.96	1
Permanent cropland	−0.600	0.003	−4.045	2	0.87	2
Permanent pasture land	−0.001	0.001	−0.010	4	0.74	4

Permanent crop land and permanent pasture are expressed in thousand hectares and represent the area occupied by crops and agricultural animals. Agricultural machineries are expressed in thousand dollars of imports. Total quantity of fertilizers used is expressed in metric tons. Food supply is expressed in kilograms of calories per capita per day (Kcal/capita/day). Total observations = 40; $r^2 = 0.985$, adjusted $r^2 = 0.983$; *f* value 551.455

land (*t* value, −0.010; r^2, 0.74; and *r*, 0.86) (Fig. 5).Therefore, while the use of fertilizers appears to be more important in Asia, the least important variable here is permanent pasture land (see Tables 1, 2; Fig. 5).

While the use of fertilizers is an important variable that has led to increased food supply in Asia, it is only considered a less important variable in Africa, showing that improvements have to be made in this area. Furthermore, in the area of machinery, Asia is also more advanced than Africa; this again shows why the gaps in food production and supply between these regions seem to be wide.

In Africa, farm sizes seen mainly in permanent crop land and permanent pasture land are more significant to food supply than is the case in Asia (Tables 1, 2, 3, 4). Therefore, the most important variable for Africa out of the four used in this study is permanent crop land. This has a *t* value of 3.515, r^2 of 0.95 and *r* of 0.97 (Fig. 6; Tables 3, 4). The other three factors in order of importance are quantity of fertilizers (r^2, 0.91 and *r*, 0.95) (Tables 3, 4; Fig. 7), permanent pasture land (r^2, 0.71 and *r*, 0.84) (Tables 3, 4; Fig. 8) and agricultural machinery (r^2, 0.58 and *r*, 0.76) (Tables 3, 4; Fig. 9). The *t* values of these last three variables for Africa do not tally with those of the r^2 and r (see Tables 3, 4). Whatever the case, the regression analysis, r^2 and r show that permanent crop land is the most important variable, while the use of machines in agriculture seems to be lowly rated by both methods.

African permanent cropland increased by 64% (14,868 thousand hectares) being that it was 27,122 thousand hectares in 1961 and 41,990 thousand hectares in 2000. In Asia, it increased by 43% (31,087 thousand hectares) (55,093 thousand hectares in 2000 and

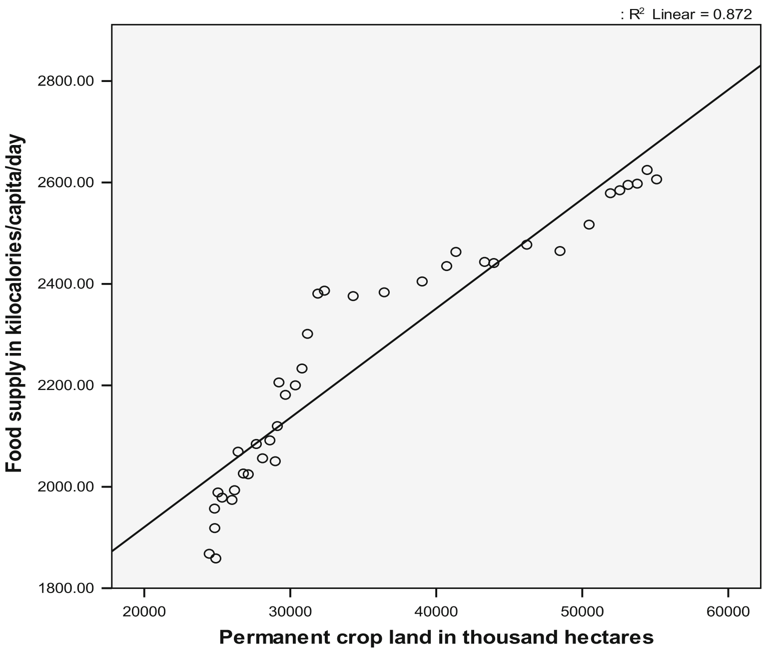

Fig. 3 Shows a close relationship between permanent cropland and food supply in Asia. Permanent cropland is the second most important variable. When compared to Africa (Fig. 6), it is observed that there is stronger relationship

