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Zambia: The Benefits of Conservation Agriculture and Integrated Soil Fertility Management

The most basic human rights are food, shelter, education and health (Nyirenda, 2004). Hunger is not an issue people generally think about when they have enough food to consume. What most people do not realize is that the luxury of retrieving food from a refrigerator and eating whenever and whatever they want is simply not an option for many. In order to eat, some individuals are required to grow, process, and cook the food themselves. Even then, their diet is limited to only what they can grow in their particular region of the world. In the event they are unable to grow enough food, there can be severe repercussions. Lack of food for an extended time period leads to malnutrition. World Food Programme (WFP, 2016) estimates there are 795 million undernourished people in the world, meaning one in nine people do not get enough food. This makes malnutrition the number one risk to health worldwide. According to WFP (2016), "the vast majority of the world's hungry people live in developing countries, where 12.9% of the population is undernourished". Malnutrition causes 45% of deaths in children under five, around 3.1 million children each year (WFP, 2016). Malnutrition affects socioeconomic factors as well. Quantifying the health impact of malnutrition, Blössner & de Onis (2005) state, "malnutrition can create and perpetuate poverty, which triggers a cycle that hampers economic and social development, and contributes to unsustainable resource use and environmental degradation". Sub-Saharan Africa has the highest population percentage of malnutrition where one in four persons is undernourished (WFP, 2016). In a compilation of facts, UNICEF notes, "Zambia is one of 22 African countries with the highest burden of under nutrition in children under five". According to (WFP, 2015) more than 350,000 people in the country are food insecure, meaning they do not have access to a regular supply of healthy food.

An average household size in Zambia is 5.1 persons (CSO, 2014). Green vegetables and cornmeal (nshima) are typical meals in low-income families of Zambia. These may be complemented with fish (kapenta), chicken offal, or goat meat once a week. According to Rural Poverty Portal (2015), the calculated GNI per capita of Zambia in 2010 using the Atlas Method was $1,760. Only 42% of Zambian households can afford three meals a day. Most families live by two meals a day: breakfast and supper. As family members are away from home during the day, lunch is normally skipped. About half the households (50.7%) can afford two meals a day, while 5.2% of households suffice with one meal a day. Generally, three meals a day are expected to suffice the minimum dietary requirements of an individual. Reduction in food intake may lead to deficiency of nutrients required to sustain health and normal growth like vitamins, minerals, proteins and carbohydrates. Especially growth of children less than five years of age is adversely affected due to inadequacies resulting from reduced intake of nutrients (Chibuye, 2011). According to Zambia Demographic and Health Survey (CSO, 2013-14) "40% of children under age 5 are stunted, 6% are wasted, and 15% are underweight". Nyirenda (2004) reports that over 70% of the population in Zambia is poor and 58% are classified as extremely poor.

Along with malnutrition, there is a high prevalence of HIV/Aids, malaria, and tuberculosis. Healthcare in Zambia is provided in a 4-tier pyramid structure. Health centers and posts provide community-level care, Level 1 hospitals provide district level care, Level 2 hospitals provide provincial level care, and Level 3 hospitals provide specialist level care. Unfortunately, due to a lack of ambulances and an underdeveloped communication system, referrals between hospitals and different levels of care are typically poor. Little or no management of patient treatment or cost reduction strategies has encouraged patients in lower levels to seek treatment for minor complaints at higher levels. This results in longer wait times for more critically ill patients as time and resources are directed to patients that are self-referred to higher level hospitals. Healthcare access disparity is a huge problem due to a shortage of clinical personnel nationwide, rural areas are affected the hardest, leaving many hospitals to be run by unqualified persons with skills lacking

to provide quality healthcare. Transportation issues such as poor road networks and limited vehicles also perpetuate healthcare discrepancies between individuals since hospitals are not always within walking distance. According to the Association of Certified Chartered Accountants (ACCA) (2013), more than half the population in rural Zambia must travel more than 50 km to reach healthcare facility. The problem is further aggravated by other factors like poor water sanitation and lack of education. ACCA (2013) estimates 80% of preventable diseases is due to improper or absence of sanitation; about a quarter Zambian homes lack basic toilet facilities.

