Economics of Potassium Based Fertilizers for Sustainable Crop Production

12. The law of the minimum: Linking potash fertilizer utilization, farm level production productivity, and economic losses in Tanzania

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In recent years utilization of in-organic fertilizers in Tanzania has more than doubled due to many factors including government subsidies through the National Input Voucher Scheme (NAIVS). However the increase is more pronounced on use of Urea, Di-Ammonium Phosphate (DAP) and Calcium Ammonium Nitrate (CAN) which accounts for more that 60% while Potash fertilizer through NPK and other compound fertilizers account for the rest. Using the "Law of Minimum", this paper analyse and model the missing opportunity for maximizing crop productivity and associated economic losses due dismal levels of Potash fertilizer utilization the country. The paper suggest for a strategic fertilizer blending programmes to increase use of potash utilization to avoid the trap evidenced by the Law of Minimum.

Key words: Fertilizer, Potash, Crop productivity, Law of minimum, Tanzania

1. Introduction

Improving agricultural productivity and production in African smallholder agriculture is widely recognized as a critical outcome in the pathway to growth and poverty alleviation. Increased productivity, especially of major staple crops allows farmers to take advantage of growing market opportunities for these crops, while increasing household food and nutrition security.

Agriculture is the dominant sector in Tanzania's economy similar to many developing countries. It employs 76% of Tanzanians with 88.2% of population living in rural areas (NBS, 2014). It is a source of food and nutritional security, accounting for 24% of GDP and about 30% of exports (URT, 2014). Agriculture sector is also related to other sectors as it is a source of raw material to industries and utilize industrial outputs, thus its growth can move the country out of poverty.

In Tanzania agriculture, it mostly dominated by crops, which accounts for more than 72% of the Agriculture Gross Domestic Product (AGDP)[2], followed by livestock (15%), hunting and forestry (8%) and fishing (6%). Hence any strategies to increase impact on poverty alleviation strategies should be focused on agriculture more so in

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[2]Food crops account for 65% of agriculture gross domestic product (AGDP) (NAP 2013)

crop production. A key ingredient to increased agricultural productivity and production is farmer access to inputs, particularly fertilizer and quality seed of superior varieties. The importance of enhancing smallholder farmers' access to fertilizer and the role this can play in raising productivity of Tanzania agriculture is highlighted in various policy and strategy documents such as the National Agricultural Policy (NAP, 2013), the Agricultural Sector Development Program (ASDP), the Kilimo Kwanza national declaration of 2009 and Big Result Now (BRN) initiatives of 2012

Despite the important role played by agriculture, the sector faces numerous challenges and constraints. The main constraints facing agriculture in Tanzania is low productivity coupled with declining soil fertility, weather uncertainty, poor application of production technologies and market problems (Kamuhabwa, 2014; Hella *et al*, 2015; and NBS, 2014). Poor productivity does not cope with food needs for population growth of 2.8% (NBS, 2014). In the last for years, Tanzania agricultural growth recorded 4.2% below Comprehensive African Agriculture Development Programme (CAADP) target of 6-7% annual growth of agricultural sector GDP. Thus yield increasing technologies such as improved production inputs linked with value added and functioning markets are inevitable in agriculture production especially when additional land for cultivation is becoming increasingly limited and climate change adversely affecting crop production.

Nevertheless, high cost of production inputs such as fertilizers limits smallholder farmers, mainly in low income bracket and marginalized groups, to apply required fertilizer rates to boost crop production. That's why the government intervention such as input subsidy provision to smallholder farmers was thought to be a rational approach to boosting agricultural productivity in the short run (Yawson *et al.*, 2010, Meertens, 2000). Studies in many places show that subsidy is linked to reduction

