



Forum Paper

Human Population Growth, African Pastoralism, and Rangelands: A Perspective[☆]



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ABSTRACT

Pastoral livestock production systems in Africa that have existed for centuries are now threatened by changing demographics, improved communications, increased availability of modern weapons, open rangeland shrinkage, global warming, and large-scale migration of people from rural areas to rapidly expanding cities. Human population increase coupled with globalization has led to major conflicts over natural resources in several African countries. If current growth rates persist, the population of Africa will double in 33 yr. Land resources available for farming are now fully used in several African countries. There is growing concern about the capability of these countries to feed their future projected populations. Africa's three most populous countries (Nigeria, Ethiopia, and Egypt) are all net food importers. Demand for meat and milk in Africa is projected to double by 2050. Roughly one-half of Africa can be classified as rangeland. Some form of pastoral grazing is the most efficient way to use most of these lands and sustain traditional cultures. Because most African rangelands are now stocked at or above grazing capacity, there is little potential to increase livestock production by increasing animal numbers. However, because offtake levels across Africa are much lower than in other parts of the world, considerable potential exists to increase meat and milk production. Local development projects oriented toward keeping people on the land and self-sufficiency have considerable potential to improve living and environmental conditions for small farmers and pastoralists. Improved and equal education opportunities for both genders, family planning assistance, renewable energy development, empowerment of women, improvement of soil and water resources, and wildlife conservation should be areas of development focus. Maintaining migration corridors, providing legal rights to historic grazing lands, and providing support services along migration corridors such as watering points, markets, schools, and health care are important strategies to sustain pastoralism.

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Introduction

Over the past 30 yr we have worked on rangeland development projects, participated in rangeland tours, provided humanitarian aid, trained students, and contributed expertise in several African and Middle Eastern countries (Turkey, Ethiopia, Sudan, Kenya, Egypt, Morocco, Mali, Jordan, Uzbekistan, Israel). It is our observation that the news media in general focuses heavily on the social instability, human suffering, loss of life, and human rights abuses that are now occurring from conflicts in countries such as Iraq, Libya, Sudan, South Sudan, and Syria, but there is little analysis of the underlying causes.

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It is our experience that many of these conflicts are based around disputes regarding control and use of rangelands brought on by changing demographics and communications. Pastoralism is typically an important component of these disputes, although seldom mentioned. Open rangeland shrinkage, climate change, improved communications, and increased availability of modern weapons are important factors now threatening pastoral systems that have existed for centuries (ARGRA, 2014; Brown, 2008, 2011; Pica-Ciamarra et al., 2007; Reid et al., 2014). So far, the general approach to solving these problems at the United Nations level has been to negotiate agreements among conflicting ethnic groups, encourage change toward more democratic governments, and partition countries as in the case of Sudan and South Sudan. However, we doubt these approaches can be successful unless they are coupled with programs that ameliorate underlying demographic and natural resource problems. Our objectives in this viewpoint article are to identify and examine factors causing rangeland conflicts, discuss possible interventions to improve both human living conditions and rangelands, and identify other significant papers that deal with the future of pastoralism.

Our primary focus is on the sub-Saharan countries of Northern Africa, although examples from other areas are included. The issue of whether pastoralism can be sustained in Africa is a key question we also address.

Human Population Growth

World human population is now estimated at nearly 7.4 billion compared with 2 billion in 1922 (United Nations, 2015; US Census Bureau, 2002). Since 1950 the world human population has increased about 180% compared with a near quintupling in Africa, slightly more than doubling in the United States, tripling in China, and increasing by 10% in Europe. The world annual growth rate has dropped from the peak of 2.3% in 1963 to 1.4% in 2000 and 1.1% presently (United Nations, 2015). Actual number of people added to the world population peaked in 1990 at 87 million and has since dropped to about 75 million per year. The world human population is projected to reach 9–10 billion in 2050 and could peak at around 12 billion before stabilizing sometime in the 2070–2100 period (Brown, 2008, 2011; United Nations, 2015). Whether 12 billion people can be supported on our finite planet is not certain and will depend on adequacy of energy, water, and food along with environmental quality. By some estimates the world's human populations may now be using 30–50% more basic resources than the world can sustainably supply (Wackernagel, 2012; Wackernagel and Rees, 1996; Wackernagel et al., 2002). In addition, the threat of global warming is of growing concern.