Quality of education in Zambia is inadequate. The adoption of United Nations Education for All (EFA) initiative by the Zambian government has not been very efficient. Limited resources, poor curriculum, lack of qualified teachers, and overcrowded classrooms have all contributed to the issue. When school is seen as having little value to the students, motivation to send children to school reduces as well (Norad, 2015).

Aside from major discrepancies in health and education between men and women in Zambia, prevailing land heritage systems also discriminate against women. Men migrate to urban areas in search of employment while women take up the responsibility for food production and other income-generating activities including farming and domestic tasks (RRP, 2015).

The contribution of Zambia's agriculture sector in poverty reduction and overall economic growth is minimal. In 2000, Zambian GDP grew by 3.5%, agriculture sector grew by 1.8%, and population grew at 2.9% per year. In essence, performance of the agriculture sector is far inferior and unable to cope up with increasing population. Some of the factors affecting this performance are inaccessibility to resources, services, and markets due to geographic isolation; lack of productive assets like farming animals and mechanized farming equipment; and lack of labor due to HIV/AIDS (RRP, 2015). Rapid population increase has also led to deforestation for fuel, wood, charcoal, building poles and timber or to make room for agriculture. Aregheore (2015) estimates deforestation rate of about 200,000 ha per year; together with overgrazing, soil degradation has been severe. Longer periods of mono-cropping and inappropriate use of inorganic fertilizers aggravate the situation further (Shitumbanuma et al.).

One of Zambia's staple crops is maize aside from beans, soya, sorghum, and sunflower. USAID (2011) observes that the farming practices in Zambia are inefficient and environmentally destructive as a result of its compulsion with maize. Abandonment of crop husbandry practices that sustain land has resulted in losses to farming families from profits in prior decades. This is a negative result of government subsidies on fertilizers and guaranteed pricing to encourage maize production (Mothabi & Weitz, 2014). With subsidies accounting for 13% of national budget and price fixation at 30% of product cost, maize production increased by 60%. Consequently, 70% of agricultural land in Zambia produced maize (USAID, 2011).

In 1989, elections and liberalization of economy ensured a drop in fertilizer subsidies and price controls of maize, which reduced maize production by 50% and forced commodity diversification. Unfortunately, this was short lived. The Government of Zambia reintroduced subsidies via the Fertilizer Support Program (FSP) (USAID, 2011).

The Fertilizer Support Programme (FSP) was later revised to the Farmer Input Support Programme (FISP) to facilitate smallholder farmers. The Food Reserve Agency (FRA) originally established (in 1995) to purchase maize directly from the farmers now operates like an agricultural marketing board (ARI, 2013). Subsidies are now delivered to farmers through the FRA and FISP for agricultural development and poverty reduction strategies in Zambia (Mason, Jayne, & Mofya-Mukuka, 2013). While these programs present an opportunity for all, small-scale farmers face some obstacles such as market accessibility and lack of storage capacity. According to the Ministry of Agriculture and Livestock, in

2013 alone, one-third of post-harvest crop was lost due to inadequate storage (ARI, 2013). More importantly, programs as these that ensure predictable income drive farmers to rely on production of targeted crops, for instance, maize in this case. The market for agricultural exports is limited. This is in part due to unpredictable government policies that have deterred the private sector from trading in maize (ARI, 2013).

Mono-cropping maize using subsidized fertilizers may increase yield in the short-term, but will deteriorate soil quality over time and reduce habitat for insects and wildlife, thereby increasing the need for pesticides. Continuous cropping and conventional tilling on these farms increases erosion and reduces organic matter. (Killebrew & Wolf, 2010). Excess production of one staple crop also negatively impacts the nutrition intake of a large population (Mothabi & Weitz, 2014). Multi-nutrient deficiencies (vitamin A, iron, zinc, iodine, etc.) are very common in these individuals. Malnutrition is rampant among thousands of women and children in various forms - low birth weight, wasting, stunting, and underweight (UNICEF). The implementation of sustainable agriculture methods will not only enable increased crop yield, but the diversification of crops will in turn increase nutrient yield thus helping to reduce malnutrition in the country.