2. The problem and Theoretical framework

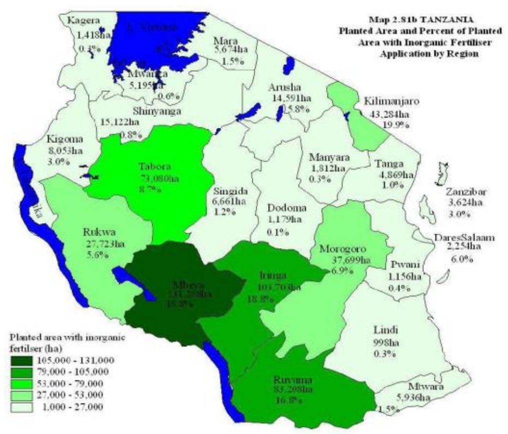
2.1 The problems

It is generally accepted that breakthrough in poverty alleviation strategies in sub-Saharan Africa in general and Tanzania in particular should be though agriculture since this is the sectors where majority of the poorest are employed. In attempt to decrease poverty, in early 2000, many African countries resumed fertilizer subsidy (Chibwana *et al.*, 2010, Danning *et al.*, 2009). The new system of subsidy was considered market "Smart" and concurrent with Abuja declaration (Wiggins and Brooks, 2010, Danning *et al.*, 2009,). The need for subsidies was further intensified following the Abuja Declaration on African Green Revolution. The declaration African Union (AU) member states was as to rise fertilizer use to an average of 50kg/ha by 2015 (Yawson *et al.*, 2010) through elimination barriers on fertilizer access such as tariffs on fertilizers and fertilizer raw materials in order to increase food supply, reduce food insecurity and poverty levels. Further, the Comprehensive Africa Agriculture Development Programme (CAADP) pillar III called African Union countries to increase agriculture growth by 6% and increase government budget on agriculture by 10% (URT, 2012, Hella *et al.*, 2015) with emphasis on increasing fertilizer use as it is reported that, no region of the world has managed to increase agriculture growth and reduce hunger without increase in fertilizer use (NEPAD, 2009).

New subsidy scheme was considered to be "market smart" as it had specific targeting, measurable impacts, achievable goals, results orientation and timely duration of implementation (Aloice, 2015). The new scheme originated from Malawi as a small starter pack in 1998 revealing significant increase in fertilizer use and high crop productivity (Dorward and Chirwa, 2011). Tanzania and other African countries such as Nigeria, Zambia, Kenya, and Ghana adopted the initiative at different time.

However for Tanzania, the programme has not reached into the forethought expectations. Ten years post CAADP it recorded little progress in crop productivity compared to other study countries[3] (Hella *et al.*, 2015). The average yields of major staple food crops such as maize and rice have changed little over the last 20 years. This reflects both the continuing expansion of planted area and the relative poverty of domestic farming systems. Estimates of input adoption rates vary across the country. According to the 2007/08 Census Survey of Agriculture, less than 8% of all smallholder farmers used improved seed, and less than 3% used inorganic fertilizer, when the NAIVS was initiated in 2002/03 growing season. Much of this utilization was concentrated in the southern highlands (Mbeya and Iringa) and northern highlands area (Kilimanjaro) where population densities and rainfall are higher (Figure 2).

In comparison, the 2008 National Panel Survey estimates that 20 percent of smallholder farmers used improved seed and roughly 12% used chemical fertilizer (National Bureau of Statistics, 2010. Tanzania National Panel Survey Report, Round 1, 2008-09). The average levels of use of chemical fertilizer were estimated to be only around 9 kilograms per hectare (kg/ha), compared with 27 kg/ha in Malawi and 365 kg/ha in Vietnam (Msambichaka *et al.*, 2010). Correspondingly, average grain yields achieved by smallholders were only 20 to 30 percent of their potential (World Bank, 2009).



Account 85% of fertilizer used inTanzania

1) Mbeya 15%★
2) Iringa 14%★
3) Tabora 12%
4) Ruvuma 10%★
5) Morogoro 8%★
6) Rukwa 8%★
7) Kigoma 6%★
8) Kilimanjaro 6%★
9) Arussha……4%★
10) Manyara 3%★

★ **AFAP** target regions(**72%** fertlizer used in Tanzania)

Intensity (%) of fertilizer use by regions	Statistics of top 10 regions in fertilizer use

Figure 1: Intensity and statistics of fertilizer use in Tanzania.
Source: NBS (2012) and Hella (2015)

It is from this background that there has been an emergency of Non-State Actors (NSA) and Non-Governmental Organisations (NGOs) such as African Fertilizer Agribusiness Programme (AFAP) in Tanzania for the purpose of spearheading fertilizer use among many resources poor farms in remote areas in the country

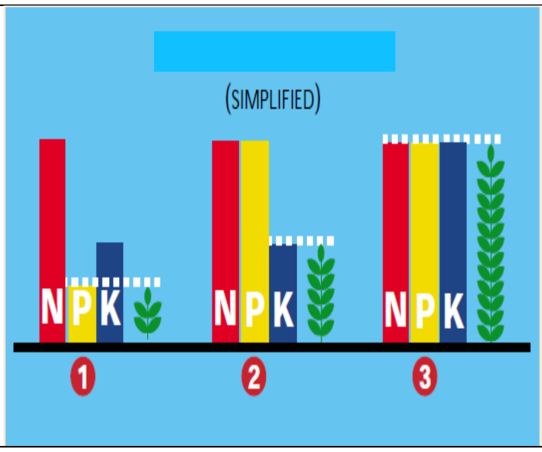
2.2 Theoretical framework and the Law of minimum