The decline in the growth rate of human population first came from developed countries in the mid-1960s when birth control pills became available and later spread to Asian and South American countries (United Nations, 2002, 2015). The population growth rate is now near 0.8% in the United States, 0.2% in the European Union, 0.5% in China, and –0.2% in Japan (United Nations, 2015) (Table 1). Most Asian and South American countries have declining population growth rates currently between 1.0% and 1.4%. Population growth rates remain high across Africa and Middle Eastern countries with the average near 2.2% per year. This equates to a doubling time of 33 yr when the rule of 72 is applied (percent growth divided by 72 gives doubling time). If unchecked at the present growth rate, the population of Africa and the Middle East will double by 2050, quadruple by 2080, and be about seven times higher in 2100. There are indicators relating to food production, freshwater availability, climate change, soil degradation, loss of farmland, species endangerment, depletion of energy reserves, and pollution that human populations in several African and Middle Eastern countries are now at or in excess of carrying capacity (Brown, 2011, 2012; Cribb, 2010). Food shortages, economic decline, civil unrest, and flight of large numbers of refugees are becoming more frequent occurrences in these countries typically referred to as failed or fragile states (Brown, 2008, 2011; Fund for Peace, 2016).

Demographic Trap

The term “demographic trap” has been used to describe the situation of chronic high population growth (1.5% or more per year) in countries with high birth rates but lowered death rates that deplete their resources and degrade their environment to the point where social instability and food shortages lead to a “failed or fragile state” (Cohen, 1995; Brown, 2008, 2011, 2012; Fund for Peace, 2016). Syria, Somalia, Pakistan, Libya, Sudan, South Sudan, and Yemen are examples of countries classified as failed or fragile states (Fund for Peace, 2016).

Since World War II, a drastic lowering of human death rates has occurred throughout the world due to vaccination for deadly diseases, lowered infant mortality, improved diet, and improved health care (Cohen, 1995; United Nations, 2002, 2015; The Economist, 2015). Of these factors, vaccination and near elimination of deadly diseases are considered to be the most important factors in human population growth. Initially after the transition from deadly disease eradication, populations rapidly increased due to constant and sometimes increased

Table 1

Numbers, growth, and density of the human population in various parts of the world in 2015

Location	Population (millions)	Percent net growth per yr	Doubling time (yr)	Density (people/km ²)
World	7 349	1.07	67	14
European Union	507	0.40	180	116
United States	323	0.77	94	35
China	1 375	0.44	164	145
India	1 284	1.25	58	436
Brazil	206	0.80	90	25
Argentina	44	0.95	76	16
Mexico	122	1.21	60	65
Australia	24	1.09	66	3
Canada	36	0.76	95	4
Russia	147	(–0.03)	–	9
Germany	82	(–0.18)	–	233
Select Mid-Eastern countries				
Saudi Arabia	32	1.49	48	14
Turkey	79	1.12	64	99
Syria	24	1.97 (–9.73)	37	121
Iraq	37	2.23	32	80
Iran	79	1.22	59	48
Afghanistan	27	2.29	31	48
Pakistan	193	1.49	42	240
Africa	1 145	2.20	33	36
Select African countries				
Morocco	33	1.02	71	76
Egypt	90	1.84	39	90
Mali	18	3.00	24	14
Niger	21	3.28	22	15
Sudan	40	1.78	40	22
Ethiopia	92	2.89	25	97
Nigeria	187	2.47	29	195
Kenya	47	2.11	34	79
Tanzania	55	2.80	26	59
Botswana	2	1.26	57	4
South Africa	55	(–0.48)	–	45

Data from Central Intelligence Agency, 2015. CIA World Factbook. Washington, DC, USA: CIA. 3360 p. and United Nations, 2015. New York, NY, USA.

birth rates (Cohen, 1995; Jacobsen, 1983; The Economist, 2015). However, in nearly all developed countries a fertility transition has eventually occurred in which birth and death rates became more balanced. This transition has been most pronounced in Europe, Japan, and Russia, where populations are near stability. Some important factors causing declining birth rates are industrialization, increased education, equal rights and education for women, and improved methods of birth control (Brown, 2008, 2011; Butler and Kanyoro 2015; Holechek et al., 2003; Jacobsen, 1983; Rieff, 2015). Political, social, and economic factors are all important in the transition toward a stable population. We refer the reader to Cohen (1995), Jacobsen (1983), Holechek et al. (2003), Cribb (2010), Brown (2008, 2011, 2012), Holechek (2013), and the Economist (2015) for detailed discussions on why lowering population growth rates and eventual population stabilization are critical in improving human living conditions and environmental sustainability.

Some of the most rapid human population growth rates are occurring in Middle Eastern Islamic countries that also have high oil reserves (Brown, 2008, 2011; United Nations, 2015). These countries are increasingly using their oil to support their growing populations, which is accentuating the decline of their oil reserves (Rubin, 2012). Syria is an example of a country that depleted its oil reserves in the 2005–2010 period, causing its government to suffer a drastic reduction in oil export income (Mushalik, 2015). The Syrian human population has increased almost fivefold since 1950 (United Nations, 2002). Before the civil war, which began in 2011, annual population growth in Syria was nearly 3% per year (United Nations, 2015). The combination of rapid population growth, oil depletion, drought, rising food prices, ethnic frictions, and authoritarian government explains the social

unrest leading to the present civil war in Syria (Klare, 2015; Lindberg, 2015; Mushalik, 2015; Perry, 2016).