Zambia, a food insecure nation, is vulnerable to major natural hazards like floods and drought. Floods cause annual displacement of thousands of households while drought directly affects half a million of the population (Groen & Jacobs, 2012). The drought of 1991-92 exposed the vulnerabilities of much of the rural population. Much of the rural population faced economic devastation and chronic hunger (RRP, 2015). The food deficit from the drought of 2001-02 threatened over 2.3 million rural agriculture dependent households forcing the government of Zambia to appeal to the international community and NGOs requesting for food aid (Nyirenda, 2004). Placing too large a focus on maize is causing issues with the overall food security. In Zambia, other factors are also contributing to the increase in the rates of malnutrition. Non utilization of sustainable agricultural practices is leading to declining soil quality due to erosion, degradation, and improper use of fertilizers. Additionally, erratic rainfall due to climate change has also contributed to the shortages of food while an increased population growth rate exacerbates the problems further (Aregheore, 2015). The solution to these problems include strategies such as crop diversification and increasing sustainable agricultural practices. One way to establish sustainable methods is to use Conservation Agriculture coupled with Integrated Soil Fertility Management (ISFM).

According to Food and Agriculture Organization, "Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment". Characteristics of CA are minimum soil disturbance and optimal use of agrochemicals, permanent organic soil cover to protect the soil and improve growing environment, and diversification of crop species grown in sequences and/or associations (FAO, 2015). Agro-ecological sustainability of soil dictates that soil erosion be minimized as this reduces fertility of soil. Besides non-sustainable land use, reduction of soil fertility is both the cause and the result of poverty.

Cropping practices that extensively disturb soil lay it bare to erosion and nutrient depletion must be minimized to protect this important non-renewable resource and ecosystems adjacent to it (USAID, 2011). According to Shitumbanuma et al., ISFM is "a set of soil fertility management practices that include the use of fertilizers, organic inputs and improved germplasm, combined with the knowledge on how to adapt these practices to local conditions aiming at optimizing agronomic use efficiency of the applied nutrients and improving crop productivity". ISFM principles used in conjunction with Conservation Agriculture in Zambia could lessen the damage done to the soil and create a sustainable agricultural practice.

There are three main agro-ecological zones in Zambia distinct in soil composition that affect crop yield. Figure 1 (JAICAF, 2008, p. 6) illustrates the various agro-ecological regions in Zambia.

Figure 1: Agro-Ecological Regions of Zambia (JAICAF, 2008, p. 6)

Table 1 (Shitumbanuma et al.) below lists soil types and crop production limitations in each of the three agro-ecological regions in Zambia.

	General Description of Soils	Limitations to Crop Production
Region I	Loamy and clay with coarse to fine tops	Slightly acidic to alkaline. Minor fertility limitations
	Reddish coarse sandy soils	Low pH, available water & nutrient capacity reserve
	Poorly drained sandy soils	Severe wetness, acidic & low fertility
	Shallow & gravel soils in rolling to hilly areas including escarpment zones	Limited depth & unsuitable for cultivation
Region II	Moderately leached clayey to loamy soils	Low nutrient reserves & water holding capacity
	Slightly leached clayey soils	Slight to moderate acidity. Difficult to work due to heavy textured soils.
	Coarse sandy loams in large valleys	Imperfectly to poorly drained. Limitations due to wetness
	Sandy soils from Kalahari sand	Medium to strong acidity, coarse textured top soil, low water holding capacity and nutrient reserves
Region III	Red to brown clayey loamy soils	Very strong acidity and strongly leached
	Shallow and gravel soils in	Limited depth

	rolling hilly areas	
	Clayey soils, red in color	Moderately to strongly leached. Fewer limitations
	Poorly to very poorly drained flood plain soils	Variable texture and acidity
	Coarse sandy soils in pan on Kalahari sand	Very strong acidity

Table 1: Soils in Agro-ecological Zones and their Limitations to Crop Production (Shitumbanuma et al.)