24,006 thousand hectares in 1961). In Africa, food supply increased by 324 kcal/capita/day (2,029 kcal/capita/day in 1961 and 2,353 kcal/capita/day in 2000), which is much lower than what was obtained in Asia during the same period (802 kcal/capita/day being that in 1961, it was 1,804 kcal/capita/day, and in 2000, it rose to 2,606 kcal/capita/day). However, these figures should be interpreted with caution because of different population sizes and land areas under consideration in the different countries.

4 Discussions

From the results, we can recall that the increase in machinery and fertilizers has been of great impetus in food production and supply in Asia, while farm size increase seems to be more vital in the African food supply equation even though it has only had minimum positive effects. This is explained by the fact that Asia has for long had a food policy of food-self-sufficiency that encouraged large-scale investments in fertilizers and machines, while Africa has for long focused on labor-driven production with a notion of large farms (Djurfeldt et al. 2005). This study therefore recommends that African economies may be able to grapple with some of the problems of food insecurity and food supply by becoming a little more intensive by adopting the use of more organic fertilizers and machines. The national governments should supervise this and create credit schemes that will enhance farmer's access to the required knowledge and these resources.

In the area of fertilizer application, the disparity is wide with Africa having 13 kg/h and Asia having about 208 kg/ha (FAO and UNIDO 2008). It has also been argued that famine

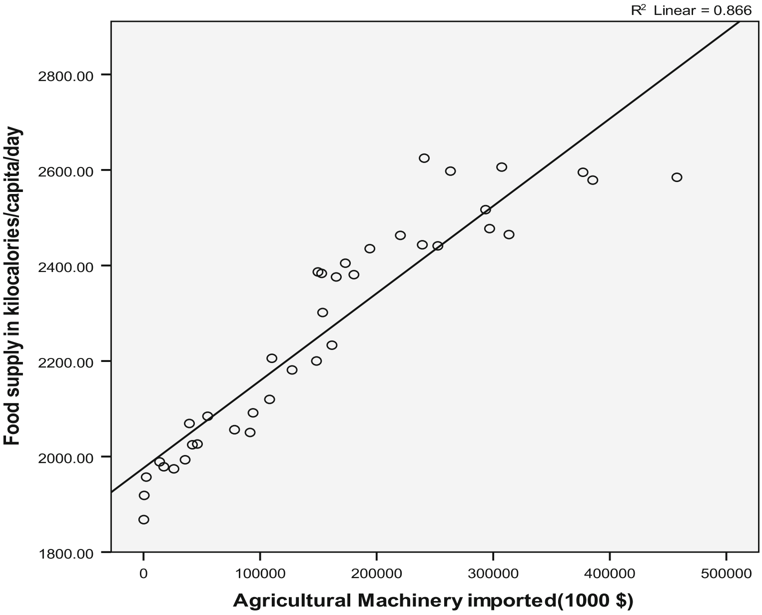

Fig. 4 Shows the correlation between agricultural machinery and food supply in Asia. Agricultural machinery is the third most important variable. When compared to Africa (Fig. 9), it is observed that the relationship in Asia is stronger