Africa Drives Population Growth

How quickly the African human population grows will have major implications for the whole world (The Economist, 2015; United Nations, 2015). African population growth is not slowing as rapidly as demographers expected 12 years ago (Brown, 2011; Rieff, 2015; The Economist, 2015; United Nations, 2015). In 2004 the population of Africa was at a little over 900 million, and it is expected to grow to about 2.3 billion in 2100 (The Economist, 2015; United Nations, 2015). The United Nations (2015) now estimates that Africa may have 4.4 billion people by 2100. Almost all the newly added people in the world between now and 2100 are estimated to be in Africa. Under this new United Nations scenario, Africa would be home to 39% of the world's 11.2 billion people in 2100 (The Economist, 2015). Pastoral populations are growing in Kenya and Ethiopia, especially as nomadism is replaced by seminomadism first and sedentarism later, with rising birth rates and falling death rates at each stage (Oxfam International, 2010).

Nigeria, Ethiopia, and Egypt are Africa's three most populated countries with 178, 90, and 84 million people, respectively (see Table 1). Doubling times for these countries are all < 40 yr (see Table 1). In the 2016 ranking of failed or fragile states, Nigeria is listed at 13, Ethiopia at 24, and Egypt at 38 (Fund for Peace, 2016). Human populations in all three countries have more than doubled since 1980 (United Nations, 2015). Nigeria, Ethiopia, and Egypt are all net food importers and confront serious problems related to feeding their present populations (Brown, 2012; Malo, 2015; Rieff, 2015). In 2016 > 10 million people (> 10% of the population) in Ethiopia are expected to suffer starvation due to drought (Malo, 2015). Conflicts over farmland and rangeland ownership and use are occurring and intensifying in all three countries (Brown, 2012; Flores, 2013). Policies of leasing or selling millions of acres of rangelands and farmlands held by indigenous peoples to foreign investors have become contentious throughout Africa (Brown, 2011, 2012; GRAIN Staff, 2016). Since 2014 these conflicts and associated human rights violations have escalated in Ethiopia and several other countries (Brown, 2011, 2012; Flores, 2013; GRAIN Staff, 2016). Construction of the Grand Ethiopian Renaissance Dam on the Blue Nile River by Ethiopia for electricity is another major controversy (Fortin, 2014; Rohan, 2016). When completed in 2017 this will be the largest dam in Africa. Ethiopia believes it will allow a large number of its citizens to enter the middle class by access to electricity. It will boost government revenues through sale of electricity to other countries. Sudan is supportive of the dam because of more stable Blue Nile flows and increased access to electricity. However, Egypt is deeply fearful of possible reduced Nile River flow. Egypt has almost complete dependency on irrigation from the Nile River to feed its relentlessly expanding human population. The reader wanting more detailed information on land and water grabs in Africa is referred to Brown (2011, 2012) and GRAIN Staff (2016).

Refugee Crisis

The massive migration of roughly 1.1 million asylum-seeking people from the Middle East and North Africa to Europe in 2015 captured international news headlines. This is more than a doubling of the numbers in 2014 and a tripling of 2013 numbers (BBC News, 2016). In 2015 about 78% of these asylum seekers were from Syria (49%), Afghanistan (21%), and Iraq (8%). Although initially several European countries (Germany, Austria, Netherlands, Belgium, Sweden) welcomed these refugees, public sentiment has turned less positive (Urban, 2016). There is growing worry that the sheer numbers are overwhelming monetary and physical support systems. Several Eastern European countries are refusing to accept refugees. Barriers to migrant travel have been erected across Europe. Various other tactics are being developed to limit migrant flows into Europe. We believe the annual number of

refugees seeking asylum in Europe could easily reach 4–6 million people within 10 yr if living conditions continue to deteriorate across the northern half of Africa.

Overview of African Pastoralism

The breakdown of traditional pastoral and subsistence agricultural systems is an important civil unrest factor in Africa (Pica-Ciamarra et al., 2007; Elias and Abdi, 2010; Smith 2014). Across Africa 70–75% of the people depend on rain-fed agriculture and pastoralism for their livelihoods (AGRA, 2014). The human populations in some African countries may have exceeded the capability of the various resources needed to support them (Brown, 2008, 2011; Cribb, 2010; Pica-Ciamarra et al., 2007; Rieff, 2015). Improved communications, increased access to firearms, freshwater depletion, and global warming are further accentuating the turmoil involving land use in several African countries.

These cultures, depending on ethnic group, derive 30–90% of their livelihood from livestock grazing on arid and semiarid rangelands from which they typically have uncertain or no formal legal claim (Pica-Ciamarra et al., 2007; Rass, 2012). They are much more dependent on rangelands than societies in most other parts of the world because of their cultural values and the lack of industrialization across most of Africa (Supplementary Materials, Figure 1). A recent study found that as many as 367 million people live in the Sahel region of northern Africa and most of these people are pastoralists (Abdi et al., 2014). This report projects that the human population in the Sahel will reach 1 billion by 2050.