2.2.1 Law of minimum and potash fertilizer use

[3] Ethiopia, Rwanda, Burkina Faso, Ghana, Nigeria Sierra Leone, and Mali

The Law of minimum is based on historical aspects of plant nutrition by Liebig in 1840. The Law states that the crop on the field diminishes or increases extract proportion to the diminution or increase of the nutrient substances conveyed to it in manure (inorganic fertilizer). The law of minimum is explained in Figure 2 and Figure 3. Figure 2 entails that even though you apply optimal amounts of N, P or both

— Deficiencies of all nutrients must be corrected to achieve maximum benefits of all nutrients



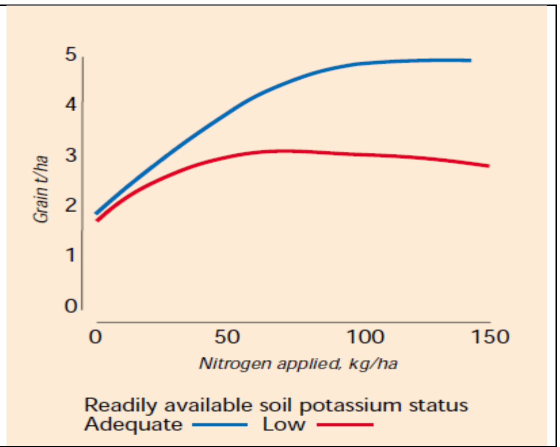


Figure 2a:	Figure 2b:
Limited potash fertilizer application (1) & (2) would cause yield performance not beyond 50% despite the level of N & P nutrients used (2). Full yield potential can be attained only if P is also applied	-With too little available potassium is justifiable to apply only 50kg N/ha (diminishing return sets in) -With adequate Potassium 100 kg N/ha give optimal yields

Figure 2: Influence of Potash fertilizer on yield depicting the law of the minimum
Source: Johnston (2003)

2.2.2 Economics of fertilizer use

The economics of fertilizer use in centred on the core objective of profit maximization. As indicated in equation (1) below, profit is the difference between total revenue and total cost (i.e. variable and fixed costs). In this analysis, short run time period is considered hence short run time period is considered hence only the variable costs will be taken into consideration. Also assuming all other variable costs except cost of fertilizer are held constant, the profit is explained by the difference between total revenue ($Q_y.P_y$) and cost of fertilizer ($P_x.Q_x$) (Equation 2)

— Profit (π) = Revenue – Cost ……………………………………………………(1)
— Profit (π) = $Q_y.P_y - P_x.Q_x$ ……………………………………………………(2)

Taking equation 2 in consideration, revenue for the profit equation (2) can be expressed as a function fertilizer which supply three macro-nutrients viz: Nitrogen (N), Phosphorus (P) and Potassium (K) (equation 3)

– Quantity of output: Q_y. =f(N, P, K) ………………………………………… (3)

Based on the Law of minimum, the yield levels (Qy) even id recommended rates of N and P are used. Non use of potash fertilizer has additional implications of the price of the produce (P_y) which is an important factor is price of the commodity through as outlined in equation (4) below

– Price of output: P_y =f(quality, colour, shelf life, appearance, less diseased..(4)

Furthermore, looking at the Law of minimum from fertilizer cost point of view while holding other production cost *ceteris peribus*, it entail that despite increased use of N and P fertilizers, in absence of K, yield response due to fertilizer use is low. d

- But costs
- Quantity of inputs Qix =f(fertilizer NP-K; pesticides. Labour,
- Price of inputs Px =
- Cost for using N, & P with low levels K: No response to yield

AIM should be –increased revenue and reduce cost. Potash play major role in both

2.2.2 Law of minimum and costs potash fertilizer use

3. Methodology

3.1 Location of the study

This paper is based on data secondary data collected in Tanzania. The United Republic of Tanzania is largely an agriculture-based economy, accounting for more than a quarter of GDP (Figure 3) and remains an important contributor to economic growth (Figure 4). More than 73 percent of the population is rural and about two-thirds of the employed population works in the agricultural sector making this sector extremely important for poverty reduction and food security (Table 1.1). Although per capita income has grown continuously for the past 2 decades, the 2010 per capita income in Tanzania of 399 thousands TZS (473 constant 2000 USD) places it among world's poorest countries. According to the World Bank figures, almost 88 percent of the population lives on less than 2 dollars-a-day and almost 68 percent is estimated to live on less than 1.25 dollar-a-day, a level that defines extreme poverty. Further, about 39 percent of the population is estimated to be undernourished, i.e. living with chronic hunger.