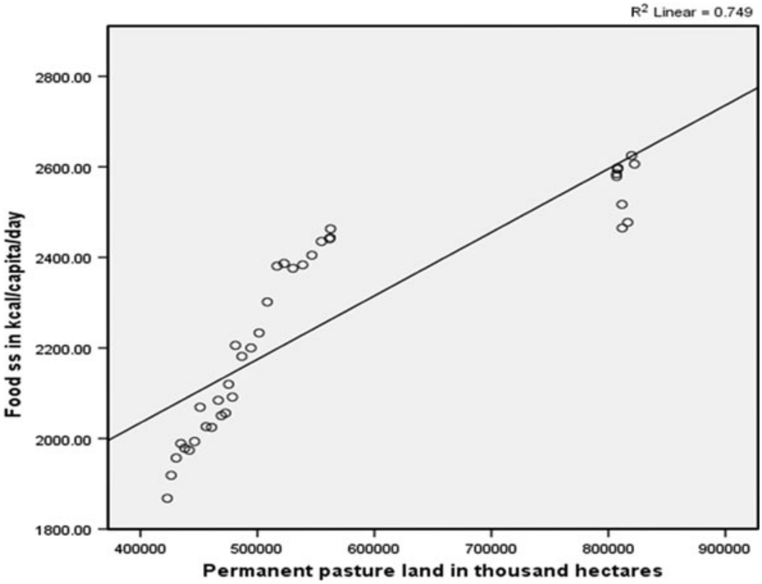

Fig. 5 Shows the correlation between permanent pasture land and food supply in Asia. In general, this is the weakest variable in the entire simulation. When compared to Africa (Fig. 8), it is observed there is a stronger correlation here than in Africa

Table 3 Correlation results for Africa

Independent variables	Dependent variable	Pearson's r	Level of significance
Permanent crop land	Food supply	0.978	0.01
Agricultural machinery	Food supply	0.762	0.01
Total quantity of fertilizers used	Food supply	0.958	0.01
Permanent pasture land	Food supply	0.846	0.01

Permanent crop land and permanent pasture are expressed in thousand hectares and represent the area occupied by crops and agricultural animals. Agricultural machineries are expressed in thousand dollars of imports. Total quantity of fertilizers used is expressed in metric tons. Food supply is expressed in kilograms of calories per capita per day (Kcal/capita/day)

Table 4 Results of multiple linear regressions, r^2 and r for Africa

Independent variables	Standardized coefficients	Standard error	t value	Rank of t value	r^2	Ranks of r^2
Agricultural machinery	0.097	0.01	1.278	3	0.58	4
Quantity of fertilizers	0.119	0.01	0.821	4	0.91	2
Permanent cropland	0.649	0.004	3.515	1	0.95	1
Permanent pasture land	0.165	0.001	1.969	2	0.71	3

Permanent crop land and permanent pasture are expressed in thousand hectares and represent the area occupied by crops and agricultural animals. Agricultural machineries are expressed in thousand dollars of imports. Total quantity of fertilizers used is expressed in metric tons. Food supply is expressed in kilograms of calories per capita per day (Kcal/capita/day). Total observations = 40; $r^2 = 0.962$, adjusted $r^2 = 0.957$; f value 213.327

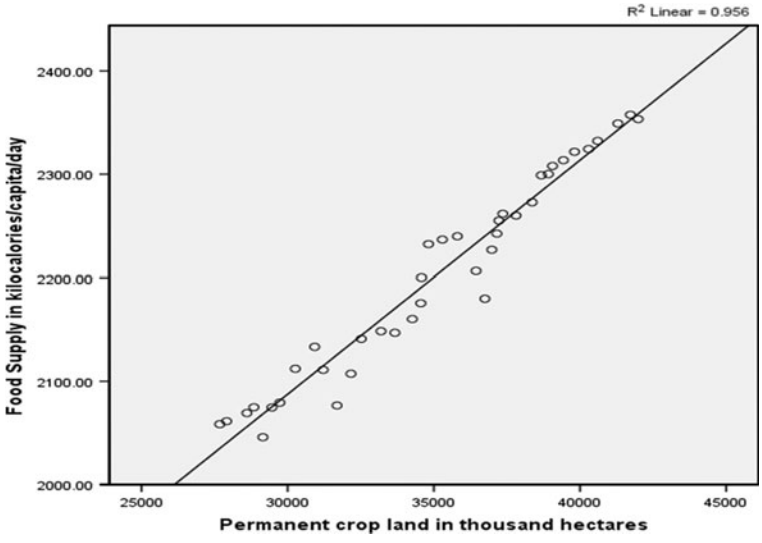

Fig. 6 Shows that in Africa permanent cropland is the most important variable affecting food supply. When compared to Asia (Fig. 3), it is observed that this variable is of greater importance in Africa than in Asia