While their populations are rapidly increasing, the pastoralists across Africa at the same time are experiencing large-scale loss of rangeland access due to expansion of farming operations, private ranches, wildlife reserves, energy developments, mining operations, and urbanization (AGRA, 2014; Ayuntunde et al., 2014; Elias and Abdi, 2010; Reid et al., 2014; Turner and Hiernaux, 2008). Several reports mention loss of rangeland to agricultural encroachment as the single biggest threat to pastoralism (Cibils et al., 2015; Elias and Abdi, 2010; Pica-Ciamarra et al., 2007; Reid et al., 2014; Turner, 2009; Turner and Hiernaux, 2008). This phenomenon has been particularly severe in the Massai pastoral community areas of Narok and Kajiado in Kenya, where rangelands have been either converted to croplands to grow wheat and vegetables or transformed into game or wildlife conservancies such that grazing areas for livestock have been significantly reduced (Campbell et al., 2005; Homewood et al., 2001; Reid et al., 2004; Tsegaye et al., 2010). Commoditization, which involves the shifting from subsistence to commercial food production, is causing a trend for pastoralists to become more sedentary (Fratkin, 1999; Reid et al., 2014). In areas where commoditization is occurring, the more powerful/politically influential pastoralists often become owners of private ranches while others who are less fortunate must find local work, often as herders for the new wealthy livestock owners, or migrate to cities for employment (Turner, 2009; Turner and Hiernaux, 2008). Pastoralists generally have difficulty in adjusting to alternative employment (Bee et al., 2002). Wages paid to African factory workers are only about one-quarter of those received by Chinese workers doing comparable jobs (Foltyn, 2014; Gara, 2014). This makes it difficult for displaced pastoralists to obtain an adequate livelihood. Because of low wages, long hours, and monotonous work in factories, farms, and mines, former pastoralists commonly experience severe trauma when forced into alternative employment. These social and cultural pressures are an important part of the conflicts in countries such as Sudan, South Sudan, Ethiopia, Mali, Nigeria, Somalia, and Rwanda (Brown, 2008, 2011, 2012; Elias and Abdi, 2010; Flores 2014; Pica-Ciamarra et al., 2007). For example, in the delta area of the Niger River in Mali, it is typically difficult to develop more rational land-use planning. This is due to the structure of the organization, which established the traditional rights of usage and also created consistent mechanisms to keep them unchanged.

Consequently, conflicts emerge between ethnic groups that have different interests (ILCA, 1983). Crop encroachment on pasture land is considered by pure pastoralists as a threat to their life, while agro-pastoralists perceive it as a means for improving their livelihood. However, the state government considers this a necessary evolution to increase rice production and to reduce imports of this commodity. While the land-use decisions in the delta of the Niger are quite political; governments need information that will assist them in sound long-term decision making.

Range livestock producers in Africa can be placed in three categories: nomadic, transhumant, and sedentary (Holeček et al., 2011). The nomadic herders have no permanent base but typically have an annual pattern of movement to optimize forage conditions for their livestock throughout the year. Transhumant herders have a permanent base to which they return each year and commonly engage in some farming activity at their base. Sedentary herders are typically farmers who raise some livestock as a side operation. The trend is for the nomadic herders to be increasingly displaced by transhumance and sedentary herders (Brown, 2008; Fratkin, 1999; Flores 2014). Conflicts among these groups are intensifying as the more productive grazing lands are converted to farmland (Brown, 2008; Elias and Abdi, 2010; Flores 2014; Fratkin, 1999; Pica-Ciamarra et al., 2007). Violent conflicts often occur when nomadic herders attempt to use historic grazing lands that are being converted to farms (Herschkowitz, 2005; Pickhardt et al., 2002; Sylla, 2003). The farmers resent the nomads' intrusion into the area that they now claim and the damage that sometimes occurs to their crops from poorly controlled livestock owned by the nomads. These conflicts are intensified by the tendency for the new farmers to acquire livestock to use their crop residues, as well as forage on nearby rangelands (Ayuntunde et al., 2014). In some cases ethnic groups have their own historic grazing lands, but conflicts over boundaries are increasing as pastoralist populations expand but grazing resources remain finite or shrink (Elias and Abdi, 2010). It is our observation that the civil wars in South Sudan and Sudan in which several hundred thousand people have been killed in simplest form involve disputes over energy, mineral, and grazing resources among various pastoral ethnic groups with rapidly expanding populations and easy access to modern weapons. Each ethnic group feels it must maximize its population in order to avoid domination and suppression by other ethnic groups. Land resources are finite and mostly controlled by the state. Typically the ethnic group in power receives preference when disputes occur and land use privileges are more formally assigned. Ethnic groups are pitted against each other because they lack legal, enforceable rights (ownership) to resources they have historically used.