In agro-ecological regions 1 and 2, alkaline soil conditions cause some plant nutrients to turn into insoluble compounds and become chemically unavailable to plants, creating unfavorable conditions for crop production (Shitumbanuma et al.). To combat this problem, nitrogenous fertilizers may be used to increase the acidity in soil. The acid produced by the nitrification process lessens or neutralizes the alkalinity of the soil. Ammonium nitrate is one example of a fertilizer that acidifies soil during nitration and can be used to neutralize and control soil alkalinity (Pennisi & Thomas, 2015).

Soil acidity is another problem limiting soil productivity, which is most common in agro-ecological region 3, but can be found in other regions as well. Shitumbanuma et al. estimate that a third of Zambian agricultural soil is acidic (pH ranging from 4 to 6.9). Soil acidity is a problem especially in areas with heavy rainfall and is generally worsened by prolonged use of nitrogenous fertilizer, decomposition of organic matter, and crops stripping nutrients from the soil. To combat soil acidity, agricultural lime, crushed fine-particle limestone should be introduced to the soil (Beegle & Lingenfelter, 1995). In doing so, acidic land can become suitable for farming and support crop production. However, application rate and lime type should vary based on soil types and solutions for optimum results.

Another method to promote soil health for sustainable agriculture includes using biochar, "charred organic material produced by incomplete burning of organic residues in an environment with limited supply of oxygen" (Shitumbanuma et al.). Biochar has a relatively high capacity for nutrient retention which helps prevent leaching. Carbon, required for healthy and stable soil, is also plentiful in Biochar, which aids in the overall soil fertility and crop yield potential (Shitumbanuma et al.).

Other methods to promote sustainable agriculture using the principles of Conservation Agriculture and ISFM include crop rotation to recapture leached soil nutrients, addressing the downsides of both chemical and organic fertilizers by using the two together strategically, and intercropping crops to break disease cycles, control weeds, and reduce soil runoff. Completely decompose organic fertilizers such as animal waste and compost prior to application to prevent acidification of soil. Retaining crop residue in fields and using green manures and crop covers alongside minimum tilling will help reduce nutrient and carbon loss through leaching, decomposition, and erosion (Shitumbanuma et al.).

Agro-ecological sustainability of soil dictates that soil erosion be minimized as this reduces the fertility of soil. Besides non-sustainable land use, reduction of soil fertility can reduce agricultural sustainability and crop yield. ISFM principles used in conjunction with Conservation Agriculture will lessen the damage done to the soil and help create a sustainable agricultural practice in all agro-ecological regions in Zambia.

Currently, the Government of Zambia is receiving foreign support to fight poverty and hunger from international organizations like the United States Agency for International Development (USAID) and the World Food Programme (WFP). WFP aims to support the Zambian government with achieving food security. Its commitments include providing nutritious meals daily to a million primary school children sourced from local produce in 2016, connecting smallholder farmers to markets to increase incomes and food security, and promoting improved nutrition and better resilience to climatic shocks across the country (WFP, 2016).

The USAID's "Feed the Future strategy aims to diversify staple food production and consumption to improve food security and rural incomes while reducing under-nutrition in children". Support via USAID includes assistance with increased production of high-value crops, promotion of conservation agriculture, improved access to agricultural inputs (fertilizer, equipment, training, etc.), technology, improving land use, irrigation, and research and development for more productive, resilient crops. Additionally, support improving household nutrition practices and health of rural families, along with increasing their incomes (USAID, 2016).