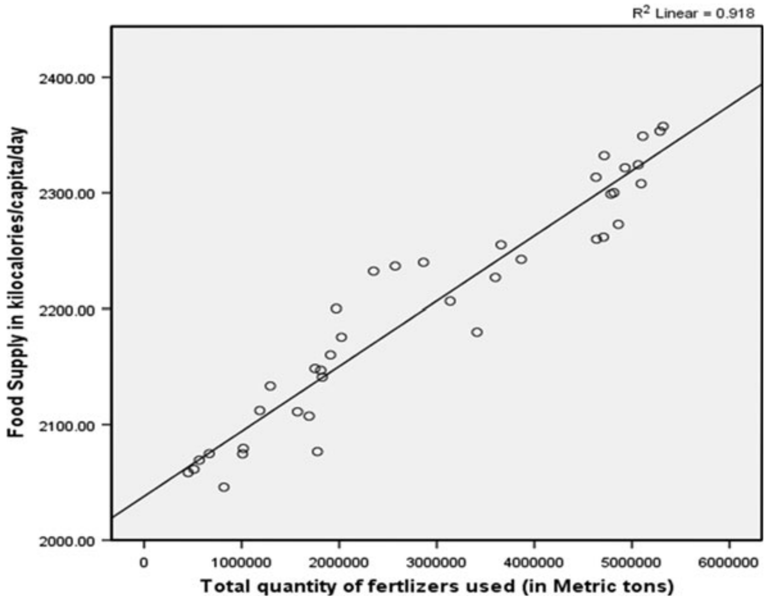

Fig. 7 Shows that total quantity of fertilizers used in Africa are the second most important variable affecting agriculture in Africa. When compared to Asia (Fig. 2), it is observed that the situation in Asia is stronger than in Africa as shown by the r and r^2

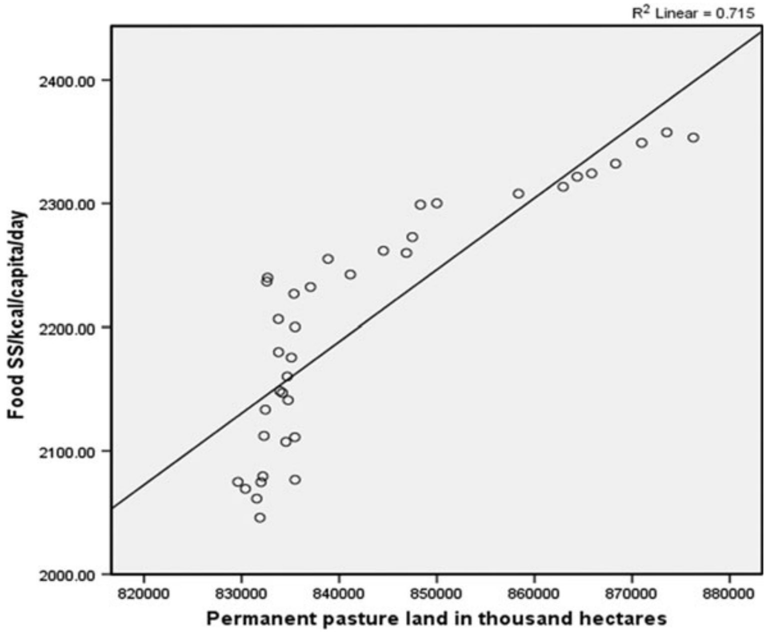

Fig. 8 Shows that permanent pasture land is the third most important variable in Africa. When compared to Asia (Fig. 5), it is observed that this variable is of higher significance in Asia as seen in the r and r^2