Table 1: Agriculture and Poverty indices in Tanzania, 2011

Agriculture, % GDP	27.1
Employment in agriculture (%)[a]	76.5
GDP per capita (constant 2000, 000 TZS)	399
GDP per capita (constant 2000 USD)	473
GDP per capita (PPP 2005 USD)	1334
Poverty headcount ratio - USD PPP 1.25 a day (% of population)[b]	67.9
Poverty headcount ratio - USD PPP 2 a day (% of population)[b]	87.9
Prevalence of undernourishment (% of population)[c]	38.8
Rural population (% of total population)	73.3
Population (million)	44.8

Notes: a. 2006 estimate; b. 2007 estimate; c. 2010-12 estimate.
Sources: Source: World Bank (2012)

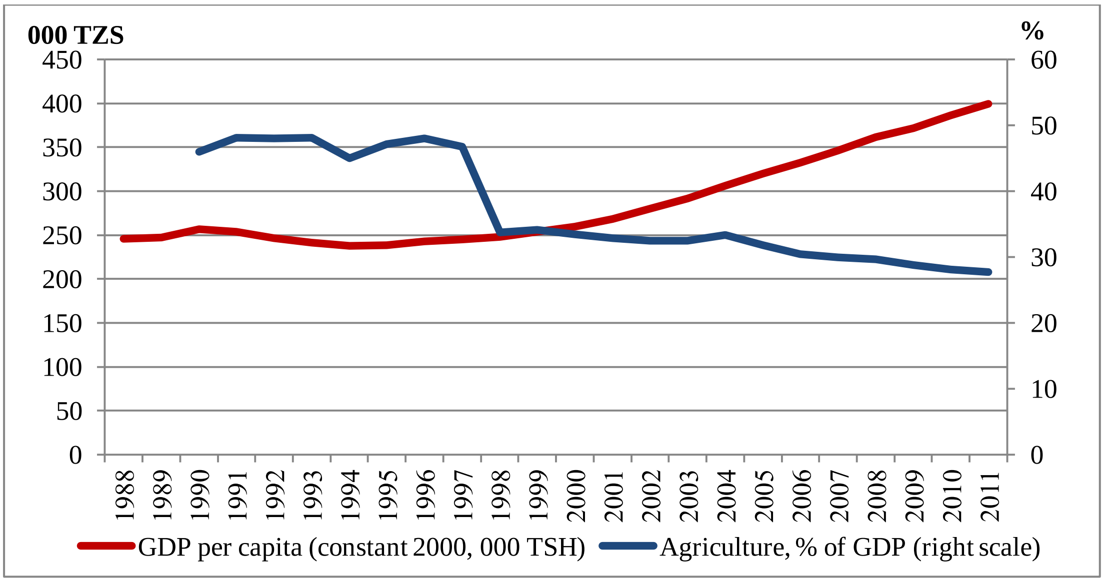


Figure 3: Share of Agriculture in GDP and GDP per capita in Tanzania
Source: World Bank (2012)

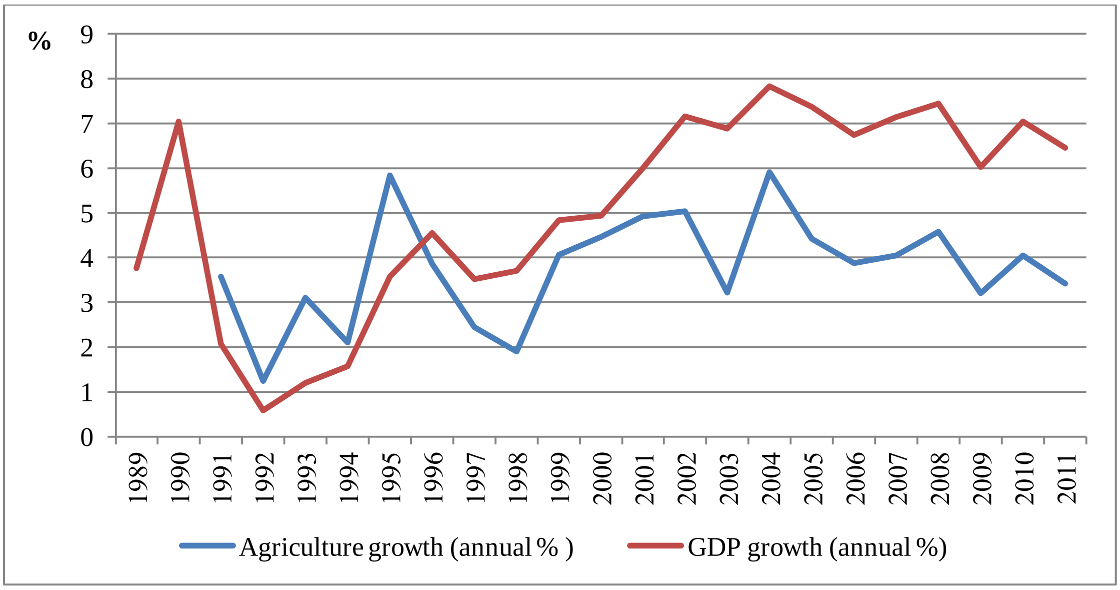


Figure 4: Agriculture and GDP Growth Rates in Tanzania
Source: World Bank (2012)