We recognize that social scientists have identified examples of sustainable use of commonly held natural resources (Ostrom, 1990; Ostrom, 2009). However, long-term success examples are lacking for situations involving relentless exponential population growth coupled with finite, commonly held grazing lands without mechanisms to absorb added people. Most pastoral cultures across Africa lack formal education and technical skills that would allow better balancing of their populations with grazing resources and facilitate development of a more diversified economy. Transferring large numbers of African pastoralists and small farmers into workers in mines, energy extraction, infrastructure projects, cash crop production, and industrialized cities as has happened in China and certain other Asian countries over the past 30 years may not now be feasible due to fossil fuel depletion, oversupply of material goods, extreme global debt, and global warming concerns. Working conditions in mines, factories, and large industrialized farms in Africa can be harsh, and the pay is typically low (Dijkstra, 2015). Cultural adjustment has been difficult for many pastoralists (Bee et al., 2002). For these reasons, unemployment is high among former pastoralists and some turn to unlawful activities for their livelihood. Finding a humane alternative for displaced pastoralists is a major challenge with no easy solution. In our experience local development models that incorporate small-scale farming productivity increases,

soil conservation, improved animal husbandry, range management, food self-sufficiency, renewable energy production, hand-crafted goods for export, and ecosystem services enhancement have potential to help pastoral societies transition to a more sedentary, modern lifestyle without forcing them completely out of pastoralism or to leave their homelands. This is discussed after we consider the livestock productivity challenge under African pastoralism.

Sub-Saharan African Pastoralism: Low Offtake Challenge

Although precise census statistics on mobile pastoralist populations are difficult to obtain (Randall, 2015), it is estimated that the livelihood of somewhere between 250 million (de Jode, 2010) and perhaps as many as 367 million people (Abdi et al., 2014) in sub-Saharan Africa directly depends on pastoral and agro-pastoral livestock raising. Recent estimates suggest that as many as 50 million people in this region of Africa rely on pastoral transhumance to subsist (Krätli et al., 2013). Innumerable research, education, and development projects have focused on pastoralism, its traditions, and its contributions to land stewardship and regional economies (e.g., Behnke et al., 2011; Homewood, 2008; Lane, 1998; Toutain et al., 2012). Collectively, this work has demonstrated the crucial socio-ecological roles of African pastoralist peoples. More recently, attention has been placed on the multiple stressors that are reshaping this ancestral livestock production system (Boru et al., 2014; Butt, 2011; Desta and Coppock, 2004; Galvin, 2009; Reid et al., 2014; Scoones et al., 2013; Turner and Hiernaux, 2008). On the basis of this evidence, a growing number of scientists are advocating in favor of supporting these traditional livestock-raising systems as a means of using large regions of marginal rangeland that are not well suited for sedentary ranching (de Jode, 2010; De Haan et al. 2016; Krätli et al., 2013).

Mobility is the core feature of pastoralist societies (Behnke et al., 2011; Turner et al., 2016). Pastoralists make their living by traveling hundreds of kilometers to strategically select the better grazing and trading sites (Brottem et al., 2014; de Jode, 2010). Sophisticated migration strategies, now aided by cellular communication technology, are used by pastoralists to capitalize on local and regional gradients of rainfall-driven rangeland vegetation green-up (Debsu et al., 2016; Waters-Bayer and Bayer, 2016). In addition to finding and accessing high-quality grazing areas, pastoralist success also depends on a detailed knowledge of livestock husbandry, forage nutritional value, available markets, access to communal grazing, and access to livestock water. They must avoid droughts, livestock disease, conflict, and theft (de Jode, 2010; Krätli et al., 2013). Increased demand for farmland and associated changes in land tenure regime, rising instances of armed conflict, and efforts by some governments to shift their nomadic and transhumant populations into alternative lifestyles are the threats to pastoral mobility (and thus pastoralism as a way of life) that have been identified by several studies (De Haan et al. 2016 and references therein; Gonin and Gautier, 2016; Turner et al., 2016). Other less visible stressors are changes in livestock ownership regimes (more affluent urban investors now hire the services of pastoralists), progressive loss of pastoral knowledge due to urban migration of younger generations, a chronic deficit in the provision of health and education services, and increasing taxation pressure at international borders (Turner, 2009; Turner and Hiernaux, 2008). Collectively, these stress factors are changing the face of pastoralism across sub-Saharan countries of northern Africa.