Fig. 9 Shows that in Africa agricultural machinery has the weakest correlation with food supply. When compared to Asia (Fig. 8), the African situation is highly inferior as seen by the r and r^2

was averted in Asia because of wide-scale irrigation and the application of fertilizers. Comparatively, between 1988 and 1996, Asia had a rate of growth in fertilizer usage of 7.3%/year, while that of Africa was 0.4%/year; it is thus evident that fertilizer usage is higher in Asia relative to Africa, and this explains why the scatter plot for Asia has its points closer to the trend line (Fig. 1). In the global fertilizer usage chart, Asia's intake increased from about 45% between 1965 and 1966 to 53% in the mid-1990s (Hossain and Singh 2000; Buresh et al. 1988; De Datta et al. 1990). Bationo et al. (1993) and Abdoulaye and Sanders (2005) also support the fact that low food yields in Africa are explained by low fertilizer use as shown by the effects of crop residue and fertilizers application on pearl millet yields in Niger.

At the moment, all statistics show that the gross intake of fertilizers in Africa is perhaps the lowest in the World. However, projections into the future hold that by 2020 sub-Saharan Africa will be leading in fertilizer use with a rate of 3.3% annual growth rate; this will be far ahead of East Asia 1.9%, South Asia 2.8%, West Asia/North Africa 1.9%, Latin America 2.3%, developing countries 2.2% and developed countries 0.2% (Bumb et al. 1996). From these statistics, it can be observed that the trends are toward increasing fertilizer use in Africa.

The issue of increased rfertilizer and machine use in most of Asia has been an issue of the Asian regional agricultural policy of grain self-sufficiency under the auspices of the Green revolution. This became rampant in Asia in the 1960s as most Asian governments emphasized the need for grain self-sufficiency. As a result, this could either be achieved through an expansion of agricultural land or maintaining the current farm sizes but producing intensively. The latter was favorable for grain production, and this resulted in small farms that were highly intensive in cultivation with the use of chemical fertilizers and machines (Djurfeldt et al. 2005). On the other hand, agriculture in Africa from the colonial days to present is labor-intensive and capital-extensive; this explains why even when farm sizes increase, the net yields are low. In fact, the focus on human labor as a key element of food production in Africa has been the pillar of the agricultural policy; it is now time for governments to shift from such labor-intensive policies to one that encompasses mechanization and a rational use of organic fertilizers (Djurfeldt et al. 2005; Christensen and Larry 1982).

Though the current increase in use of fertilizer in Asia relative to what is obtained in Africa is good news for the Asian food supply economy, environmental critics have described this as damaging to the environment. The growing environmental concerns are raising fundamental changes in the importance attached to the use of fertilizers in food production with a major shift toward organic farming (De Datta 1986; De Datta et al. 1989; Hossain and Singh 2000). The recent global decline in fertilizer use is associated with declines in the former USSR and Europe and is due mainly to environmental concerns with an increasing demand for organic farming (Rosegrant and Svendsen 1993). To be concrete, recent studies conducted in the Subandean Amazon of Peru have shown that the need to establish new farming plots and to increase yields has led to an increase in the demand for chemical fertilizers and pesticides. While this is argued as being good for the yields, these studies also note that with a lack of functional riparian zones, there is a high level of risk for the degradation of soils and water systems in the long run (Lindell et al. 2010a, b, c). These views have been supported by studies on chemical fertilizers that have degraded soils in Bolivia and West Amazonian (Abe et al. 2007; Araujo et al. 2004).