Agricultural growth has been only 1.5 percent higher than population growth (2.7 percent). Production of the major staple food crops (maize, rice, cassava, and beans) grew at an average rate of 3.5%, compared to 5.4 percent for cash crops. Tanzania's agriculture is dominated by low productivity smallholder farms. Because agriculture in Tanzania depends almost entirely on rainfall, it is highly susceptible to climatic shocks, particularly in the semiarid areas of central and northern Tanzania. Farmers' yields are only 20–30 percent of potential yields (World Bank, 2009). Moreover, improved agricultural technologies have been adopted at extremely low rates in Tanzania. Figure 1.3 shows the percentage of farmers using fertilizer in Tanzania by districts. As shown in the figure, fertilizer utilization rate in Tanzania has generally been low. Between 2002 and 2003 less that 5 percent of farmers in approximately 50 percent of the districts in Tanzania used fertilizer. On average, Tanzanian farmers use approximately 9kg/ha of fertilizer as compared to Malawi that uses 27kg/ha, and

Vietnam that uses 365kg/ha (Msambichaka *et al.*, 2010). This paper explores the use of Potash in Tanzania and tries to establish the linkage between economic gain/loses based on the famous Law of minimum

3.2 Data type, sources and methods of analysis

Amount of fertiliser use and output level of major crops (mainly maize) were main type data for this study. Desk research, and key informant interviews work were the main data collection methods as discussed below. Desk review was the principal method used in collecting data for this report. Various reports from Agriculture sector lead Ministries (ASLM) especially those related to government sponsored input voucher schemes were reviewed. Other sources included reports from NGO (e.g. AFAP), government institutions (e.g. ARI Mlingano), fertilizer companies (YARA, TFA, & ETG) and crop bodies (e.g. Tobacco, sugarcane, and tea). Collected were analysed by using descriptive statistics (mean, variance, chi-square supported by figure and graphs).

4. Results and Discussion

4.1 Trend of fertilizer use by type and crops

There are different soil conditions obtaining around the country, a situation which dictates what crops can grow where and in the same manner this also influences whether and what fertilizers should be applied. The list of top ten fertilizer types used in Tanzania include

(i) **Urea:** Up to 120,000 Mt of urea are used annually. The product is of 46% Nitrogen.

(ii) **NPK- 10:18:24; 20:10:10 (tobacco NPK):** Consists of three Nitrogen, Phosphates and Potassium and is also used in different areas. An annual amount of 40,000 MT of NPK 10-18-24 on average is applied mostly by tobacco growers in Tabora, Mpanda, Chunya and Iringa. Around 20,000 MT of 20:10:10 are used by tobacco growers in Ruvuma but also by other crop growers.

(iii) **DAP (Di-Ammonium Phosphate)**:18% Nitrogen and 46% P_2O_5: This is the most commonly used fertilizer for basal application during planting. These are used mainly in areas where soils are deficient in Phosphorus, especially in the Southern Highlands of Iringa, Njombe, Mbeya, Rukwa, Katavi and parts of Kigoma, Kilimanjaro and Arusha. The annual consumption is estimated at 50,000 MT.

(iv) **CAN (Calcium Ammonium Nitrate)**: 26-27% Nitrogen. Annual consumption is around 40,000 MT.

(v) **SA (Sulphate of Ammonia):** 21%Nitrogen. Used extensively for top dressing, especially in Ruvuma region whereby around 10,000 MT are used annually.

(vi) **Minjingu Rock Phosphate**: (MRP) 28 - 30% P_2O_5, Produced locally at Minjingu factory near Arusha. Annual consumption is estimated to be around 20,000 MT and has increased substantially in recent years due to government subsidy.

(vii) **NPK 25: 5: 5 + 5S** Mainly used in the tea production with annual consumption at 2000 – 3000MT

(viii) **TSP (Triple Super Phosphate)** : 46% P_2O_5 - Annual consumption is around 3,000mt

(ix) **NPK 17:17:17** Used in sugarcane growing and annual consumption is estimated at 1,000mt other types in very small quantities.