Debate in academic and development circles regarding the role of transhumant and nomadic pastoralism in sub-Saharan Africa has revolved, for the most part, around its high efficiency as a low-input but low-offtake livestock production system relative to western ranching enterprises (e.g., Krätli et al., 2013). More broadly, the debate has focused on the case for sustaining ancient, traditional, pastoral range livestock production systems because of their cultural and environmental values. Less emphasis has been placed on assessing the capability of pastoralism to supply animal origin food products for the rapidly growing

human populations of northern Africa. It is estimated that African demand for meat and milk will double between now and 2050 (AGRA, 2014). Despite sustained growth of livestock inventories across the region, human consumption of meat and milk in much of sub-Saharan Africa is about half the average annual per capita consumption rate of other developing localities (11.0 vs. 26.4 kg meat and 27.2 vs. 48.6 kg milk, respectively) (Otte and Chilonda, 2002). Because livestock numbers are now at or above carrying capacity in the humid and subhumid parts of Africa, further expansion of livestock inventories is unlikely to meet the rapidly increasing regional demand for animal protein. We recognize that lack of water is still a major constraint on livestock grazing in the more arid portions of Africa typically used for wet season grazing (Supplementary Materials, Figure 2). However, carrying capacity in these areas is much lower than in humid and subhumid areas. Offtake rates, historically at about one-third of western hemisphere systems, have remained stagnant for several decades (Otte and Chilonda, 2002). Increasing productivity of northern Africa's livestock production systems appears essential to meet future human nutrition needs without increasing reliance on imported meat and milk (Pica-Ciamarra et al., 2007). Northern Africa's people, who are among the lowest in the world in income, in general cannot easily afford imported meat and milk.

More than two-thirds of meat offtake in sub-Saharan Africa comes from pastoral and agro-pastoral livestock raised in the arid, semiarid, and subhumid zones. In Kenya, for example, close to 50% of livestock are raised on rangeland (Government of Kenya, 2003). Cattle offtake rates (animals slaughtered divided by total inventory) are slightly higher in pastoral versus agro-pastoral systems (Otte and Chilonda, 2002). However, at 7–10%, they are well below offtake levels worldwide (21%) and in developed countries (35%) (Otte and Chilonda, 2002). Cattle comprise 72% of all tropical livestock units across sub-Saharan Africa compared with 16% for small ruminants. The offtake rate for small ruminants (20.4% and 21.4% for sheep and goats, respectively) is twice the rate of cattle but still well below worldwide averages. Low meat offtake is driven by high mortality rates (approximately 22% and 27% for calves and lambs, respectively), low reproductive rates (59% calving rates), and slow growth, all of which are caused by chronically deficient nutrition and inadequate veterinary inputs (Otte and Chilonda, 2002). Nontraditional smallholder dairy farmers, who own only 4% of the region's cattle population, supply approximately 43% of sub-Saharan milk offtake. Interestingly, offtake rates are dramatically higher among nontraditional smallholders versus traditional agro-pastoralists in the same East African region for both milk (599.8 vs. 24.8 kg/animal) and beef (18.3 vs. 6.8 kg/animal) (Otte and Chilonda, 2002). So while exceptionally low levels of input make pastoral livestock systems one of the most efficient on the planet, this comes with the tradeoff of very low offtake. Unsustainably large herd numbers would be needed to meet the region's demand for animal protein, which is expected to double by 2050, if productivity were maintained at current levels.

Much of the loss of pastoral land to crops is occurring in the productive subhumid areas of traditional migration routes, which play a key role in providing dry season grazing (Campbell et al., 2005; Homewood et al., 2001; Reid et al., 2004; Tsegaye et al., 2010; Turner et al., 2016). Therefore, further integration of herding and farming appears inevitable (Watete et al., 2016). In our opinion, researchers and policy makers must concentrate efforts on finding ways to facilitate and enhance this integration to boost livestock productivity. Our work with agro-pastoral communities in Mali suggests that modest improvements requiring little or no capital investments, such as enhancing capacity building of women grassroots organizations to help them make more efficient use of existing crop residues, planting double-purpose crops, and/or incorporating herder know-how to improve animal husbandry, could significantly boost current productivity levels (Cibils et al., 2015).

Local Development Strategies

In general, US policy regarding African and Mid-Eastern countries since the 1980s has focused on encouraging change away from

authoritarian to democratic governments. At the same time China has helped African countries design and fund megadevelopment projects involving construction of roads, dams, public buildings, and other types of infrastructure (Moyo, 2012). Industrial agricultural projects with the goal of producing cash crops for export have often been emphasized, although they have been contentious because they typically displace small farmers and pastoralists (Brown 2012, Brown, 2008; Elias and Abdi, 2010; Flores, 2013, 2014). Only a few projects have directly helped low-income people deriving their livelihood from small-scale farming, ranching, and pastoralism. Family planning programs to reduce population growth have not been heavily emphasized by African governments, although they have been widely and successfully used in East Asian countries.