The question now is, with the cost associated with organic farming, will African countries be able to invest in organic farming? If they do, will the middle class African family be able to meet their food needs? Should African countries now concentrate on organic farming rather than investments in fertilizer use and machinery? The answers to these questions are complex. While it is proposed that African countries increase their use of fertilizers, this study argues that due to the environmental short comings reported above, the solution will come from whether Africans adopt the use of organic fertilizers or not. In fact, in Peru, it has been reported that farmers who were involved in cooperatives had a better understanding and potential of using organic fertilizers because the cooperatives they belonged to organized this for the farmers (Lindell et al. 2010a, b). It therefore means that it does not help to simply say investments should be made in fertilizers, the types must be specified and the means should be put in place to get the organic fertilizers to the farmers; in most cases, this is most effective through cooperatives as seen above.

In Asia, there have been more advances in mechanization of agriculture, and this has been responsible for the rapid increase in food supply, while Africa is still lagging behind (World Bank 1987; FAOSTATS 2011; FAO and UNIDO 2008). In Africa, it has been argued that mechanization of agriculture is either facing stagnation or retrogression (FAO and UNIDO 2008; Kepner et al. 1978). The reasons for this stagnation and retrogression are the absence of sound strategies and policies of mechanization such as investments in tractors and other farm management schemes such as irrigation, lack of coordination between government and private sector (Yohanna 2006; FAO and UNIDO 2008). When Africa excluding South Africa, Egypt and Mauritius is compared with 9 Asian countries, we observe stagnation in agricultural production and food supply in the 1970s and 1980s where cereal yield for Africa has stagnated at about 1 ton per hectare or 1,040 kg/ha, while that of Asia is about 3,348 kg/ha. At the same time, the number of tractors in Africa stands at 28 per/1,000/ha, while that of Asia was reported at 241 per/1,000/ha (Reid et al. 2003;

FAO and UNDO 2008). It is further reported that increased mechanization would lead inter alia to increased food production, improved land use, enhanced rural prosperity, and greater exports and less reliance on imports (Yohanna 2007; FAO and UNIDO 2008; FAOSTATS 2011). In 1798, Malthus advocated the principle of preventive checks in his book, 'An Essay on the principle of population'. Preventive checks are reflected in the area of investments that would prevent famine and subsequent population decline. Such checks in today's world would include machines and fertilizers that would enhance productivity (Rosegrant and Cline 2003).

As concerns permanent cropland, it is observed in the results that the farm sizes in Africa have not doubled between 1961 and 2000, while those of Asia have almost doubled during the same period (FAOSTATS 2011). In the case of Africa, farm size increase has been the main cause of the minor increase in food supply presented in the results above (FAOSTATS 2011). In fact, Rosegrant and Cline (2003) argue that expansion of agricultural land or cultivated area is one means of boosting up production that is sufficient to meet rising demands. The process of increasing land in order to cultivate more crops is not sustainable for the environment. This is why it has been argued that arable and permanent crop land increase in Cameroon, for example, to enhance crop production has been described as the second most vital cause of deforestation (Epule et al. 2011). In Asia, the changes in land sizes presented in this paper have been seen as the second vital factor that correlates with food supply during the same period. This increase is mainly accounted for by agricultural intensification; however, permanent crop land is also of importance in explaining the observed trend (Zhao et al. 2006). It can be said that permanent crop land is of importance in both regions in affecting food supply, but the response has been more positive in Asia than in Africa probably because Asia has invested more on fertilizers and agricultural machines. In Asia, permanent pasture land is less important when compared to the situation in Africa; this is seen in the differences in the slopes of the curves where in Africa the points for permanent pasture land are closer to the trend line than in Asia (Figs. 4, 7).

In a nutshell, these results should be considered with caution because the multiple linear regression models were fitted in consideration of the following variables (fertilizers, machines, permanent crop land and permanent pasture land). It can be argued that several other factors such as rainfall, temperatures, soils, cultural setting and political instability can influence food supply (Van and Wold 1986; Stewart 1985; Bernstein and Pearson 1954; Antle et al. 2004). It suffices to say that this study acknowledges the role of all these other variables, but the interest here is to see how the four specified variables affect food supply. The methods of correlation analysis and multiple linear regressions are suitable for such analysis as they ease specification of variables to test the behavior of specific variables with the knowledge that many variables may affect a phenomenon under study (Motulsky 1999).