(x) **Others nutrients** – Negligible

From the list of fertilizers indicated above, it is obvious that use of potash fertilizer is very small. Nitrogenous fertilizers and Phosphates are used in most areas of the country for food crop growing such as maize, rice and other cereals. NPK 10-18-24 is applied mostly by tobacco growers in Tabora, Mpanda, Chunya and Iringa districts while for NPK 20-10-10 an annual amount of 20,000 MT is used by tobacco growers in Ruvuma but also by other crop growers like coffee. NPK 25:5:5+5S is mainly used in the Tea crop growing. Analysis of fertilizers used as subsidies through the input voucher schemes (NAIVS) programme to smallholders maize and rice growers show similar pattern.

According to realizable sources, the main objective of the program is to improve farmers' access to critical agricultural inputs (fertilizer and improved seeds) for maize and rice production, and it has been implemented by the Ministry of Agriculture, Food Security and Cooperatives (MAFC) to provide input vouchers to a total of 2.5 million maize and rice farmers until now. Each eligible farmer receives vouchers for a maximum of three years. Beneficiaries obtain an "input package" consisting of three vouchers[4]: one voucher for a N or nitrogenous fertilizer (1 bag of urea); one voucher for a P or phosphate fertilizer (1 bag of di-ammonium phosphate (DAP), option 1, or 2 bags of Mussoorie Rock Phosphate (MRP), option 2) with nitrogen supplement depending on farmers' choice); and one seed voucher (10 kg hybrid/open pollinated variety (OPV) maize or 16 kilograms of a rice variety) providing inputs for an average of 0.5 hectare of maize/rice cropped area (Table 2).

Table 2: Input packages for maize and rice (for 0.5 ha)

Crops	N source	P source	Seeds
Maize farmer (Option 1)	1 bag of Urea	1 bag of DAP	10 kg (OPV or hybrid seeds)
(Option 2)	1 bag of Urea	2 bags of MRP + 10N	10 kg (OPV or hybrid seeds)
Rice farmer (Option 1)	1 bag of Urea	1 bag of DAP	16 kg OPV seeds
(Option 2)	Bag of Urea	2 bags of MRP + 10N	16kg OPV seeds

Source: World Bank (2014)

4.2 Trend of crop yield in Tanzania

In order to understand the influence of fertilizers on crop production, we are presenting yield of two main staple crops in Tanzania, *viz* maize and rice which are also covered by NAIVS. Maize is considered the most important food crop in Tanzania covering 45%of total arable land and generating close to 50% of rural cash income, an average of 100 USD per maize producing household in 2008 (USAID, 2010). Rice is the third most important food and cash crop after maize; and it's among the major sources of employment, and income for many farming households. According to the Agricultural census of 2004, 17% of all agricultural households grow rice. Rice production in Tanzania covers approximately 681,000 ha, representing 18% of cultivated land. Almost all rice (99%) is grown by smallholder farmers using traditional seed varieties.

The overall trends in maize as well as paddy production and productivity for the past three decades from 1981/82 to 2009/10 in the NAIVS program area are increasing over time despite the fact that its productivity over the period shows a declining trend. While maize recorded 1.1 million metric tons in 1981/82 and 2.2 million metric tons in 1995/96, a total of 3 million metric tons were produced in 2009/2010. On the

[4]Seeds package would cover 0.5 hectare (100 percent) and 0.25 hectare (50 percent) for maize and paddy respectively.

other hand, maize productivity was 1.1 tons per ha in 1981/82 and 1.8 metric tons per ha in 1995/96, while in 2009/10 productivity declined to 1.5 metric tons per ha.

For paddy, both production and productivity over the period have been increasing. In 1981/82, 145200 metric tons were produced in the NAIVS project regions with productivity at 1.6 metric tons per ha. In 2009/10 production of paddy was 1.6 million metric tons in the project regions with productivity at 2.4 metric tons per ha. In terms of quantity produced maize has been far better compared to paddy, while in terms of productivity paddy performs slightly better in comparison to maize. This trend in production and particularly productivity of maize and paddy can be explained by the fact that over time paddy becomes a more attractive crop to farmers due to its higher prices in the market compared to maize. In addition, the government has developed a number of projects to promote paddy production through irrigation in the country (Figure 5), which also leads to the good performance of paddy compared to maize which depends mainly on rainfall.