In our view, local development projects helping small farmers and herders should be greatly expanded. These projects should involve equal education for both genders, family planning assistance, empowerment of women, food self-sufficiency, development of renewable energy, development of hand crafts, improvement of ecosystem services, improvement of soil and water resources, and wildlife conservation. Ecotourism can often be incorporated into these programs. Capacity building among pastoral women, who are often leaders of collective action groups (Coppock et al., 2011, Coppock and Desta, 2013), needs to be a central focus of development programs. Such interventions have shown great potential for alleviating poverty in Ethiopian (Coppock et al., 2011) and Kenyan (Coppock and Desta, 2013) pastoralist communities. We believe they should be oriented toward keeping people on the land rather than encouraging migration to the cities or other countries. Following is an example of where this approach has been successful.

The Cuba Story

Cuba provides an interesting example of how a densely populated country with limited natural resources can transform from dependency to self-sufficiency. Before 1990 Cuba was highly dependent on the former Soviet Union for financial aid and trade (Pfeifer, 2006). Trade sanctions by the US government kept Cuba mostly isolated from world commerce. The entire economy of Cuba was structured around three cash crops: sugar, tobacco, and citrus. The Soviet Union provided Cuba with most of its oil, food, and fertilizer. After the Soviet Union collapsed in 1990, Cuba lost 85% of its trade, causing agricultural production to drop by over 50% (Pfeifer, 2006). Although undernourishment sharply increased, the government's food safety net program prevented large-scale famine while restructuring occurred in food production. Out of necessity, Cuba proceeded to create a new system of sustainable agriculture based on organic/ecological methods, low fossil fuel inputs, self-reliance, worker-owned cooperatives, and vibrant local markets (Pfeifer, 2006). Ancient farming techniques like intercropping and manuring were combined with new organic technologies such as biopesticides and biofertilizers. Biopesticides involve using microbes to combat pests while biofertilizers integrate earthworms, animal manure, green manures, and compost to boost soil fertility. Both draft animals and human labor were used to replace tractors. A major part of Cuba's agricultural restructuring was the development of urban agriculture (Pfeifer, 2006). Urban gardens now produce > 50% of the vegetables Cubans consume. Cuba is becoming a popular destination for ecotourists.

Cuba's agricultural transition has been acclaimed as a major success by various international economic aid organizations, including the World Bank. It is now viewed as the leading country in agro-ecological farming (Pfeifer, 2006). As a nation Cuba ranks high in human development, health care, and education but low in economic freedom (Pfeifer, 2006). A key cornerstone in Cuba's success in achieving food self-sufficiency has been population stabilization, which was an important goal of its leader, Fidel Castro. Since 2006 Cuba has had a slightly negative (−0.09%) population growth rate. Cuba's success in population

stabilization is attributed to education in combination with high availability of various birth control methods.

We consider Ethiopia an interesting comparison with Cuba because both countries have similar population density and have limited natural resources, especially fossil fuels. Even though both countries have long histories of authoritarian government and high poverty levels, human living and environmental conditions in Cuba are rated much higher than Ethiopia (Fund for Peace, 2016). Because Cuba has attained population stability, a high level of education, and food self-sufficiency, we consider it to have a much brighter future than Ethiopia. We believe that the approaches used in Cuba have many applications to African countries such as Ethiopia. However, we do recognize that cultural traditions may inhibit their applications. Ethiopia is the best case available testing how effective the standard development model focusing on rapid industrialization and infrastructure development can be in Africa (Rieff, 2015). Ethiopia has achieved a remarkable annual economic growth rate of nearly 10% over the past 10 years. However, most of the people living away from Addis Ababa, the capital of Ethiopia, still live in extreme poverty. Reduction in population growth has been a goal in Ethiopia's development plan (The Economist, 2015). It is encouraging that in Addis Ababa, two children are now the average family size but large families of six or more children characterize most of the country, especially those dominated by pastoralism (The Economist, 2015). Ethiopia does have a large network of health care extension workers that provide family planning assistance as part of their mission. The Gates Foundation, the world's biggest philanthropic organization, has committed \$140 million a year to family planning that gives women in African countries such as Ethiopia access to contraceptives (The Economist, 2015). Although Ethiopia is often held up as a major African economic success story, there is deep concern that its rapidly growing population will soon overwhelm its recent progress, causing it to descend into political instability (Rieff, 2015).

Within Ethiopia the first author (Holechek) has recently witnessed successful local development projects that placed high emphasis on reducing soil erosion and increasing food output using traditional methods involving energy input from humans and draft animals rather than fossil fuel mechanization. Green technology involving solar energy for cooking, composting, and improved education availability were other important components in these projects aimed at keeping people on the land. Soil erosion levels were drastically reduced where these projects were observed (Supplementary Materials, Figure 3). Unfortunately, the amount of area with these projects appeared to be no more than 5%.