The United States should work with the Zambian government to encourage more diverse markets. One way to do this would be to encourage increased and full usage of The African Growth and Opportunity Act (AGOA). AGAO is a United States Trade Act enacted by the 200th Congress in May 2000 and later renewed (2015) until 2025. This Act grants US market access to qualifying Sub-Saharan African (SSA) countries (AGOA, 2016). Unfortunately, since the enactment of AGAO, Zambian businesses had failed to develop a practical and sustainable strategy to access American market until its expiry in 2015. Renewal of AGOA 2015 vitalized several African countries including Zambia, which has indulged in non-traditional exports to America markets (AGOA, 2016). The United States should also encourage the Zambian government programs like FRA to move away from an agricultural marketing board mandate and instead allow all scale farmers to benefit to the highest extent from the trade deal.

Work should also be done with the Department Of Agriculture (DoA) in Zambia to educate small scale and large scale farmers to use Conservation Agricultural practices in conjunction with Integrated Soil Fertility Management to increase crop yield, diversity, and sustainability - thereby feeding the population better and reducing the deforestation for farmland. The Department of Agriculture plays an important role in promoting new and improved technology to farmers and coordinating various agricultural activities and services like disseminating technical information and services to the farming community in regards to crop production, nutrition, crop protection and soil fertility, Field Crops Agronomy, etc.(MAL). Work with the DoA in Zambia to educate farmers should specifically be done through The Crops Production Branch, which liaises between farmers at one end and agricultural research and other organizations like institutions and stakeholders on the other end (MAL) and the Agricultural Advisory Branch, which facilitates information to farmers so they may make informed agricultural decisions that result in increased production, productivity and profitability (MAL). In this way, the people and government of Zambia can help themselves, rather than constantly rely on different forms of external aid.

Whilst policy changes and education are taking place, the current aid for malnutrition from international organizations like the United States Agency for International Development (USAID) and the World Food Programme (WFP) should not be stopped. Rather, the end goal should be to be able to remove these programs in their entirety once the population begins to feed itself sufficiently and malnutrition rate drops. Support must be conditional on accomplishment of results to ensure dependency on international aid does not keep Zambia from progressing.

Currently Zambia is producing maize in surplus and has the capacity to become the “bread basket” to world (ARI, 2013). In essence, there is a global interdependency between food producing and consuming nations in promoting optimum levels of food production and is mutually beneficial to everyone. Besides, it is a moral obligation on the part of developed nations to assist developing ones. To this affect, the United States is facilitating the growth and stabilization of Zambia educationally, economically, and politically while maintaining a mutually beneficial trade agreement with Zambia. According to the US Department of State, US export cars, farm equipment, etc, while importing minerals resources like copper. Additionally, political and economical stability of Zambia translates to a more stable Sub-Sahara. When people are able to fulfill basic needs like nutrition they can shift their focus to other things like education, which in-turn will increase the overall quality of life. This is a win-win situation for all. In order to this to work, Zambian citizens and the government must be welcome to change and be willing to maintain the implementation of new policy changes and agricultural practices. US citizens should also

realize the importance of improving the world situation in whichever way possible is imperative because, in today's global economy, the ripple effect of any distressed nation cannot be ignored; isolation is not a viable option.

The top two Sustainable Development Goals, as defined in Transforming Our World - The 2030 Agenda for Sustainable Development, are to end poverty in all its forms everywhere and to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture (SD, 2015). Promoting Conservation Agriculture in conjunction with Integrated Soil Fertility Management will align Zambia with this goal.

In conclusion, Zambia isn't a place where people can eat whatever they want whenever they want, but can be improved to make this a reality. The food insecurity resulting from unsustainable agricultural methods and mono-cropping can be fixed by simply changing the current farming practices. Switching to Conservation Agriculture will not only improve and sustain productivity, but will also ensure profit and food security all while increasing nutrient output, an essential solution to malnutrition. With support from international agencies and civilian organizations the Zambian government can adapt efficient agricultural practices and help feed their growing population.

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