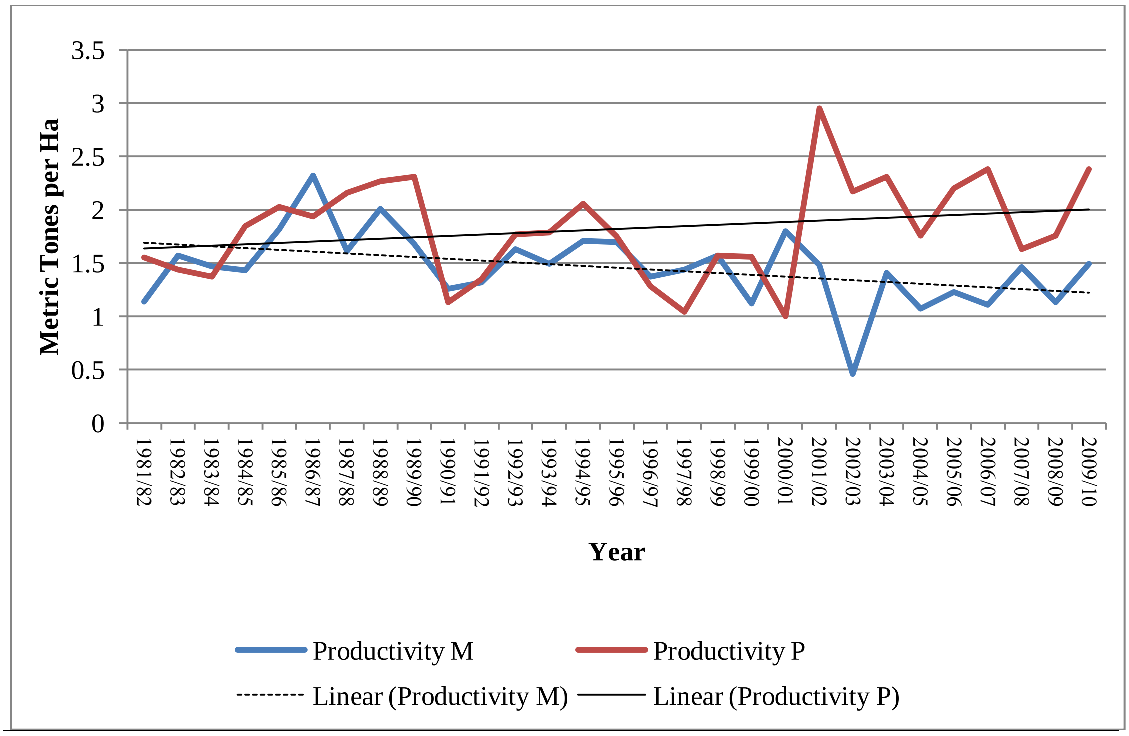


Figure 5: Productivities of main food staples (maize & rice) in Tanzania

Source: Constructed using data from MAFC – Agricultural Input Section

As observed in Figure 5, despite investing much in fertilizer use through input voucher scheme programme, productivity of main staples in particular maize (M) show negative linear productivity, denoting declining trend. Many reasons can explain this strange behavior including rainfall variability and other biotic factors such as pests and diseases, but minimum or limited use of Potash fertilizer as depicted by the Law of minimum in Figure 2 cannot be ruled out. The Law requires optimal use of Potash fertilizer for realizing the responses of the use of other fertilizer nutrients such as Nitrogen and Phosphorus.

4.3 Added advantage of Potash fertilizer on crops quality

Despite the limited use in Tanzania, Potash fertilizer is used by farmers all over the world due to its unique advantages. It keeps plants healthy by allowing nutrients and sugars to move throughout the plant, helping to keep it stress and disease free. Potash fertilizer is therefore an essential ingredient for producing good crops of vegetables and beautiful flowers. Good quality crop is an important ingredient for price it fetches as the market and hence high profit to the farmers (see derivation in section 2.2.2 above). Using a potash fertilizer helps to increase the use of other nutrients in the plant and promotes root growth. It also helps to cope with drought situations and increases the plant's ability to survive in frosty conditions. This is an important attribute especially in recent years where vagaries of weather caused by climate change have increased in Tanzania (See Figure 6). In agriculture potash fertilizers among other things, help grains and fruits to increase the protein oil and vitamin C in their harvest, and gives food a better color and flavor. It retains its nutritional value for longer period when packed for storage or travelling purposes thus increased shelf life.

(a) Maize crop failure due to drought

(b) Paddy crop seriously attacked by white flies

Figure 6 (a&b): Cost for not using Potash fertilizer on major staple in Tanzania

For a gardener potash is an important ingredient for fighting disease and resisting pests, making plants grow faster and healthier, making plants will produce better flowers, and vegetables. In monetary value, these benefits associated with potash add revenue to the producers through increased price of the produce or decreased cost of inputs such as pesticides.