Conclusion

Although the human population of Africa has increased roughly fivefold since 1950, this increase has not attracted much attention or concern by world leaders and the news media. This is because for decades Africa has been commonly viewed as a primitive developing continent with a large land base and low human population. However, many demographic experts believe Africa in general is now fully populated. Importantly, at the current growth rate of 2.2% per year Africa will double in human population in 33 years. Nigeria, Ethiopia, and Egypt, which have the largest populations in Africa, are all classified as fragile (failed) state countries. They now have a combined population of 369 million, which is more than the United States (323 million). All three countries must import food, have high poverty levels, and are experiencing increased civil unrest. A doubling of the human population in these and other African countries over the next 35–40 yr will have a major impact on the world in terms of food security, water security, global warming, global conflict, and refugees.

Throughout northern Africa, grazing livestock play an important role in meeting food needs but are also a source of draft animal power for farming and transportation. However, open rangelands that provide most of the feed for African livestock are shrinking due to conversion

to farmland, desertification, urban expansion, industrial development, establishment of wildlife reserves, and roads. Quantitative data on rangeland losses for different countries are lacking but needed. Nomadic pastoral grazing, which has provided a livelihood for various African ethnic groups for hundreds of years, is now undergoing decline and transformation, but the magnitude of these changes has not been assessed and varies by country. Nevertheless, we believe that nomadic pastoral grazing will continue at some level across Africa because roughly half the land is unsuited for farming and will remain as rangeland. Concern is growing that the ecological condition and productivity of these rangelands may be declining, but quantitative documentation is lacking.

There is great potential across Africa to increase both offtake from livestock and rangeland productivity through implementation of proven management practices. This is because livestock productivity is lower, especially in sub-Saharan Africa, than any other world region due to emphasis on increasing animal numbers rather than offtake. Practices such as improved breeding, supplemental feeding, vaccination, herd management, and record keeping have great potential to enhance African livestock productivity. This also applies to range management practices such as proper stocking, rotational grazing, prescribed burning, water development, fencing, and seeding. Across Africa, aggressive planting of leguminous shrubs could improve livestock nutrition, increase soil fertility, reduce soil erosion, and provide firewood (Chakeredza et al., 2007; Franzel et al., 2014; Bogie, 2015) (Supplementary Materials, Figure 4). Sub-Saharan African rangelands are typically grazed through common use of cattle, sheep, and goats. Fine-tuning the mix of animals through higher proportions of sheep and goats can potentially increase offtake in many areas. In our view the primary problem is that socio-political frameworks relating to property rights, markets, the financial system, and education presently do not well support an offtake-oriented livestock production system.

We believe local development projects have high potential to improve living and environmental conditions for pastoralists and farmers across Africa. Local development projects at the village level typically involve provision of schools/education, family planning, soil and water conservation, solar energy for cooking, improved sanitation, micro-loans to small innovators, support for crafts and trade, and training in farming, range management and animal husbandry practices that increase food, commodities, and ecosystem services. Experience has shown that improving living conditions, availability of family planning, and income are the keys to slowing population growth, creating social stability, increasing food production, and reversing environmental decline. Providing jobs and keeping people on the land are important goals of local development projects.

It is our view that nomadic pastoralism, which depends heavily on mobility, can and should be sustained throughout Africa where feasible. This view is based on the fact that large rangeland areas (about 50% of the continent) occur throughout Africa that will not support farming because of low precipitation, lack of water for irrigation, and soils/terrain limitations. Nomadic pastoralism will continue to be the most efficient agricultural production system for these lands while at the same time sustaining traditional cultures. We consider maintaining migration corridors, providing legal rights to historic grazing lands, and provision of support services (watering points, health care, markets, schools) along key migration routes to be of critical importance in sustaining nomadic pastoralism. In return for security in their livelihood, pastoralists will need to make some lifestyle adjustments such as payment of taxes, making more use of markets, and lowering of family sizes. Some African countries such as Morocco have already taken important steps to maintain and enhance pastoralist migration corridors and protect primary grazing lands and grazing rights. For additional information on strategies to maintain nomadic pastoralism, we refer readers to Pica-Ciamarra et al. (2007), de Jode (2010), Rass, 2012, Reid et al. (2014), and Turner et al. (2016).

If economic and environmental conditions continue to decline in northern Africa, we have the deep concern that within 10 yr civil unrest and political instability will cause widespread human suffering and an epic flow of refugees from war, famine, and global warming. Detailed discussions pointing out the severity of these risks are provided by Cribb (2010), Brown (2008), Brown, 2011, Brown, 2012), and Rieff (2015). Therefore we urge strong focus and action by world leaders, Western governments, and nongovernment aid organizations on the challenges and opportunities confronting people in African countries. We consider sustaining and improving rangelands for both livestock grazing and ecosystem services to be a critical component in sustainable African development strategies. We do not believe that endless exponential growth in human populations and natural resource consumption is compatible with rangeland sustainability. Destruction of the rangelands results in loss of essential components for human existence. When properly managed, rangelands can sustainably provide the necessities of human life (food, water, fiber, energy, ecosystem services), but they are a finite resource. We hope this is recognized by the people and their leaders in African countries when planning their future.

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Appendix A. Supplementary Data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.rama.2016.09.004>.

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