5 Conclusions

The evidence provided by this study shows that fertilizers and machinery are very important factors that affect the food supply in both Asia and Africa and that Africa could revamp its food supply by increasing its investments in agricultural mechanization and the application of organic fertilizers. This does not the least mean that the other variables do not play a role. In Africa, for example, permanent cropland is also another variable though its effects on food production are minimal. Though it is therefore advocated that African countries work towards increasing their fertilizer and machinery use, the unanswered questions are how will the environmental degradation resulting from fertilizer application be handled? As such, this study proposes the adoption of organic fertilizers and farm mechanization by African economies with the governments coordinating to see that farmers get subsidies and are educated on the use of organic fertilizers and the dangers of chemical fertilizers. Furthermore, this study recommends that other studies be carried out on smaller scales to test the results presented here, and if possible, the influence of other factors that affect food production and supply be incorporated.

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Appendix 1

See Table 5.

Table 5 Raw data used in assessing the Asian food supply model

Years	Food supply in kcal/capita/day (y)	Agricultural Machinery imported(1,000$) (x1)	Total quantity of fertilizers used (in Metric tons) (x2)	Permanent crop land in thousand hectares (x3)	Permanent pasture land in thousand hectares (x4)
1961	1,804.76	220	2,588,668	24,006	416,992
1962	1,858.69	331	3,020,607	24,900	420,018
1963	1,867.9	226	3,592,249	24,451	422,972
1964	1,918.55	581	4,356,839	24,826	426,354
1965	1,956.99	2,366	5,385,459	24,813	430,571
1966	1,988.83	13,807	6,440,727	25,049	434,598
1967	1,978.59	17,398	6,366,671	25,329	437,899
1968	1,974.15	26,039	6,459,101	26,008	441,794
1969	1,993.25	35,706	7,642,173	26,182	446,279
1970	2,069.18	39,353	8,724,031	26,425	451,001
1971	2,026.14	46,211	9,677,379	26,787	456,099
1972	2,024.67	41,925	11,412,688	27,121	460,820
1973	2,084.36	55,038	12,274,073	27,671	466,544
1974	2,056.16	78,105	12,831,264	28,101	472,729
1975	2,091.51	93,961	13,760,341	28,602	478,644
1976	2,050.42	91,423	13,908,383	28,971	469,127
1977	2,119.68	108,165	17,176,384	29,114	475,372
1978	2,205.7	110,116	19,916,777	29,222	481,210
1979	2,181.25	127,451	22,815,782	29,667	486,703
1980	2,200.06	148,389	25,073,705	30,348	494,485
1981	2,233.21	161,631	25,879,982	30,805	501,404
1982	2,301.51	153,680	27,377,365	31,180	508,437
1983	2,380.83	180,487	29,837,374	31,889	516,783
1984	2,386.6	149,628	32,755,117	32,341	522,742
1985	2,375.97	165,315	32,884,891	34,306	530,347
1986	2,383.45	152,836	35,496,636	36,434	538,703

Table 5 continued

Years	Food supply in kcal/ capita/day (y)	Agricultural Machinery imported(1,000$) (x1)	Total quantity of fertilizers used (in Metric tons) (x2)	Permanent crop land in thousand hectares (x3)	Permanent pasture land in thousand hectares (x4)
1987	2,404.84	173,135	39,042,504	39,033	546,556
1988	2,435.22	194,130	42,234,039	40,711	554,707
1989	2,463.06	220,351	42,832,992	41,345	562,546
1990	2,443.35	239,174	44,158,415	43,309	562,331
1991	2,441.11	252,460	44,922,829	43,941	561,685
1992	2,477.28	296,883	48,722,914	46,199	816,468
1993	2,464.85	313,526	47,976,985	48,473	811,780
1994	2,516.95	293,448	49,611,601	50,467	811,586
1995	2,578.77	385,389	55,191,549	51,929	807,050
1996	2,584.7	457,570	57,561,926	52,569	807,004
1997	2,595.24	376,993	58,931,627	53,134	807,798
1998	2,597.62	263,341	61,863,717	53,764	807,991
1999	2,624.67	240,828	64,082,894	54,444	819,782
2000	2,606.13	307,298	62,922,312	55,093	822,357

* The data on this table are for the entire Asian region as found on http://www.faostats.org

Appendix 2

See Table 6.