4.4 Cost implication of limited use of Potash on cost due poor response of other fertilizers on crop yield

Cost implication for limited use of Potash fertilizer in Tanzania is huge. As mentioned above, the value of Potash fertilizer on increasing the efficiency of other fertilizers (Nitrogenous & Phosphate) as elaborated in the law of minimum is cost to the producers. First major const is that of using fertilizer without realizing the required level of output. Based on the law of minimum, even when you apply optimal level N and P without K, farmers can realize only 50% of the expected yield. This situation suggests that we in Tanzania incur costs for realized low levels of outputs. For example in 2011/2 reason, the government of Tanzania used 81.2 Tsh to 1,658,888 households as subsidies vouchers for purchasing Phosphorus and Nitrogenous fertilizers (Table 3). The subsequent impact on yield based on the Law of minimum is low (50%) because Potash fertilizer is not used.

Table 3: Number of vouchers distributed to regions in 2011/12 crop season

Regions	Number of households	Phosphorus Fertilizer		Nitrogenous fertilizer		Total Cost (Tsh '000)
		No of Voucher	Total Cost/ Value (Tsh '000)	No of Voucher	Total Cost/ Value (Tsh '000)	
Iringa	231,000	231,000	6,468,000.0	231,000	4,273,500.0	10,741,500.0
Mbeya	300,000	300,000	8,400,000.0	300,000	6,000,000.0	14,400,000.0
Ruvuma	192,469	192,469	5,389,132.0	192,469	3,849,380.0	9,238,512.0
Rukwa	146,000	146,000	4,380,000.0	146,000	3,212,000.0	7,592,000.0
Morogoro	177,541	177,541	4,971,148.0	177,541	3,284,508.5	8,255,656.5
Kigoma	160,000	160,000	4,800,000.0	160,000	3,520,000.0	8,320,000.0
Dodoma	24,776	24,776	693,728.0	24,776	458,356.0	1,152,084.0
Lindi	21,197	21,197	593,516.0	21,197	392,144.5	985,660.5
Tanga	47,292	47,292	1,324,176.0	47,292	874,902.0	2,199,078.0
Tabora	60,138	60,138	1,804,140.0	60,138	1,323,036.0	3,127,176.0
Shinyanga	53,192	53,192	1,595,760.0	53,192	1,170,224.0	2,765,984.0
Mwanza	54,201	54,201	1,626,030.0	54,201	1,192,422.0	2,818,452.0
Kagera	53,192	53,192	1,595,760.0	53,192	1,170,224.0	2,765,984.0
Mara	63,596	63,596	1,907,880.0	63,596	1,399,112.0	3,306,992.0
Kilimanjaro	74,289	74,289	2,080,092.0	74,289	1,485,780.0	3,565,872.0
TOTAL	1,658,883	1,658,883	47,629,362.0	1,658,883	33,605,589.0	81,234,951.0

Source: World Bank (2014)

Another indirect cost related to not using Potash fertilizer in production in Tanzania the fact that our crops become very prone to diseases, pests and succumbing to drought. For example, in the Table 3 above, Tshs 81.2 billion used as subsidies for nitrogenous and phosphate fertilizers. However since Potash fertilizer was not used it is very likely that farmers who were recipients of input vouchers incurred extra costs for inputs for buying pesticides and fungicides cause by increased incidences of pests and diseases for not using potash fertilizer. Other cost associated with crop failure due to droughts is related to decline in yield which has direct impact on revenue from crops. Putting in a better way, a functional relationship which exists between cost and yield (revenue) is not linear mainly because of limited use of potash fertilizer.

As mentioned earlier, the role of Potash fertilizer on improving the quality of the produce which has direct impact on price, then revenue and hence profit is affected. Linking to the huge cost in Table 3 above, definitely there are several other costs which farmers incur for not using potash fertilizer.

5. Conclusion and Recommendations

The main objective of this paper is to explain how the limited use of potash fertilizer has huge limitation of efficient use of other fertilizer. The fact is very small amount of Potash fertilizer is used for staple crop production in Tanzania. Potash fertilizer is common in tea and tobacco production. Based on the law of minimum, it is evident that even with optimal use of both Nitrogenous and Phosphorus fertilizers, yield potential cannot surpass 50%. Hence the country is incurring double cost, first is that of applying fertilizers (Nitrogen & Phosphorus) which is not translated to optimal yield. Secondly the cost of crop protection due to declining ability of the plants to tolerate vagaries of nature associated to limited use of Potash fertilizer. The importance Potash fertilizer in increasing the quality of the produce which is associated with high price, increased revenue and hence profit to farmers. Unfortunately very few farmers and policy makers know the value of Potash fertilizer in crop production and the associated Law of minimum.

This paper conclude that in a situation of increased cost of production, declining productivity and climate change which has increased incidences of crop failure due to drought, build up pest and disease incidences, use of potash fertilizers is imperative. The government through local authorities should promote use of Potash fertilizer hand in hand with nitrogenous and phosphorus fertilizers. Directives for the purposeful fertilizer blending to include potash fertilizer should be taken communicated to fertilizer companies throughout the country.

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