Table 6 Raw data used in assessing the African food supply model

Years	Food supply/kcal/ capita/day (y)	Agricultural machinery imported (1,000 $) (x1)	Total quantity of fertilizers used (in Metric tons) (x2)	Permanent crop land in thousand hectares (x3)	Permanent pasture land in thousand hectares (x4)
1961	2,029.94	1,060	394,288	27,122	833,827
1962	2,058.48	1,160	451,391	27,678	832,626
1963	2,061.34	2,337	511,457	27,914	831,552
1964	2,069.25	6,835	566,665	28,606	830,388
1965	2,074.85	5,336	668,723	28,844	829,621
1966	2,045.87	8,911	818,595	29,152	831,875
1967	2,074.66	9,196	1,009,207	29,462	831,981
1968	2,079.36	10,048	1,016,908	29,732	832,169
1969	2,112.16	8,477	1,185,269	30,264	832,292
1970	2,133.38	8,209	1,293,541	30,924	832,431
1971	2,111.11	11,743	1,572,057	31,216	835,456
1972	2,076.58	12,578	1,776,412	31,688	835,473
1973	2,107.31	21,167	1,691,418	32,166	834,541
1974	2,141.09	40,820	1,826,696	32,520	834,767
1975	2,148.52	44,482	1,751,765	33,192	833,909

Table 6 continued

Years	Food supply/kcal/capita/day (y)	Agricultural machinery imported (1,000 $) (x1)	Total quantity of fertilizers used (in Metric tons) (x2)	Permanent crop land in thousand hectares (x3)	Permanent pasture land in thousand hectares (x4)
1976	2,147.02	38,248	1,810,732	33,668	834,183
1977	2,160.25	46,104	1,910,712	34,264	834,668
1978	2,175.58	66,679	2,022,714	34,554	835,096
1979	2,200.15	66,139	1,969,305	34,578	835,478
1980	2,232.3	75,566	2,352,554	34,818	837,057
1981	2,236.69	113,588	2,573,180	35,292	832,583
1982	2,239.88	142,286	2,863,279	35,804	832,660
1983	2,206.4	134,499	3,137,522	36,444	833,767
1984	2,179.94	125,858	3,412,138	36,746	833,780
1985	2,226.81	111,642	3,599,742	36,982	835,361
1986	2,255.05	167,848	3,658,102	37,224	838,846
1987	2,242.41	103,443	3,865,099	37,158	841,137
1988	2,261.67	95,283	4,708,028	37,358	844,527
1989	2,259.88	86,272	4,636,644	37,812	846,882
1990	2,272.77	86,854	4,860,401	38,364	847,489
1991	2,298.97	73,999	4,783,410	38,676	848,316
1992	2,300.09	69,277	4,814,894	38,920	849,993
1993	2,307.92	73,221	5,094,078	39,062	858,357
1994	2,313.5	66,968	4,630,679	39,432	862,935
1995	2,321.67	107,608	4,929,240	39,812	864,373
1996	2,324.33	90,501	5,063,950	40,292	865,851
1997	2,332.18	90,922	4,715,421	40,602	868,305
1998	2,349.05	129,537	5,110,960	41,296	870,983
1999	2,357.53	93,792	5,319,362	41,724	873,548
2000	2,353.35	78,284	5,287,128	41,990	876,265

* The data on this table are for the entire African region as found on http://www.faostats.org

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